God’s dice: Randomness can have purpose

by James Bradley in the February 3, 2016 issue

Photo by John Brueske

When Charles Darwin declared that evolutionary variations occur by chance, many of his contemporaries were alarmed, worrying about the implications of chance for people’s belief in the God who designed the world. The very mention of chance in the mid-19th century hinted at a godless universe.

In the early 20th century, chance began to play a key role in physics too. In 1928 a group of physicists centered in Denmark formulated the Copenhagen interpretation of quantum mechanics, which stated that elementary particles possess a fundamentally indeterminate nature. Albert Einstein had significant misgivings about such claims for indeterminacy, and he famously expressed these by saying, “God does not play dice.” Einstein made this remark too often for Niels Bohr, one of the Copenhagen group, who retorted, “Albert, stop telling God what to do.”

Western science and religion long assumed that we live in a coherent world that can be understood. Classical Christian thinkers argued that the order, harmony, and beauty of the world clearly point to a designer. The existence of randomness in biology and physics has undermined such arguments for many people.

Darwin, unable to see evidence for an underlying intelligence behind the process of evolution—which operates by chance variation and natural selection—concluded that evolution was “unintelligent.” He also felt that evolution was cruel in a way that could not be reconciled with the existence of a loving God. His concerns have become part of the fabric of contemporary culture.

But much of the theological concern about randomness arises from either misunderstandings about what is being claimed or an ambiguity in the terminology. I have worked my whole career in the field of probability and statistics, in which randomness is a regular topic. The existence of randomness has not led me to doubt the Christian faith, for I have no trouble believing that indeterminacy can be purposeful.

Before we get to that topic, let's begin with terminology. Greek philosophers used the word *chance* to refer to events that were gratuitous, unplanned, and apparently without intelligent direction or design. The Greeks deified this aspect of experience in a goddess, Tyche, whose name literally means luck. In the three centuries preceding the birth of Christ, fortuitous and unpredictable events in the lives of a person or a city were typically attributed to her action. If your city experienced a drought or a flood, that was Tyche's doing. An image of her appears on many coins of this era, and temples were built to honor her. The earliest Christian thinkers denied the existence of Tyche and rejected the notion that chance played a significant role in people's lives. Nevertheless, elements of Tyche's legacy live on, as in gamblers' references to Lady Luck.

Chance in the Greek sense is quite different both from what Charles Darwin meant in his study of evolution and from the scientific concept of randomness. The Greeks meant that a certain amount of unpredictability was a part of human experience. Darwin meant that he could not see purposefulness in the process of evolution. Much of the theological anxiety surrounding this issue arises from a confusion of the two understandings.

Complicating things further, randomness means different things in different scientific disciplines. In mathematics, randomness means unpredictability. In the field of statistics, randomness refers to the relationship between individual numbers and large collections of numbers. While individual numbers are not predictable, the overall distributions may follow certain well-understood patterns.

For biologists, randomness means that there is "no correlation between the production of new genotypes and the adaptational need of an organism in a given environment" (to quote Ernst Mayer). In other words, mutations are not a response to the environmental opportunities available to a species. Elliott Sober adds: "There is no physical mechanism (either inside organisms or outside of them) that detects which mutations would be beneficial and causes those mutations to occur." The key

meaning of randomness here is independence from environmental factors. When joined with natural selection, random variation in offspring provides the foundation of evolutionary theory.

Nothing in any of these concepts of randomness, however, excludes the possibility that randomness can be purposeful. And a reference to causelessness could simply mean that the cause is unknown. It could also be interpreted as lacking a *material* cause. Some Christian thinkers have seen “causeless” events as occasions of divine action.

Conflating chance and randomness imports into science the Greek sense that chance events are gratuitous. But because the universe involves randomness does not mean that it is without purpose or meaning. That question remains open.

Before roughly 1600, explanations of natural phenomena typically included a reference to purpose. In Aristotle’s view, everything has a final cause, a *telos* or “end,” for the sake of which it happens. In the course of the scientific revolution, however, Aristotle’s analysis of final causes was judged to be circular and vacuous. It seems only to describe what happens, as when he said that heavy objects fall because they have an inherent tendency to return to the earth, or that sparks fly upward because the true home of fire is in the heavens.

Pressing that same argument, Francis Bacon wrote that “inquiry into final causes is sterile.” Inquiry into final causes—teleology—dropped out of scientific practice. Galileo and Newton saw themselves as describers of phenomena, focused on the how, not the why. Today physical sciences explicitly exclude teleological explanations.

Yet biologists remain conflicted about teleology, because many biological phenomena appear to be directed toward a goal. For instance, while the beating of a heart can be described mechanistically in terms of muscle properties and electrical signals, that description omits the fact that the heart beats in order to circulate blood, which in turn carries oxygen in order to nourish the cells of a body. Mechanistic explanations in biology seem incomplete.

At the same time, many biologists are wary of explanations that suggest goal directedness. The “in order to” clause can be easily replaced by “for the purpose of,” and such explanations seem to head down the slope toward talk of an ultimate purpose rooted in an ultimate cause, and hence a classic philosophical proof for God.

But there are many ordinary ways that randomness can be purposeful. For instance, flipping a coin to decide who gets the ball first in a football game is widely seen as a fair way to make a decision. Board games often involve dice and introduce an element of uncertainty. In both of these cases, randomness is clearly purposeful: it serves the purpose of the game.

Random processes in our own bodies are purposeful as well. For instance, the delivery of nutrients depends on diffusion, a random process. The nutrients are carried into cells and waste products removed via diffusion through the cell walls. The human immune system does not include antibodies for every pathogen that could enter it; rather, it consists of a large number of building blocks. When a pathogen enters the body, these building blocks are randomly combined until an antibody is found. Then it is rapidly reproduced to counter the pathogen.

Even the aspects of evolution that Darwin saw as unintelligent can be seen as highly purposeful. For example, Darwin thought a lot about why giraffes have such long necks. Other biologists of his time accepted the Lamarckian view that as ancient giraffes stretched their necks to reach leaves high in trees, subsequent generations of offspring grew increasingly longer necks.

Darwin partially accepted this idea, but as he grew older he had reservations. For the Lamarckian account to be true, there would have to be some mechanism in the giraffes' bodies that would enable their reproductive systems to detect the opportunity to reach more food if they were taller. In fact, every creature would have to have a mechanism that would enable it to detect competitive advantages in the environment and pass the related genes on. But what could such a mechanism be like? It would have to be unimaginably complex.

Today biologists would say that giraffes randomly produced a variety of offspring, and those with longer necks turned out to have a competitive advantage and hence were more likely to pass on their genes. The process of random variation plus natural selection provides a straightforward means of explaining how species adapt to changing environments in a way that transcends the capacity of individuals to adapt.

For Darwin, *unintelligent* meant offering no evidence of being guided by or originating in an intelligent designer. Yet that term is misleading, for I cannot imagine a process that could be more effective at enabling entire ecosystems to

adapt dynamically to change than the one he describes. It's inefficient, perhaps, but not necessarily unintelligent.

So randomness can be highly purposeful. It can be orderly, too. Unlike the Greek notion of chance, in which pretty much anything can happen, randomness involves a limited number of options that are often well understood and whose probabilities are known. When someone rolls a die, there are only six possible outcomes and each is equally likely; it's not the case that any gratuitous thing can happen.

Furthermore, the aggregate of random outcomes can be highly structured and predictable. Some years ago, mathematicians proved the central limit theorem, which provides the theoretical foundation for much of modern statistics. It says that if one has a collection of measurements, no matter how diverse or disorganized, and one takes lots of random samples of the same size from those numbers, as the size of those samples increases the distribution of their averages will look increasingly like a bell-shaped curve.

This result is so astonishing that it prompted statistician David Bartholomew to opine that "God can have it both ways," meaning that God can have all the power that low-level randomness (such as diffusion) provides as well as having order, structure, and pattern at higher levels.

When I teach this theorem, I often jokingly write on the chalkboard "QED. God exists." The presence of randomness in nature does not entail a fundamental irrationality or incoherence.

But if God uses randomness, doesn't that conflict with the notion that God is in control? Doesn't *random* mean being out of control?

Consider again the referee in a football game. The coin flip is carefully organized and accomplishes its purpose of providing fairness. The referee is in charge without determining the outcome of the flip. God does not have to be a micromanager to be in charge. A strict Calvinist might say that every event in creation has to be directly ordained by God. But the presence of randomness in nature would suggest that God's oversight is more subtle than that.

Much of what we perceive as random is not gratuitous but arises from complexity. For instance, cosmic rays are protons or atomic nuclei that originate outside our solar system and pass through it. With the right equipment, they can be easily

detected. If one carefully records the precise time of their arrival, these arrivals satisfy all of the mathematical requirements to qualify as a Poisson process, a well-understood random process. The randomness results from two factors: there are lots of these particles and each acts independently of the other. But randomness like this is not the result of gratuitous chance or causelessness. It is simply a property of many complex systems.

It would be nice if all randomness could be accounted for by invoking the independence or complexity of systems. But it cannot. Deep mysteries remain. For instance, in spite of being the object of inquiry by philosophers and scientists since Aristotle, causality is far from understood. Can any event really be uncaused? That is, can some entities initiate action independently of any identifiable agent? Or are there hidden causes that are completely different from anything we currently understand? Are events that seem causeless to us really a venue for divine action?

Another challenge, perhaps the biggest one for theology, is how to reconcile the concept of a loving God with the seemingly gratuitous suffering of innocent creatures. Theologians have called this natural evil, and it has troubled philosophers long before and since Darwin. Both the scientific and theological mysteries associated with randomness are far from solved.

What we can say with confidence is that the claim, present in much popular conversation on religion and science, that randomness implies a universe without meaning or purpose is invalid. God’s creation is amazingly subtle. Even something that seems like the epitome of disorder or randomness can be the means of accomplishing good things such as nourishing bodies and resisting diseases. It is part of an astonishing world that can turn low-level randomness into high-level order.

Finally, both God and creation have depths that we have not begun to plumb. This should not be surprising, given that God is infinite, as Christian theology has consistently maintained.