The Missing Link

A Novel about the Philosophy of Biology

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Introduction

The Missing Link is a novel for high school-age students about the philosophy of biology—the study of the foundations and methods of the life sciences. This branch of philosophy primarily focuses on biology's core concept: evolution. Evolution is the gradual process through which all species in nature have come to be the way they are. Philosophers of biology consider questions concerning the nature of species. They also explore the relationships between biology, other sciences, and society.

The novel follows seventeen-year-old Theo Taara as she uncovers a mystery that teaches her about the philosophical ramifications of evolution. Theo joins the Chicago College Archaeology Crew, a group of college students who travel to Kenya searching for a seven million-year-old skull belonging to the species that produced both chimpanzees and humans. The skull has fangs for fighting but also an opening at the base for upright walking. Why is this "missing link" in the evolutionary chain so important? How far would her crewmates go to find it?

As Theo investigates these questions, she bumps up against the thesis that evolution explains everything. Is this true? She and her new Kenyan friend Wafula, whom Theo affectionately calls "Waffle," explore various objections: What about morality, art, true love, free will, and the soul?

The novel's storyline is actually a series of flashbacks that occur during a presentation given by an anthropologist who speaks about the very subjects that Theo and Waffle grapple with in the

narrative. Each subject is one that has been examined in depth by philosophers and other great thinkers who explored the extent to which the concept of evolution can be applied to human beings. Selections from some of the most relevant and significant works by these thinkers are featured in the "Explore More" section at the end of the novel. These selections are presented in the order in which their subject matter appears in the story. **I recommend reading the novel chapters first, followed by the corresponding reading(s) in the "Explore More" section.**

At the end of each reading are two discussion questions that will help you think more deeply about the author's argument. Note that, even if you don't fully understand everything in the reading, the questions contain enough explanation and context that you should be able to engage actively and thoughtfully in the discussions. The claims that the various authors have made are controversial and well worth debating.

I created Theo years ago for the elementary level of Royal Fireworks's Western philosophy curriculum, and she has gone on to have some exciting adventures that have led her to examine her thoughts deeply and honestly. I hope her stories help you to do the same.

Sharon Kaye

The Missing Link

Prologue

I was staring at a skull.

It looked like burnt enamel, cobbled together from many pieces. It had only a few teeth, which were uneven and broken, and yet there was something rivetingly beautiful about it. The two deep holes where the eyes had been suggested primeval intelligence. The arch of the brow was somehow familiar. It looked like a long-lost ancestor, staring into the future—staring right at me.

Someone in the audience coughed, and I blinked, breaking the skull's hypnotic spell. I shifted my gaze from its image on the screen to the man with flyaway silver hair at the podium.

"This skull," Dr. Earnest Northrup pronounced, swiveling toward it, "is seven million years old. Its discovery has exploded the entire field of anthropology—and landed Chicago College at ground zero."

Hushed murmurs rippled through the audience.

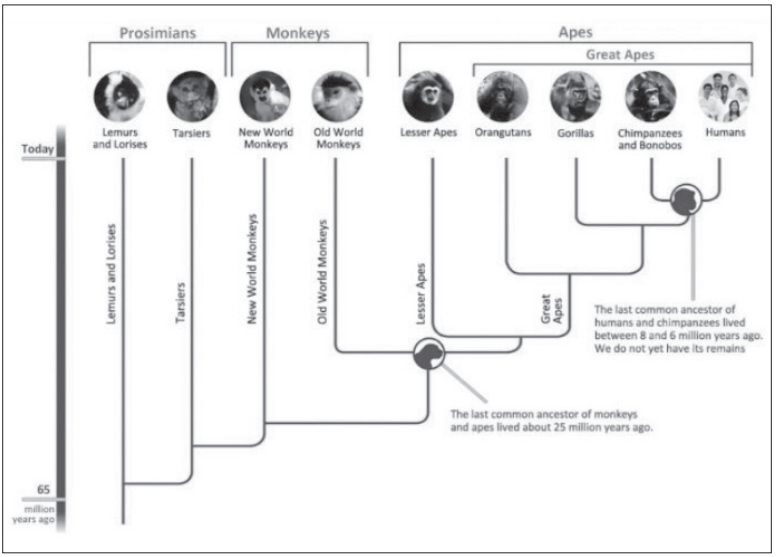
"Why is this skull so important?" Northrup asked, puffing out his chest with pride. "Because it belonged to the long-sought last common ancestor between chimpanzees and humans. In 2005, the world learned that chimps and humans share ninety-nine percent of our DNA, proving that chimps are our closest living relatives. That being the case, we knew that we had to share a common ancestor. Exhaustive excavations, however, produced no fossil evidence—until the discovery of this skull. It is," he paused for effect, "the missing link."

The image on the screen changed to a set of photos of the skull from all sides.

"The man who owned this skull had a small chimp brain and fanglike canines, yet the position of the hole at the base of his skull proves that he walked on two legs, just like you and I."

Northrup paused to let this information sink in. I ran my tongue over my canine teeth. My hand reached around and searched through my hair at the back of my neck to feel the spot where my spine connected to my head. I tilted my head back, picturing how hard it would be for me to walk on all fours like a chimp.

Northrup continued. "Genetic analyses tell us that humans and chimpanzees started separate branches on the tree of life about seven million years ago."



The image on the screen changed to a branching chart published by the Smithsonian Institution. It showed how all of the different species of primates descended from a common ancestor.

"But bones don't usually survive for seven million years, which is why, ladies and gentlemen, it has been so difficult to find evidence of a common ancestor between humans and chimpanzees. Heretofore, we had no physical proof of a last common ancestor between our two species. But the owner of this skull happened to die in a volcanic eruption in Kenya. The silica in the volcanic ash mineralized his remains, and the lava flow hardened into a tube, shielding him from decay."

The screen changed to a photograph of a dig site. It showed a rocky pit and several people working with tools. I squinted to see if I could recognize any of them, but they weren't facing the camera.

"Much of the seven million-year-old skeleton was found last year without the skull. Only the skull, however, could provide decisive evidence of common ancestry. This year, Dr. Darius DeLong went back and found the skull."

On this cue, the audience burst into applause. Northrup waited for silence.

"Dr. D is here with us tonight to share his perspective on the importance of his discovery. It is my great pleasure to introduce such a distinguished faculty member."

More applause erupted. A burly man with shiny black hair came out from behind the green velvet curtain. He grinned and waved, heartily shook Northrup's hand, and then settled in at the podium.

Chapter One

There he was: Dr. Darius DeLong. He'd been such a looming presence in my life over the past few months that I felt like I knew him. But I didn't actually know him. I was looking forward to hearing what he had to say.

Dr. D spoke into the microphone with a deep and resonant voice:

> Thank you very much. It's a pleasure to be here.
>
> As Dr. Northrup stated, I've dedicated my career to finding the missing link in the evolutionary history of humanity. Now that I've found it, I've turned my attention to sharing that discovery as far and wide as possible—because I believe that our evolutionary history is critically important to understand.
>
> I first heard about evolution in middle school, just as you probably did, but it took me a long time to understand its significance for my life and for the future of humanity. I hope I can save you some time and trouble by laying it all out for you here tonight.
>
> First off, we need to be clear about what evolution is. Evolution is the gradual process through which all of nature has come to be the way it is. That definition is so important that I'm going to say it again: *Evolution is the gradual process through which all of nature has come to be the way it is.*
>
> The natural world is a thing of extraordinarily complex beauty. Biologists look out at it and ask: How did it come to be this way? Why are there trees and birds and humans?

The answer is reproduction. Living things come from their parents. And their parents come from parents, and so on and so on. Reproduction is the core of evolution.

Reproduction enables each individual to make a copy of itself. But the copy is not exact. Humans reproduce sexually, meaning that our offspring receive half of their traits from their mother and the other half from their father. That makes every single one of us a unique combination of traits—even siblings because parents don't pass along the exact same traits each time they reproduce.

Sometimes these combinations turn out to provide an advantage. Perhaps some of the offspring in a species are a little bigger, some are a little faster, some are a little smarter, and so on. This variation among offspring won't matter much if their habitat provides ample food, water, and shelter. But nature is rough—the basics needed for survival are often scarce. This means that individuals must compete to survive. And in competition, even the smallest advantage can make a big difference.

Imagine a population of primates living in a thick African forest. Due to moderate temperatures and abundant rainfall, the forest has provided them with plenty of food for many years. Now, however, the region is growing hotter and drier, causing the forest to shrink into separate patches of trees. The primates can't find enough food in their patch. They must travel to other patches to gather food.

All of these primates are capable of walking on two legs while holding things for short distances, but some are born with longer legs that enable them to go farther. Those who go the farthest find the most food, enabling them to reproduce successfully most often.

The long-legged primates pass on their long legs to their offspring, and the next generation are even better at traveling and gathering food. The drought persists, leaving the primates that have short legs unable to compete. Only the long-legged individuals survive to reproduce, each time passing on their long legs to the next generation.

The drought drags on, and this species of primate continues to change. As they travel and gather, they find that they don't need fangs for fighting but rather brains for cooperating. Individuals with bigger brains along with their longer legs are especially successful, while individuals who try to survive by fighting with their fangs die out.

Over time, this long-legged, big-brained population may change so much that it is no longer able to mate with small-brained knuckle-walkers. Then it will be a new species. This is an example of evolution.

The English naturalist Charles Darwin first discovered this process in the nineteenth century. Through intensive study of a multitude of examples, Darwin showed how nature has produced different species over time. He called the process "natural selection." The environment "selects" the traits that enable an organism to survive. Organisms with successful traits pass them on; organisms with unsuccessful traits can't compete for resources and therefore don't survive, so those traits slowly disappear.

We look out at the natural world today and see the winners of a great competition. Humans and birds and trees are here because we are descended from a long line of survivors. And that's why we are so complex and beautiful....

Chapter Two

So complex and beautiful...

As Dr. D spoke, my mind gave way to an onslaught of memories.

It had all started in the middle of April. I was sitting at the kitchen table doing my math homework. It was the first warm day of spring. The window was open. Trees in the yard were budding. The long, cold, gray of winter was giving way to green. Potatoes were boiling on the stove. The familiar smell of chicken parmesan wafted toward me from the toaster oven. I was trying to focus on the numbers in my notebook when suddenly I heard my mother scream.

I froze.

She had walked through the kitchen just a moment before, talking on her phone. She was upstairs now.

Was she still on the phone? Was it a good scream or a bad scream?

I hopped off my stool and crept toward the stairs. Silence. And then a waterfall of muffled chatter, along with a few excited shrieks.

Ah. A good scream, then.

I went back to the kitchen to mash the potatoes, hoping the phone call wouldn't delay dinner. I sighed. I would have preferred to have a mother who was not prone to screaming. I used to have that kind of mother—stable and predictable, boring

even. But ever since the divorce, about a year ago, she had begun to change. Far from it being "just us girls," as she'd assured me after the final divorce hearing, life had become a process of her "finding herself" again, with me inconveniently needing an adult caretaker at times along the way. She would forget my dentist appointment or randomly disappear to a yoga class, and dinner was often "catch as catch can." It was annoying.

She came trotting into the kitchen a few minutes later, her frizzy black hair tied in a loose knot at the back of her neck.

"Guess what?!" she grinned.

I eyed her suspiciously.

"We're going to Africa!"

I didn't stop pummeling the potatoes. I just blinked at her politely and waited for her to explain. During the course of dinner, the entire story came out.

My mother's best friend, Jennifer DeLong, was a professor of anthropology at Chicago College. For the past few summers, Jennifer and her husband, the anthropologist Darius DeLong, popularly known as "Dr. D," had been hosting a student dig site in Kenya. Last summer they'd made an extraordinary discovery in the Tamba Hills: a seven million-year-old skeleton. It had been preserved in a volcanic lava tube. The bones were special—not just because of how old they were but because their shape suggested that they may have belonged to the long-sought "missing link"—a common ancestor between humans and chimpanzees. The skull would have been the decisive proof of a common ancestor because it would have had both human features and chimp features. But the skull was missing.

"So we're going back to find it," my mother concluded.

"I'm sorry," I interjected, "but I don't see how this involves you, much less you and me both."

The answer was that they needed another chaperone. Jennifer and Dr. D disagreed about where to look for the missing skull, so they had decided to split up. Dr. D believed the skull was moved by nineteenth-century explorers to a military fort in the coastal city of Mombasa. He wanted to search for it there. Jennifer, on the other hand, wanted to search further in the lava tube where the skeleton had been found.

"Without Dr. D, Jennifer needs another chaperone at the Tamba Hills site," my mother explained.

Although my mother was not an anthropologist, she was a professor of environmental studies at Chicago College.

"Jennifer told me about the problem weeks ago," she explained. "I told her I'd be happy to help, provided that you could tag along. The dean gave us the green light today."

That's how it all started. An unwanted interruption in my life. An invitation to be a "tagalong." I told my mother I didn't want to go. I called my dad to ask if I could stay with him instead. I made a bit of a fuss. But the truth is that I wasn't as against the trip as I pretended. What I was against was the way my mom simply announced her plans for my summer, as though she were the Queen of England.

"You'll have the time of your life!" she promised.

I refused to show any enthusiasm. As my school year meandered toward its underwhelming conclusion, however, I secretly began looking forward to the trip.

In late May, I accompanied my mother to a meeting at Chicago College with Jennifer and the seven students selected for the trip. We met under flickering fluorescent lights in the basement lounge of the Carlton Natural Sciences building.

Jennifer was arranging lemonade and oatmeal cookies on an old wooden table when we arrived. She had long straight hair that was white under a light blonde rinse.

"Annika!" Jennifer erupted, throwing her arms around my mother. The two women rocked back and forth, clinging to each other as though they hadn't seen each other in years, even though they actually worked on different floors of the same building.

"And Theo," Jennifer added, pulling me in for an awkward hug, "how are you? I haven't seen you in such a long time! You're growing into such a beautiful young woman." She ran a finger down one of my long brown braids. "I'm so happy you can join us for this adventure."

I pasted on a smile and made some polite noises.

Jennifer asked us to make nametags for ourselves. Soon her students began trickling in with their overstuffed backpacks, water bottles, cell phones, and earbuds. We all sat around the table. Jennifer passed out copies of a sheet of paper containing details about the trip. Then she asked us to go around and introduce ourselves.

"Uh, okay," said a boy with thinning brown hair. "I guess I'll go first. My name is Max Uhler. I'm a senior and an anthropology major. Oh, and I was on the trip last summer. It was awesome. I can't wait to get back to Africa."

This last comment was met with some enthusiastic cheers from around the table.

Max raised a fist in the air in a semi-ironic gesture of solidarity. I looked away for fear he might think I was staring at his disabled arm. I'd noticed when he sat down that his left wrist ended in a stump, with no hand. I couldn't help wondering what had happened to him. Whatever it was, it couldn't have been recent, since the skin was healed over.

Max turned to the girl sitting to his left. She wore large round glasses that made her eyes seem extra-large.

"Right," she said, realizing that she was next. "I'm Nora Knoll. I am Max's assistant. The University Accessibility Office says that Max qualifies for full-time assistance, so they're paying my way to Africa—"

"Even though I had no assistance last year," Max cut in. "Now suddenly this year I need assistance."

"It's not that he needs assistance," Nora countered, "but we're working with a new artificial hand. It's a big adjustment. And if the Accessibility Office can pay my way, why not?"

Max nodded resignedly.

"Absolutely!" Jennifer chimed. "Welcome aboard, Nora."

Nora turned toward the girl with ginger hair and freckles on her left.

"I'm Rowan McAvery," the girl said, tearing herself away from her phone. "I'm new. I'm a sophomore. I'm a women's studies and archaeology double major. I took Dr. D's special seminar this spring, even though it was supposed to be just for seniors. I really loved it. And so here I am. He recommended me for the trip."

As if on cue, the creaky door to the lounge swung open. In swept a burly man with shiny black hair and a deep voice. "Greetings, comrades!" he boomed, giving us a jaunty salute. "Are you ready for battle?"

Jennifer reacted with a cringing smile. "And for those of you who don't know," she said, "this is Dr. D, my partner in crime."

As Dr. D helped himself to two cookies, Jennifer motioned for him to sit down. "We're right in the middle of introductions, babe."

Dr. D obediently took a seat. My mother waved at him. He didn't notice.

Everyone turned their attention to the boy sitting to the left of Rowan. He had dark skin and a carefully groomed crewcut.

"Yeah, I'm Troy Miller," he drawled. "You can call me Mr. Miller, or preferably Lord Miller."

Several members of the group groaned in objection.

"Okay, okay," he chuckled, "then just call me Mill. Um, what else do you want to know? Oh yeah, I'm a senior and a philosophy major, and what on earth am I doing going to Africa? Well, it's a long story involving missing credits I need for graduation and

lousy summer school options. And I happen to have some good buddies on the crew. So I'm psyched! Let's goooooo!"

This cheer prompted shouts of agreement from the two boys who hadn't yet introduced themselves. Mill playfully punched the boy sitting to the left of him on the shoulder.

"Ow!" protested the boy, flashing bright blue eyes. He wore a crisp white polo shirt. "Okay. Hello. I'm Cameron Burgess. I'm a senior. I was on the trip last year, and I've just been accepted into the master's program in archaeology at Yale. So hopefully I'll be able to continue working on this project when I'm there."

Jennifer applauded in a muted, motherly way at Cameron's mention of Yale.

Cameron turned to the girl sitting next to him, who looked remarkably similar to him. Her eyebrows tented as she ran a hand with expertly polished nails through her honey-colored hair.

"Hi," she said. "I'm Cameron's twin sister Camilla. I've been on safari to Africa before, so although I wasn't on the trip last year, I kind of already know what it's all about. But I won't be doing much digging. I'm a communications major. I'll be filming a documentary of the trip."

"That leaves me," said the last student, sitting to the left of Camilla. He had heavy black eyebrows and olive skin. "I'm Ahmed Wakim. I've never been to Africa. I *have* been to other dig sites, though. I'm a junior and an anthropology major."

"Thanks, everyone," Jennifer said. "You all know me already. However, I would like to introduce my friend and colleague, Dr. Annika Taara. She's a professor of environmental studies here at

Chicago College. And next to her is her daughter, Theo Taara. They'll be joining us at the Tamba Hills site as chaperones."

I felt my eyebrows shoot up. Me, a chaperone? I liked the sound of that.

Explore More

A Guide to Thinking Deeply about
the Concepts in *The Missing Link*

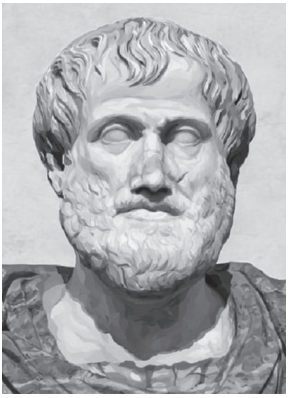
EDITED BY
SHARON KAYE

with contributions from Jennifer Ault

II. *THE MISSING LINK*, CHAPTERS 4-7

EARLY THEORIES OF NATURE

A. ARISTOTLE



In this selection, the ancient Greek philosopher Aristotle asserts that natural processes operate with a purpose. He critiques the opposing view—which claims that nature is explained by chance—on the grounds that natural events occur with predictable regularity. Because mistakes in nature (monstrosities) are failures to achieve the intended end, we can confirm that there does indeed exist an intended end—in other words, a purpose.

PHYSICS, C.A. FOURTH CENTURY B.C.E.

Book II, Part 8

We must explain then that Nature belongs to the class of causes which act for the sake of something....

A difficulty presents itself: why should not nature work, not for the sake of something, nor because it is better so, but just as the sky rains, not in order to make the corn grow, but of necessity? What is drawn up must cool, and what has been cooled must become water and descend, the result of this being that the corn grows. Similarly if a man's crop is spoiled on the threshing-floor, the rain did not fall for the sake of this—in order that the crop might be spoiled—but that result just followed. Why then should it not be the same with the parts in nature, e.g., that our teeth should

come up of necessity—the front teeth sharp, fitted for tearing, the molars broad and useful for grinding down the food—since they did not arise for this end, but it was merely a coincident result; and so with all other parts in which we suppose that there is purpose? Wherever then all the parts came about just what they would have been if they had come to be for an end, such things survived, being organized spontaneously in a fitting way; whereas those which grew otherwise perished and continue to perish....

Such are the arguments (and others of the kind) which may cause difficulty on this point. Yet it is impossible that this should be the true view. For teeth and all other natural things either invariably or normally come about in a given way; but of not one of the results of chance or spontaneity is this true. We do not ascribe to chance or mere coincidence the frequency of rain in winter, but frequent rain in summer we do; nor heat in the dog-days, but only if we have it in winter. If then, it is agreed that things are either the result of coincidence or for an end, and these cannot be the result of coincidence or spontaneity, it follows that they must be for an end; and that such things are all due to nature even the champions of the theory which is before us would agree. Therefore action for an end is present in things which come to be and are by nature.

Further, where a series has a completion, all the preceding steps are for the sake of that. Now surely as in intelligent action, so in nature; and as in nature, so it is in each action, if nothing interferes. Now intelligent action is for the sake of an end; therefore the nature of things also is so. Thus if a house, for example, had been a thing made by nature, it would have been made in the same way as it is now by art; and if things made by

nature were made also by art, they would come to be in the same way as by nature. Each step then in the series is for the sake of the next; and generally art partly completes what nature cannot bring to a finish, and partly imitates her. If, therefore, artificial products are for the sake of an end, so clearly also are natural products. The relation of the later to the earlier terms of the series is the same in both. This is most obvious in the animals other than man: they make things neither by art nor after inquiry or deliberation. Wherefore people discuss whether it is by intelligence or by some other faculty that these creatures work—spiders, ants, and the like. By gradual advance in this direction we come to see clearly that in plants too that is produced which is conducive to the end—leaves, for example, grow to provide shade for the fruit. If then it is both by nature and for an end that the swallow makes its nest and the spider its web, and plants grow leaves for the sake of the fruit and send their roots down (not up) for the sake of nourishment, it is plain that this kind of cause is operative in things which come to be and are by nature. And since "nature" means two things, the matter and the form, of which the latter is the end, and since all the rest is for the sake of the end, the form must be the cause in the sense of "that for the sake of which."

Now mistakes come to pass even in the operations of art: the grammarian makes a mistake in writing and the doctor pours out the wrong dose. Hence clearly mistakes are possible in the operations of nature also. If then in art there are cases in which what is rightly produced serves a purpose, and if where mistakes occur there was a purpose in what was attempted, only it was not attained, so must it be also in natural products, and monstrosities will be failures in the purposive effort....

Moreover, among [the seeds or the eggs or immature forms of an animal] anything must have come to be at random. But the person who asserts this entirely does away with "nature" and what exists "by nature." For those things are natural which, by a continuous movement originated from an internal principle, arrive at some completion: the same completion is not reached from every principle; nor any chance completion, but always the tendency in each is toward the same end, if there is no impediment.

The end and the means toward it may come about by chance. We say, for instance, that a stranger has come by chance, paid the ransom, and gone away, when he does so as if he had come for that purpose, though it was not for that that he came. This is incidental, for chance is an incidental cause, as I remarked before. But when an event takes place always or for the most part, it is not incidental or by chance. In natural products the sequence is invariable, if there is no impediment.

It is absurd to suppose that purpose is not present because we do not observe the agent deliberating. Art does not deliberate. If the ship-building art were in the wood, it would produce the same results by nature. If, therefore, purpose is present in art, it is present also in nature. The best illustration is a doctor doctoring himself: nature is like that.

It is plain then that nature is a cause, a cause that operates for a purpose.

From www.logoslibrary.org/aristotle/physics/28.html

DISCUSSION QUESTIONS

1. Aristotle believed that "those things are natural which, by a continuous movement [that is] originated from an internal principle, arrive at some completion: the same completion is not reached from every principle; nor any chance completion, but always the tendency in each is toward the same end, if there is no impediment." In other words, everything in nature is gradually evolving toward a specific endpoint. This happens step by step: "where a series has a completion, all the preceding steps are for the sake of that. ...Each step then in the series is for the sake of the next...." Whatever the endpoint might be for each organism, that is the point at which it would be complete—perfect, we might say, in the expression of its essence. Now, given our current scientific understanding of evolution and natural selection, the idea that all living things are evolving toward a specific endpoint is an interesting one—and one we may never have considered. So let us, then, consider it. Is there any merit in that idea? Could it be possible that all living things are gradually evolving toward some sort of final perfect form, and everything we see around us right now is in an imperfect stage along the way? Or, perhaps more likely, *would it have been possible* for everything to reach a perfect endpoint in which everything was in harmony with everything else *if humans had not come onto the scene and altered things irreparably*? If there had been no human intervention in the natural world, do you think it could have been possible that all of life would ultimately have reached a complete harmonious balance—Aristotle's

point of "completion"—and then simply stopped evolving? Why or why not?

2. Aristotle distinguished between natural processes and coincidence, writing that "natural things either invariably or normally come about in a given way; but of not one of the results of chance or spontaneity is this true. We do not ascribe to chance or mere coincidence the frequency of rain in winter, but frequent rain in summer we do; nor heat in the dog-days, but only if we have it in winter." To understand this a bit better, we should note that it rains often in the winter in Greece but not in the summer, and of course it is hot in the summer there but not in the winter. So Aristotle's point was that his fellow Greeks expected cool, rainy weather in the winter and hot, dry weather in the summer, and they saw any divergence from that as a random, chance event. However, Aristotle wrote, "when an event takes place always or for the most part, it is not incidental or by chance. In natural products the sequence is invariable...." Thus, there is nothing in nature that takes place by chance, nothing that is simply coincidence. It was all designed to be the way it is, to do what it does, to happen the way it happens. Do you agree, or do you think that nature can be coincidental? Can natural events or processes happen by chance? Can they be spontaneous? Why or why not? Does Aristotle's assertion that "clearly mistakes are possible in the operations of nature" undercut his view that nothing in nature happens by chance? Explain your answers.