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Introduction

Have you ever asked yourself what it was that made you the person you are?

Take me, for example. Looking back, I feel that I am the product of three main factors: a company going bankrupt; a sleepy Sunday afternoon; and my father's first car, a bright blue VW Beetle 1200. In actual fact my father had not really wanted the car in the first place. He only owned it because my uncle had a good nose for a deal. A car vendor had offered him the Beetle cheap – on the condition that he bought two of them. So one day my uncle paid a visit to my father, at that time a young chemist who was not earning a particularly good salary, and waved a contract under his nose. "I've bought you a car. Now all you've got to do is sign on the dotted line."

That same year, a company in the Austrian Alps went bankrupt. Although the weaving looms it made were world famous, there was no longer any call for them. After all, in 1959, nylon shirts were busy conquering the international markets. Already experiencing difficulties with cash flow, the company had a large bill that was due for payment. Despite the fact that various credit transfers were in the offing, the banks lost patience and the loom-maker was forced to declare bankruptcy. By the time the credit came in but a few days later, it was all too late. Even the private furniture of the factory owner's family had already been requisitioned. In the wake of the bankruptcy, the family had to count every penny, and the eldest daughter, still a student, therefore left home for Munich, where she had found a paid job as a research assistant.

One of her acquaintances told her about the young man with the blue Beetle who likewise commuted between his job in Munich and Innsbruck, where his family lived. From then onwards, every Friday he picked the young lady up and chauffeured her back to Austria, and every Sunday the two set out on the return journey. Years passed, without any romantic feelings developing between the commuting couple. And then, one bright autumn day, my mother, for it was she, fell asleep after a long night out partying. Her friends got fed up waiting for her and set off on the mountaineering trip they had all arranged without her. When she awoke, the sun was still shining and, on a hunch, she phoned Mr. Blue Beetle driver and asked whether he would like to spend the afternoon with her. Which he did. And they married only a year later.

I have often asked myself what would have happened if only one of these events had happened differently. What would have happened if the car seller had not offered my uncle such a strange deal? How would things have turned out if the money had been credited to my grandfather's account on time and he had been saved from declaring bankruptcy? What course would events have taken if on that September day in 1963 the Alps had been shrouded in clouds? Would I exist? Can it really be such ostensibly minor and apparently unconnected details that we have to thank for our lives – and which determine the course lives take?

Such questions are as riveting as they are uncanny. It must have been this ambiguous emotional admixture that philosopher Johann Gottfried von Herder sensed when he termed chance “one of the two major tyrants in human life” (the other was, incidentally, time).1 Terror likewise sent a shiver down the spine of scientists when they stumbled upon the chaos of the universe – fear struck their hearts on realizing that nature by no means obeyed our ideas of it. Only as short a time ago as 1970, French molecular biologist and Nobel prize winner Jacques Monod described human beings as the lucky strike in the big game of chance that is nature, and insisted that we humans should at long last concede that we are lost: “Humans now know that they occupy a place akin to that of migrants on the edge of a universe that is deaf to their music and indifferent to their hopes, suffering or crimes.”2

Perhaps not surprisingly, in the course of recent years science has concerned itself with the unforeseeable to a far greater extent than ever before – and in the process has gained a completely new idea of chance. In so doing, the shiver has given way to astonishment. What is this strange apparition “chance”, which so many commentators suggest is nothing but an illusion, actually entail? Mathematicians have proved that chance even plays a part where everything proceeds strictly according to rules. Physicists have investigated how the unforeseeable arises and why there is no escaping it. Evolutionary biologists are increasingly realizing that human life is to a great extent itself the product of chance. And far-reaching psychological studies demonstrate how unforeseeable the development of personality is, not least as regards the path taken by love. Not to forget that specialists in brain neurology and philosophers are busy exploring why it is we find it so difficult to make our peace with this creative force. Many are the learned articles that now explain why we have such a deeply ingrained belief in fate, in some grand design.

Chance is more powerful than we mortals have ever dared to imagine. Researching chance addresses the greatest puzzle facing science today, namely the fabric the world as we know it and with it the origins of life. At the micro-level, a scientific inquiry into chance thus also touches on the path through life each and every one of us takes. And what we see here is not that of the Demon of Disorder, whom philosopher Herder so condemned in the name of Enlightenment, but an Angel of Opportunity, for “chance” tends to emphasize the up side to coincidence, and thus the good fortune, rather than the downside.

Science has likewise realized that chance can come up trumps and is now learning to exploit it. Sensitive systems such as electronic switches can be stabilized by the introduction of chance; in fact, our brains also work that way.3 And chance, or so it has transpired, is not only the driving force behind evolution, but also that behind human creativity. Even the most human of our characteristics, be it altruism, sympathy or the ability to act morally, would not exist were we always able to predict our action. That said, we pay a price for these abilities in the form of uncertainty. After all, do not most of us feel ill at ease in uncertain situations? And as a consequence we tend to avoid them wherever possible – and thus forgo any number of opportunities. So how can we

better cope with the stress of uncertainty? Are there strategies for deriving the greatest benefit from surprises? Can you learn to be a lucky devil?

This book endeavors to familiarize you with the phenomenon of "chance". Because all avenues of human action, emotion and thought are essentially unforeseeable, we can only do justice to chance by treating it from the broader viewpoint. Chance has a lot to do with unexpected linkages and it would therefore be meaningless to spotlight only one aspect of it to the detriment of the others. Only the big picture or panoramic view will give us a basis for understanding how chance determines our lives.

In the first section you will find out what chance is all about and how it arises. However great the number of different guises chance dons, all the related phenomena (be it in a gambling house, in the realm of physics, or in human society) can be reduced to two common denominators: complexity and self-referentiality. Which bring us up against the problem of whether events that seem to be a matter of chance are in fact the product of regular laws? Or is it simply that we cannot grasp those laws? Is this itself not simply a way of paraphrasing that old chestnut: "Was it chance or fate?"

In this first section, chapters 3 and 4 are the most challenging in the book, as they address the fundamental enigma of how chance arises. I have tried to make the reader's path through the complex physics here as simple and tangible as possible. Anyone not wishing to immerse themselves so deeply in the scientific background may want to simply skip these chapters, as this will not mean the following chapters are less readily comprehensible.

Chance the Creator is the subject of the second section, which will take you on a journey from the beginnings of life on earth through to the evolution of the computer, from the emergence of human life through to personality development in each of us. To what degree does chance determine the path our characters take, how we live and how we love?

The new arises only by chance. This section is therefore also meant to illustrate how we arrive at ideas. However, not every good idea wins out. It requires chance and ingenuity to make sure an innovation is a success and, as with any competition, often that novelty emerges victorious which behaves in an unforeseeable manner. In many cases, chance is the best strategist.

Normally we do not notice how much we owe to chance. Our brain is programmed *not* to believe in chances. In order to be able to find our way in the world, our brain often suggests that we enjoy more certainty than actually exists. The third section of the book deals with how we tackle chance and uncertainty – it describes our path through the realm of illusion. One of the most dangerous of these is when we feel safe, or believe there can be absolute certainty. For it is precisely then that we run an uncontrolled risk and things often subsequently have a nasty twist to them.

In an increasingly opaque world, we find ourselves constantly having to take decisions

without having all the necessary information at our fingertips. The fourth section shows ways in which we can protect ourselves against drawing calamitously wrong conclusions. We can gear our action to making certain that it also is to our benefit even if the external conditions change dramatically. In this way, we welcome chance on board as our ally. This ability to playfully countenance the unexpected also generates strategies for developing ideas and creating systematically favorable circumstances.

However, opportunities such as these do not come for free. Anyone wanting to benefit from chance will need to abandon a favorite illusion: namely that we can plan our lives from the cradle to the grave. A focus on chance swiftly teaches us we need to be more modest in this regard.

Underneath we all know how often we simply try to tell ourselves that something is certain. If we go into the phenomenon of chance in greater depth, then such illusions give way to a trust in the unexpected – and a confident awareness that we can make the best of the surprises that may or may not lie ahead. Looking chance squarely in the face is calming. If we accept uncertainty as part and parcel of life then it will tend far more frequently to be a gift than we might otherwise imagine. In fact, it is fair to say we can expect miracles…

CHAPTER 7
The World as a Lottery

Why the better side doesn't always win

Sometimes fate decides things right from the word "go". When a new film comes out, people feel the urge to queue up outside the box offices from the very first night. In which case the ad boys have won, as they've set the ball rolling. If the cinema-goers are enthusiastic, they will tell their friends. The film plot gets narrated at parties, and the soundtrack runs in the music stores. However, if the film does not grab people's attention from the outset, then it will soon disappear from the movie houses, if only because not enough people recommend it to others. And it will be forgotten at the latest by the time the next film comes out.

Evolution functions exactly the same way. Although the better side is always the enemy of the good, it is not always the good that wins out. What can superior genetic material achieve when faced by the dangers of life? It bears remembering that a mutation only spreads if the animal that bears it reproduces, whereas if while still a baby that animal simply gets gobbled up by the next-best predator, then the advantageous gene simply gets lost.

A fortunate innovation in nature, say faster legs for an antelope, is not a sure-fire move forwards; all it offers is a better opportunity that the animal with it will reproduce. Just like the good sides to a film need to be spread by fans, good genetic material requires a sufficient number of parents who will spread it. In the beginning there are only a few of the swift antelopes, meaning some stroke of misfortune can severely decimate their number. Among the slower-version animals, by contrast, and they are the large majority, it makes little difference from the viewpoint of their genetic material, whether a hungry lion or two just happens to stroll by.

If four out of the ten offspring of the mutant with the faster legs survive and reach an age when they can reproduce, and three of the offspring of the non-mutant animals survive, then the animal with the changed genetic material has an advantage. Nevertheless, the probability that the better genetic make-up will persevere in that population of animals as a whole is hardly more than 50 percent, as Viennese biomathematicians Paul Schuster and Karl Sigmund have computed.

In evolution, in other words, chance holds sway not only as regards the prospects of the genetic material that engenders new organisms. Luck and misfortune also decide whether a new step in evolution gains a sustained lease of life, or simply disappears again. Indeed, many of the principles that determine the future of an innovation in nature likewise apply to human society – above all to the economy.

Chance plays the greatest role during the early generations. If the better gene comes

lucky, it soon spreads to so many individuals that it can hardly be exterminated. If, by contrast, the especially fleet-footed antelopes get turned into a leopard's lunch before they have reproduced, then they contribute nothing to the future of their species.

Put differently, innovation in nature only stands a chance if it happens at the right time and under the right conditions. Because each new invention of nature must first win the day against what already exists, and because there is usually no foreseeing how the competition between the traditional population of a particular habitat and the newcomers will unfold. Even if the new characteristic has established itself in a given population, catastrophes such as sudden climate changes, the arrival of a meteorite, or deforestation by humans can all wipe out all the bearers of the preferential gene overnight, as it were, and thus set evolution back a step.

The development of plants and animals thus resembles less a game of chess, where the best move counts, but instead one huge lottery. Is human life itself indebted solely to chance? US paleontologist Stephen Jay Gould is at any rate convinced that the film of natural history would have an utterly different script if it we were to hit the reset button and start it all off again.

Two steps forward, one step back

The straight and narrow path does not always lead to the goal. If you want to move forward you must sometimes be prepared to accept setbacks – the common fly has sacrificed the outstanding flying abilities of its forefathers in favor of robustness. Often, a species does not actually make up for the initial loss until a lot later. Hardly surprisingly, one individual instance of chance rarely immediately produces a new and better creature. In fact, evolution tends to take lots of small steps before a real manifest advantage emerges. To return to the original example: the progression to swifter antelopes could, for example, perhaps entail an interim stage of animals that limp. The transformation in their skeleton means the first generations suffer a handicap and only following additional mutations do the antelopes' progeny boast greater mobility or agility. If you want progress you will initially have to tolerate half-baked solutions. Novelist Günter Grass once famously declared that progress only ever happened at snail's pace.

For this reason, evolution not only implies cutting and pasting, but above all doing so in secret, away from the eyes of the lions. A novelty has to be nurtured away from the limelight before it can bring its potential to bear. Were Boris Becker to have played in the senior's at Wimbledon at the age of 13, his opponents would no doubt have blasted him off court and the history of men's tennis would possibly have been different. However, in nature and in society, a new solution often has to persevere from the very first serve – in a competition where the new server initially has no advantage.

How can this be? A community that generates something new must leave scope for experimentation and make certain the pressure to compete is not too great. Otherwise the inventions that still need to mature will be nipped in the bud. In such an in-between

state, chance in the form of the smile on the face of the lion about to have an antelope dinner, may wipe out innovation before its time has come. Equally, it may come to pass that chance comes to the aid of the new. An unforeseeable twist of fate may shift the weighting in the competition in favor of the new. And the invention, still unsteady on its feet, may find its path in life – for example if an epidemic suddenly breaks out with a vengeance among the non-mutant members of the population who are actually still the stronger group. Chance often fights on the side of the weaker, creating opportunities for those who would otherwise not have one.

This principle is again aptly visualized by the case of the limping antelope. Under normal conditions this pitiful animal would have little prospects of survival. It would not only constantly risk being eaten, but would also be at a disadvantage compared with its peers, who will gobble up the lush grass and leave it to try and satiate itself on the stubble. Let us assume in such a scenario that a virus hits half the herd. Consider a small group of four antelopes, two of whom limp. There is a 1-in-2 probability that each animal will get the virus. The risk that both limping animals get it is 1-in-2 times 2, meaning 1-in-4. The chance that both normal antelopes book it is equally great. So assuming probability goes to plan, the limping antelopes win out. Initially there will enough fodder to go round and one day their descendants will give birth to young animals who, by a further chance mutation, run faster than an antelope has ever done before.

Islands of the new

Chance only creates a haven for the new in a small population. After all, it is highly improbable that among a set of 1,000 antelopes only the limping variety will be spared contracting the virus. (You surely would not bet on the next flu virus only infecting the men in a large corporation. In a four-person company, by contrast, that might well be the case.)

So do innovations have a better chance in a smaller group? That depends on whether the changed in quality is an advantage from Day 1. If it is, then the mutant will benefit from tough competition, as it will initially not require a safe haven. It will more surely assert itself in a large population, as there will be less danger, i.e., probability that a stroke of misfortune will wipe it out. However, if the innovation first has to grow like a tender shoot, then it will more likely blossom in a small population, for there chance sometimes puts a halt to the laws of competition.

Nor should one forget that the more individuals there are, the more opportunities nature has to experiment. In a large population, the new has a harder time gaining sway, but in return it arises more frequently. Therefore a large society develops best when sub-divided into many sub-segments – such as the animals on the widely scattered Galapagos Islands, whose diversity prompted Charles Darwin's pioneering ideas. The new finds a protective zone in which it can develop within a community, because in the latter it is spared the overly harsh wind of competition. If an innovation is superior to the tried-and-true, then it has decidedly good prospects of first winning out in its group

and using that as the launch-pad from which to spread through society as a whole. “Diversity serves progress because it gives chance a chance,” wrote Karl Sigmund, the scholar on evolution, “whereas monopolies of any kind constrain evolution.”

This law certainly applies not just to nature. Millions of sorely-tried computer users know the consequences of having one corporation more or less dominate the entire market for drive operating systems and programs. US physicist Freeman Dyson has even argued that only thanks to diversity did the human race develop swiftly, for variety enabled chance to help the new break through. Only because the world population disintegrated into any number of small groups at so early a stage, and because these then formed cultures and languages of their own, could the human race as a whole advance. A regular, undifferentiated culture would have gone hand in glove with a merciless pressure to conform that would have left no chink for change. In smaller communities, by contrast, new ideas arose and fertilized other cultures via the world’s trading routes.

As in nature, progress also finds the best seedbed in society in those areas where the new can initially develop in a relatively protected environment and then spread without hindrance – conditions that are not bad for a league of nations such as the European Union, within which diversity is upheld. For the very basis for any advance is, as stated, the diversity of cultures. Yet precisely this is what is apparently under threat in an increasingly globalized world. Of the more than 6,000 languages, for example, which humans speak, more than half will disappear in the course of the next century if the current trend persists. We would do well to preserve this linguistic wealth. The plethora of languages following the Tower of Babel was not a curse, but a blessing.

Evolution rewound

Scientists can today actually play through minute sections of the thought experiment that Stephen Jay Gould came up with, namely the notion of hitting the reset for natural history and playing it through again. Indeed, scientists can run through evolution on fast forward using test-tubes and Petri dishes.

One of them is Oxford-based geneticist Paul Rainey, who has done just this with the smallest living organism, *pseudomonas fluorescens*, a bacterium found on almost all plant leaves and one that naturally reproduces quickly and mutates almost as frequently. Rainey was able to observe how new variants arose under lab conditions – and to play with evolution by restarting the development again and again. He ascertained in this way that the bacteria did indeed develop more diversity and adapted better to their environment if they lived in many small colonies rather than in large populations. Exactly this is what we would expect in light of our example with the limping antelopes.

Rainey was specifically able to study the conditions under which evolution becomes predictable – and those where it simply offers random results. Only if the population is large, competition wide-spread, and, moreover, the bacteria reproduce very quickly,

does development always take the same course. If, however, initially only a few bacteria flourish in the Petri dish, they then reproduce more slowly and are not under such pressure to conform. In such instances chance remains the driving force and, under the same initial conditions, life in the colony developed differently in each case.

Real natural history was of course less predictable than the events in Rainey's miniature world. For in the laboratory only a single type of bacterium had to cope with the new environmental conditions, whereas in nature most species enjoy a shared destiny. Frogs disappear if there are not enough insects, and where there are no frogs, the storks start to go hungry. In other words, if one species changes suddenly, this impacts on many others.

These forms of interaction likewise render evolution unpredictable. Back in the 1950s Australian scientists were given a nasty surprise by such loops. Ever since European immigrants introduced rabbits to Australia, farmers had been forced to watch the animals reproduce willy-nilly and damage crops. To contain the damage the scientists came up with the idea of introducing a virus that only affected rabbits. The virus was unleashed in a river valley; mosquitoes swiftly spread it across the entire continent. After three years, the farmers breathed a sigh of relief: most of the rabbits had fallen prey to the epidemic. However, the smile was soon wiped from their faces, as after a while the rabbits returned with a vengeance and in ever larger numbers. It emerged that the myxoma virus used had mutated and now no longer killed 99.5 percent of rabbits but only 95 percent. And the animals infected no longer died after only a few days, but after several weeks – much to the virus' advantage.

As a consequence, enough rabbits were able to reproduce to prevent the extinction of their species. Without victims, a virus itself dies out. In other words, the fast-acting strain of the virus was killed by its own success, to be replaced, quite logically, by the new, less radical variant. The moral of the story is that superiority in evolution is never a proven fact, but always depends on changing circumstances. Good fortune may smile on one particular species one moment, but not the next.

The rabbits also adapted to meet the new situation. An increasing number of them started to exhibit mutated genetic material that rendered them immune to the virus. In the course of time, a new balance asserted itself, one in which both the pathogen and its host did well – and infected rabbits today enjoy burrowing their way through Australia's fields.

The early bird stays longest

As in everyday life, in evolution it is also not necessarily the better side that wins, but the side that manages to assert itself. This is yet another factor that makes evolution so hard to predict. It is often easy to find out who is superior; but who will win a competition also depends on chance. Once the competition has been decided, however, the victor can create facts that leave new and even superior opponents no chance – winner takes all.

Take a look at your PC. The keys on the keyboard are in a strange sequence that does not appear logical at all. Either you arduously learn QWERTY off by heart or your fingers have to hover like an eagle over the keyboard ready to take the plunge. Have you ever asked yourself how the strange configuration came about?

The answer may calm those of us who have always had a tough time typing: the sequence of letters was deliberately designed to run against our intuitive sense when writing. The story dates back to the days of the first typewriters. Back then, engineers were struggling with the fact that the type arms constantly snagged in one another – until in 1868 US inventor Christopher Sholes came up with a solution that defines our keyboard to this very day. Instead of placing those letters together that are frequently used together ("e" and "i" for example), which would have made typing an awful lot easier, Scholes deliberately placed them as far as possible away from each other on the typewriter. That way, the arms of the letters encountered in the most frequent combinations would hit the paper from opposite sides of the typewriter frame and not snag as easily.

Sholes registered the idea as a patent, and the rights were later acquired by New York gunmakers Remington, who swiftly emerged as the world's major typewriter manufacturers, and QWERTY won out everywhere. Back then, no one protested against the strange logic behind the keyboard, and when other ideas were voiced, they fell on deaf ears. In the 1930s, for example, a man called August Dvorak came up with a layout that ensured your fingers traveled shorter distances, enabling you to type far faster. Although Dvorak's keyboard was without doubt more logical and although the mechanical difficulties had long since ceased to play a role, he got nowhere. Everyone had simply already become accustomed to QWERTY and no one wanted to have to learn something new.

All those good original reasons are of absolutely no import nowadays. Type arms and typewriters are as good as extinct, and hardly anyone sitting in front of one of the now ubiquitous PCs today is a trained typists. Nevertheless, the keyboard from the pioneering days of typewriters has remained, and hardly anyone knows that you can switch over any modern computer keyboard to the more comfortable Dvorak layout at the click of a Mouse. QWERTY is no longer to be eliminated.

The history of technology is full of such anecdotes. It is hard to get rid of the solution to a problem, once the solution has become received knowledge or practice. It is easy to create a niche for yourself in some area if you come first, both in business and in nature. And once you have staked out your claim, you can muster very fierce resistance to any attack. Because usually you the defender have changed the world in which you fight to your advantage – the interactive loop.

The first drop of rain that falls on a pile of sand finds its more or less random path downwards; the more drops then fall, the stronger the trickle, the deeper the channel that is cut into the sand. If the rain persists, all the water will eventually flow in the same

current. This is the way innovation interacts with its environment and can irrevocably change it. Like the path cut by the beads of water in the sand, an initial chance occurrence intensifies and then defines the later course of things.

Is, therefore, all of nature “a frozen coincidence”, as Francis Crick, one of the two men who deciphered DNA, put it? What we do no is that random chance has evidently determined evolution from the outset. There is no compelling reason why genetic molecules had to be spiral in shape, something that has persisted to this very day in each and every one of our cells. As lab tests have shown, another chemical structure for our DNA or another translation code for genetic information in proteins would have functioned just as well.

Possibly, there were such alternative forms of life at the beginning of evolution almost four billion years ago. But they disappeared because they were inferior. It is more probable that life with a different chemistry never got a look in, as by pure chance the single-celled organisms that are typical today developed somewhat earlier and spread extremely quickly. In the course of natural history, creatures have repeatedly won out simply because they had a head start and the rest did not succeed in making up the lost ground. Often, only a disaster can change that edge.

The End of the Dinosaurs

Geologically speaking, not that long ago the inhabitants on earth seemed to have found their masters. About 200 million years ago, dinosaurs were the driving force on land, sea and the air. Evolution had spawned about 1,000 different species of dinosaur, from the two-legged aggressive *compsognathus* saurian, which was smaller than a chicken, to the vegetarian *brachiosaurus*, which was larger than a four-storey house. The species came and went, many existed only for a few million years. But it was always new dinosaurs that squeezed out other saurians: evidently evolution had come up with an unbeatable model for success. At the end of the day a hypothetical observer in the Cretaceous period 70 million years ago would hardly have placed his money on the saurians that were just tentatively emerging – creatures about as big as a mouse, of which many bore their children in a pouch. How could these unobtrusive creatures manage to assert themselves when faced by the predominating reptiles?

Ten million years later the former masters of the world had been destroyed. There has been much controversy over why the dinosaurs died out and today most experts agree that a collision between the world and a meteorite about ten kilometers in diameter brought about their demise. In 1991, scientists were able to prove the existence of remains of a gigantic crater off the coast of the Mexican Yucatán peninsula, and in terms of timing this fitted the bill for the decline of the saurians. The so-called Chicxulub crater is now buried under a 1,000m-deep layer of sediment.

The cosmic bomb that impacted there about 65 million years ago must have unleashed an energy that was 10,000 times greater than the explosive force of the entire arsenal of

nuclear weapons in existence today. Earthquakes and gigantic waves towering up to heights of over 100 meters destroyed all life in the vicinity; immense masses of poisonous dust were released into the atmosphere and turned the collision into a world-wide catastrophe. Half of all the species at the time (some estimates put the figure at closer to 90 percent) disappeared from the face of the earth once and for all. As fossilized remains show, only the smaller creatures survived, those that were no bigger than today's dogs. The giant reptiles were wiped out, and this heralded the beginning of the victorious age of the mammals.

There have repeatedly been collisions of this sort in the course of natural history, but most of them did not trigger such mass death. So what was different about the one at the end of the Cretaceous period? Possibly, the dinosaurs were unlucky in that the meteorite hit a stratum of stone made of carbonate that contained much chalk. On impact, the chalk deposits released sulfurous compounds that then floated around in the atmosphere in aerosol form for a long time to come, the heavens darkened and the climate cooled. By far the largest number of saurians probably died not as a result of the immediate impact but from climate change.

A new theory asks the question whether the impact of the meteorite at Chicxulub only weakened life on earth toward the end of the Cambrian period, before a second meteorite (and where it struck is still unknown to us) then acted as the actual trigger for the extinction of so many species. Geologist Gerta Keller from the University of Princeton, who is the leading scientist championing this hypothesis, believes that recent drill cores prove that the Chicxulub crater arose 300,000 years before the widespread death of the dinos. A sequence of two major meteorite collisions in a row over what is geologically a very short space of time, is quite conceivable, albeit improbable.

At any rate, the strange concatenation of events led to a major ecological disaster. One that was a stroke of good fortune for the humans. If the Chicxulub meteorite had gone down only a few hundred kilometers to the left or right, the mammals would perhaps never have got their chance – and the dinosaurs would still be masters of our universe.

Humans – a coincidence?

Catastrophes, such as the impact of the meteorite at Chicxulub have repeatedly changed the course of evolution. Volcanoes erupt, ice ages come and go, continents drift. The last major ecological chaos arose about three million years ago when the then still separate land masses of North and South America collided to form the land bridge that is now Panama. Over this bridge, animals from the North went South and vice versa; on both continents the newcomers exterminated any number of other species that had hitherto been leading a pleasant sedentary existence in their respective ecological niches. The biological invasions eradicated, among others, the marsupials in South America; had the earth's crust only shifted slightly differently, most probably kangaroos would still be bouncing around in Argentina today.

In other words, it is not just biological suitability that decides on success in evolution,

but also chance occurrences in the course of history. “We tend to blame the extinct species themselves for their fate, which merely reflects some Protestant ethic and idolizes success,” writes Karl Sigmund. “But it would not really have helped the dumber dinosaurs much if they had had larger brains and leaner bodies, at any rate not if the cause of their demise was the impact of an asteroid.”

Anyone who likes reading fantastic stories will be able to well imagine how things could have turned out differently. US astrophysicist and scientific author Carl Sagan has written precisely such an imaginative account, and a highly intelligent one at that. He even appoints a replacement candidate for homo sapiens as the determinative form of life on earth; clever small saurians such as are to be admired in Steven Spielberg’s film Jurassic Park. “To judge by the ratio of brain to body mass, the saurornithoids are the most intelligent dinosaurs,” Sagan writes. “On average, they had 50g brain mass and an average body mass of 50kg – about the same ratio as that of an ostrich. In fact, they resembled ostriches… They probably hunted small animals and used their four fingers for a variety of tasks. If the dinosaurs had not become extinct, would the descendants of the saurornithoids have been the dominant form of life on earth today, using non-QWERTY-keyboards to write the books, reading them, and pondering what would have happened, if the mammals had been victorious? Would they be thinking that a system based on the number eight in arithmetic is natural and a decimal system merely nonsense taught in ‘new maths’?”

We will never know the answer. But we can hardly assume that humans would once again be at the preliminary culmination of the evolution story if we reset natural history and played it through again. For too many of the events that were one-off occurrences were crucial to the emergence of our dominant species.

Charles Darwin robbed man of the flattering notion that the development of life was geared only to peak in human life. We must accept that we are the children of chance. Nevertheless, we do not simply have coincidence to thank for our origins. While in nature only unforeseeable mutations in genetic material engender the new, two opposing forces ensure that it is not only chance that holds sway. First, the new must beat what already exists – this means nonsensical inventions get abandoned. Some of nature’s ideas are so obviously brilliant that there is probably nothing that could better them – the eye, for example, that has developed in the course of evolution in different groups of animals, and a powerful brain. If humans had not gained the upper hand, then the earth today would probably nevertheless be ruled by creatures that have three-dimensional vision and can control their own behavior.

Second, evolution can only play with what it has at its finger tips. Nature creates the new by reassembling given elements in a new and different way. In other words, by no means everything is possible at any one point in time. And chance thus only comes into the equation within specific limits.

