Origin of science:

We, the Homo sapiens, on our arrival here, found a world full of information. Each bit of information served as data that helped us. The question why there exits such data did not bother us initially. Science originated when we started asking questions regarding these. Then suddenly there was a revelation: what we see is the handiwork of demons, mysterious creatures, good and bad, residing in an unknown world. Mythology, primitive science based on observation, thus came into existence.

Later, some patterns were identified in that handiwork that we could predict certain things, or it seemed that the world follows some laws. We thought we were intelligent enough to understand the work of the demons or the demons revealed the same to us. We started explaining whatever possible, and left the rest to the demons to be revealed later. Thus, the next level science, pseudoscience, based on observation and prediction came into being.

Modern science emerged when we identified that the laws are essentially mathematical. That was again a revelation: we could verify things by experimentation. Observation, prediction and experimentation thus became the integral parts of science, and with that theoretical physics became the basic science, the rest, biology, chemistry, etc. being extensions. The present strategy is to explain whatever is directly observable on the basis of laws, and leave the rest to hypothesis to be explained again based on laws; no real demons are allowed, but 'virtual demons' (phenomenons that do not exist in the directly observable world) are allowed.

The role of mathematics:

Basic mathematics, arithmetic, is background free, and do not require any space, time or matter for existence. The laws of arithmetic are universal, unchangeable and stand on their own. There is no basic-mathematics other than the arithmetic we know, only that we have discovered newer and newer mathematical laws pertaining to different situations. Even an omnipotent creator cannot defy the laws of arithmetic, nor can he create any new arithmetic. He may, however, create a computer programme that gives results based on some fictional arithmetic, but to create the programme, he has to follow real arithmetic.

However, it is not the sanctity of mathematics that makes it the law of nature. If the world does not change with time, then there will be nothing to be explained, or there will be no laws. Or it is the changes in nature that we try to explain. Basically, the only change in nature is that the relative positions of atoms (and subatomic particles) remain changing with time, causing fragmentation or accumulation. That is, whatever may be the cause, changes happen entirely by way of motion. Both motion and fragmentation/accumulation follow laws of arithmetic. So any change in the physical world has to follow the relevant mathematical laws.

Mathematics has a role in all branches of knowledge whether it is science, economics, politics or philosophy. But other branches have no role in mathematics. The evolution of everything associated with us, be it our life, our science, our society or our knowledge is determined by mathematical laws. Naturally, our science modeling is also based on mathematics. Any other method that we may imagine for modeling science will have some underlying mathematics that ultimately it will turn out to be mathematical.

That leads to the question whether we will be able to model science in any newly discovered law of mathematics. Even now, we are able to model science based on discrete and continuous mathematics. This is possible because discrete entities can create continuous patterns and a continuous entity can create discrete loops. So the emergence of some new laws cannot be ruled out. Whether we use differential equations or discrete computation or some other form of mathematics, the result will be approximately the same, only that our physical picture about world will differ.

That is the limitation of mathematical modeling. Different equations can describe a given phenomenon, and each equation can give different physical pictures. So an indiscriminate use of mathematical modeling will lead to wrong physical pictures being inferred from equations and that may lead to the creation of 'virtual demons'.

A classic example is Newton's laws of motion. Based on the laws, we can say straight-line motion is a property of matter, absolute rest is a property of matter, straight-line motion and rest are equivalent, both motion and rest are not properties of matter, etc. The fact is that it is just a law regarding motion, and says nothing about the properties. That is, the basic properties of matter do not depend on any mathematical law.

So we can conclude that given the inherent physical properties of nature, the changes in it follow relevant mathematical laws. This implies that science modeling should be based on laws and properties; the laws are invariably mathematical and we can frame equations. The equations are valid for the given properties, but the properties are not inferrable from the given equations. So the physical picture including properties should not be inferred from equations, but has to be ascertained independent of the laws.

The evolution of our Science:

In the beginning, we started collecting data because it helped our survival. Identifying the correlations was just natural, and the process was continuous leading to the understanding of the world little by little, and science thus started evolving. The moment of revelation comes when an unexpected connection between two totally unconnected bits of information is found. This leads to a quantum-jump. Thus the evolution that led to the current science was continuous with intermittent quantum-jumps.

Revelations are just unconscious acts; the action is spontaneous, not a consequence of well thought out strategy. So, it may or may not work; even if it meets with immediate success, in the long run, it may turn out to be of little or no use. It is a form of trial and error method, and has worked and has also failed many a times. A good example is Einstein's 'cosmological constant', a revelation he discarded shortly after announcing it. Revelation requires previous data as a prerequisite, and its impact depends on the available data.

Newtonian laws are one such revelation. It had a high impact and Newtonian mechanics continued for nearly three hundred years. Then, Quantum mechanics, another revelation, dismissed the deterministic world of Newtonian mechanics, and the Relativity theories, yet another revelation, dismissed the Newtonian concept of absolute space and time. Both had high impacts, and both continue to rule the field of physics. However, the possibility that either or both being abandoned or relegated to an inferior position cannot be ruled out.

In the case of evolution of life, natural selection had a crucial role. It is a trial and error method. It has worked, but is slow and may lead to occasional collapses. For example, the dinosaurs started acquiring more and more body mass, a trial and error strategy that helped them initially, but led to their collapse later. However, life did not end with that; evolution led to homo-sapiens who are capable of understanding and designing. The evolution of our science was decided by trial and error combined with understanding and design.

Understanding the science behind any phenomena makes it possible to design machines or instruments for any given purpose, trial and error giving it more perfection. Thus science and technology developed hand in hand. Technology gave new instruments for science research, and that in turn gave more and more data. So technology had a crucial role in the evolution of science. Philosophy, economics, politics, etc. also had their roles in the evolution of our science.

Initially, available data is little and so identifying correlations is difficult. As data increases, correlations get revealed, and this leads to understanding of the laws, which leads to designing instruments, which in turn provide more data leading to more correlations and better understanding. Such a pattern of evolution follows mathematical laws. Or it is mathematical determinism that decided the evolution of our science.

In a reductionist approach, science is physics. In present day physics, we have two separate theories, Quantum mechanics based on 'uncertainty', to explain the quantum world and General Relativity based on 'spacetime' to explain the cosmic world. 'Uncertainty' and 'spacetime' are not observable in the normal world and hence are virtual demons. There are many such virtual demons and many arbitrary parameters in present day physics. QM and GR are mutually inconsistent, and the explanations are highly complex. So the present day physics is both imperfect and incomplete.

The future of physics:

Science is understanding nature. As science evolves, our concept about science also evolves, philosophy having a crucial role in that. From a philosophical point of view, beauty and logic are essential for any theory in physics. Beauty implies that there should be only one theory; it should be simple and complete with minimum arbitrariness. Logic implies that science is a journey from the 'known' to the 'unknown'. The unknowns are to be explained based on what is known, and not vice-versa. That is, the quantum and cosmic worlds should be regarded as extensions of the observable world. The concept that they are entirely different goes against beauty and logic. So theoretical physics will be more beautiful if 'virtual demons' are not present.

As explained, mathematical modeling has limitations and may lead to 'virtual demons' being invoked. Science modeling should be based on properties and laws, and physical pictures should not be inferred from equations. But, at present, mathematical modeling is used indiscriminately and in many cases physical pictures are inferred from equations. Moreover, 'virtual demons' having no physical meanings are freely invoked as and when required, and it is regarded as the accepted way of physics. The present incompleteness of our theories may be due to these reasons.

Explaining everything based on the basic 'stuff' (whether it is matter, energy or fields) with which the world is made, is an extremely helpful reductionist approach. Mathematics has no role in deciding the properties of that 'stuff', but has a role in deciding the emergent structures, and thus an indirect role in deciding the emergent properties. To explain the emergent properties, a holistic approach is required. Physicists, however, are reluctant to admit the role of holism in physics. This may be another reason for the incompleteness.

So the first step for a complete theory is identifying the 'stuff' and its properties. It is the physical properties of the 'stuff' that decide science. If the number of properties is infinite or the properties are not measurable, it will be impossible to arrive at any science. The fact that we have a solid science implies that the 'stuff' has a finite number of properties, and the properties have finite values. That implies our science is deterministic. We discover the predetermined science little by little, and may eventually arrive at a complete theory.

Is it possible to have a complete theory? I think Godel's incompleteness theorem gives the answer. The theorem implies that any theory based on a set of axioms cannot be proved from within the theory, thus making it incomplete. But the proof can come from outside, from some other theory. So a suitable combination of two or more theories can give a complete description of a system. For example, Euclidean geometry is a combination of geometry, a theory of shape, and arithmetic, a theory of numbers. The arithmetic of the shapes provides the proof for the theory, and so Euclidean geometry is a complete theory.

In the same way, theoretical physics can be reduced to three basic theories, theory of the 'stuff' (properties), theory of shapes (geometry) and theory of numbers (arithmetic). Independently, the three theories are incomplete as per Godel's theorem, but in combination, it can lead to a complete theory. Given the basic properties, arithmetic decides the geometry of the emergent structures, then geometry and arithmetic together decide the emergent properties, which are to be explained based on holism.

Naturally, we can expect that a new revelation based on holism will lead to a Theory of Everything, and the 'virtual demons', the complexities and much of the arbitrariness will disappear. But as our understanding of science have matured so much, new revelations are hard to come. If at all any revelation comes, its impact will be low; it will just plug the loop holes, making the theory perfect; it may not even lead to any new technology. But still, it is a goal to be achieved so that we can claim our science is complete.

Then, starting from the given 'stuff' with the given properties, we will be able to explain everything including the geometry and emergent properties of the universe as a whole. Even then, there will be some arbitrariness at the most fundamental level. Why the 'stuff' the world is made of exists? How it came into existence? Why it has the given properties? Science cannot answer these; we can leave these as such, and not invoke any demons. That is the way of physics, the beauty of physics, and the purpose of theoretical physics.

Can science be different?

Life and neural network are emergent structures allowed by nature. These are inherent in the 'stuff', and emerge wherever possible through natural evolution. Intelligence, a property of the neural network, can be defined as the capacity to 'understand the situation

and design actions accordingly'. If the efficiency of the neural hardware is above a certain level, 'understanding' gradually evolves into science and 'designing', into technology. That is, the origin of science is somewhat deterministic, and that explains why we have science.

The efficiency of the neural hardware depends on various factors. Collecting data, storing it, processing it and maintaining the neural hardware are entirely different jobs. Being too efficient in a certain field will reduce efficiency in the others. So, there has to be some trade-off that there is an upper limit to efficiency. Nature achieved this through trial and error, and we have the most efficient neural hardware. Naturally, intelligent creatures with incredibly powerful neural network may not exist. So the evolution of science will always be a slow process, as has happened in our case, and cannot be instantaneous.

Basically, our science depends on the properties of the 'stuff' with which the world is made. Neither we nor the laws of mathematics have any role in deciding these properties. Our understanding of the properties and the relevant laws enable us to model our science and design our machines. We have been able to conceive and implement different technologies, including that of artificial intelligence. These are 'allowed by nature', and we just discover what is inherent in the 'stuff'. So the basic nature of our science and technology cannot be different.

The evolution of our knowledge depends on the amount of data collected and the probability that some 'connections' between the bits of information are identified. So different branches of knowledge evolve hand in hand. It is like the information wave-front advancing in all directions, and our understanding of mathematics, science, philosophy, economics, etc. evolving together, each branch contributing something to the rest. So the questions like what would have happened to the evolution of physics, if mathematics evolved slower, biology evolved faster or society evolved faster, etc. are irrelevant.

Philosophy introduced the concept of beauty in science. Beauty implies that theories should be consistent, logically valid, and simple. A theory of everything is the most beautiful concept in physics. Observation, prediction and experimentation are the three pillars of modern science; consistency is the benchmark for these, and logical interpretation of the consistent results leads to theories. However, complexity can cover up inconsistencies and logical fallacies. So simplicity is a desired quality, if not essential. Philosophy and science evolving together implies that ideas that have relevance in science migrate from philosophy to science; this is somewhat deterministic.

The evolution of knowledge leads to the evolution of society. A fully egalitarian society remains a dream for us; there were always some underprivileged, and revelations came from them. Einstein was not in the field of physics and was not brought up with the established norms of then physics when he brought out his theories. He was less privileged in that sense, and so was bold enough to think against the norms. In an egalitarian society, the motivation for change will be less, because the established norms will be good for all. When the evolution of knowledge reaches its end, the evolution of science will be complete and the society will become fully egalitarian.

Our current practice of institutions, funding, journals, peer-review, etc. are also part of the grand evolution of knowledge. Trial and error, understanding and design, and trade-off between various factors have resulted in the present establishment. An effective peer review is a very difficult process, especially if there are many players and many ideas. Similarly, an equitable distribution of funds is also very difficult to achieve. Naturally, there will be some shortcuts, a trade-off between various interests, and it is unavoidable. Making science more effective and equitable is desirable. As in the case of society, we may achieve this when the evolution of science is finished.

Evolution of science depends on data collection, identifying the correlations, thereby understanding the properties and laws, then designing instruments based on these, which in turn provide more data, and so on. Here simple arithmetic works; the more the number of bits of information, the more will be the number of correlations, and the more will be our understanding. New ideas come as revelations and the establishment always resists these. These opposing interests guarantee that the evolution is always in the right direction, with only minimum deviation at any given time. So the path of evolution is somewhat deterministic, and cannot be different in the long run.

Mathematical determinism:

The essay will be incomplete without referring to mathematical determinism, which arises from the fact that the laws of arithmetic are unchangeable. Adding up integers will always give a finite value, a predetermined value. We have to add the condition 'go on adding infinitely' to get the result as infinity. A 'halting statement' (like, add only integers less than 'n' and each integer just once) can solve the problem of infinity creeping in, and make it finite and completely deterministic. Here, the number of allowed paths for adding up is finite and if 'n' is very small, number of paths will be limited.

So a system of interacting discrete entities having finite properties will tend to be finite, and will become finite, if there is a 'halting statement'. In the case of the 'stuff' the world is made of, motion (energy) tries to move it apart and gravity (force) tries to confine it. The balance between the two can provide stability, and thus act as a 'halting statement', making the system deterministic. The changes in the system will follow the laws of arithmetic, and will have predetermined ends depending on the situations. That is, its evolution follows only 'allowed paths', not 'all paths'.

Thus mathematical determinism decides the evolution of the universe, which leads to the origin of life, humans, our society, our knowledge and our science. The basic properties of the 'stuff' seem to be very few (mass, volume, motion and force) that the number of allowed paths can even be 'just one' at certain situations. Starting from the singularity that allows just one mathematical option, expansion, the universe becomes extremely diverse with mathematics allowing a wide variety of options, and ultimately winds up to a singularity with just one mathematical option, which we have not yet understood. That is the the beauty of mathematical determinism.

Conclusion:

Thus we can conclude that our science, its evolution, its philosophy, its institutionalization, etc. are deterministic, and cannot be different from what we have seen. As far as we know,

the universe is built of the same 'stuff' as we are, and so the science and the path of evolution of science will be the same for any aliens. So at a certain time during the evolution, they also will have the same level of scientific know-how and technology as we have now. That is, maths says 'science' cannot be different anywhere in our universe.

However, in other universes, the 'stuff' may be different, having different physical properties. Though the arithmetic is the same as ours, the relevant mathematical laws they follow may be different. So for the aliens from other universes, physics may be different, science may be different, technology may be different, and society may be different.
