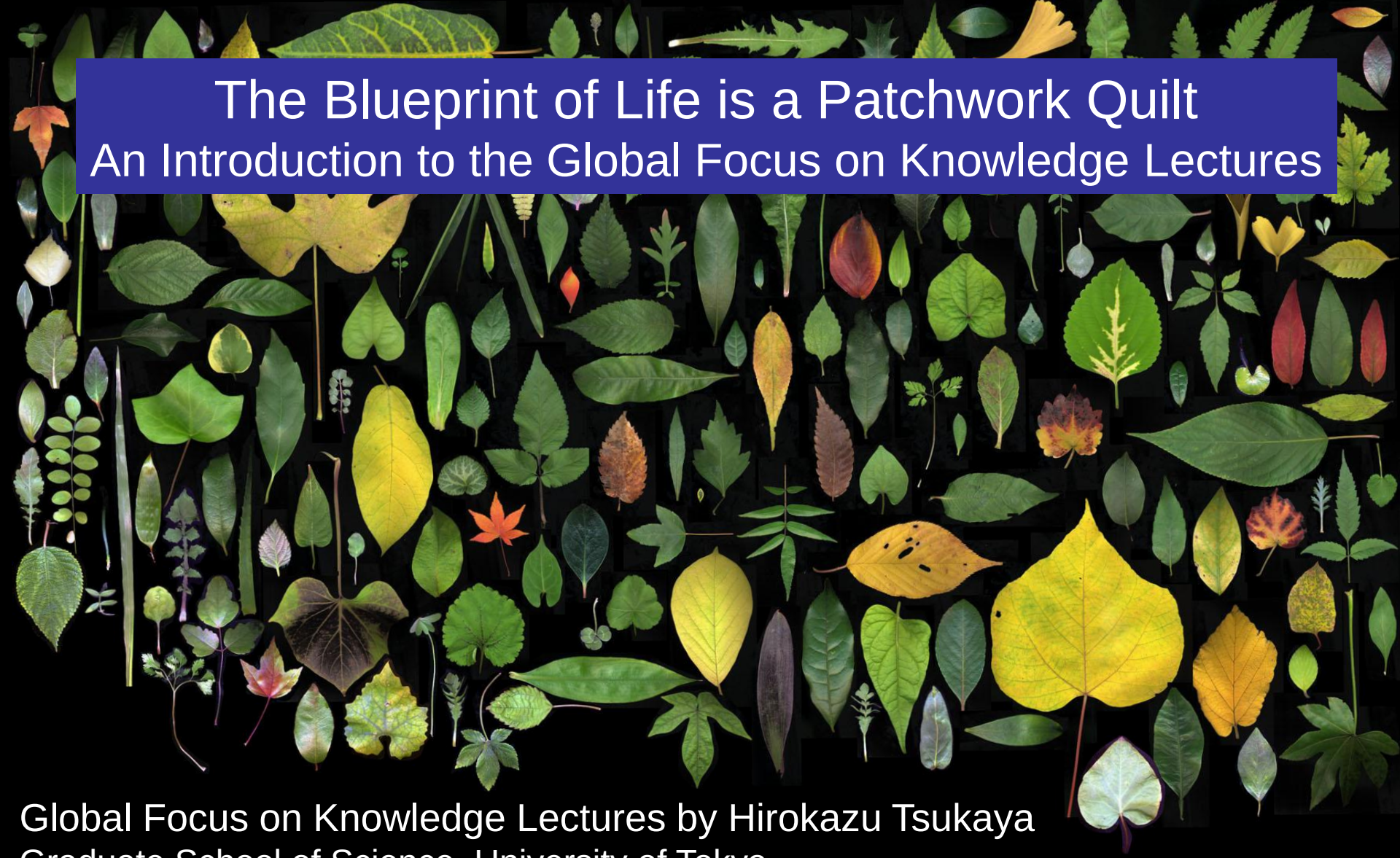
The Blueprint of Life is a Patchwork Quilt

An Introduction to the Global Focus on Knowledge Lectures



Global Focus on Knowledge Lectures by Hirokazu Tsukaya
Graduate School of Science, University of Tokyo
April 13, 2011

In ancient times, people depended on theology or philosophy for thought.

Then along came physics as the new framework of thought for natural science.

Some disciplines in physics believe in the existence of absolute truth, in other words, that everything in the universe is naturally born from a single and absolute truth.

Biology, on the other hand, does not establish one common absolute principle. It has even been treated with contempt for accommodating too many.

Even so, the one established basic principle shared in biology is the “principle of genetics.”

But this principle was considered a lower-level concept, unlike typical principles in physics and chemistry. It was deemed as simply naturally induced properties, with genes assumed to be discrete factors.

Thus, compared to physics and chemistry, biology was regarded as a developing, immature science that lacked universality and absolute principles.

By the end of the 20th century, however, genetics managed to uncover the full scope of genes, thus entering the realm of molecular genetics. This process revealed that all life is controlled by a common mechanism, or common DNA codes, as well as the central dogma of DNA-RNA-protein.

At this point, those physicists who had anticipated the existence of common principles joined the research in biology.

And there is no doubt about their contributions.

But quite a few physicists held misconceptions.

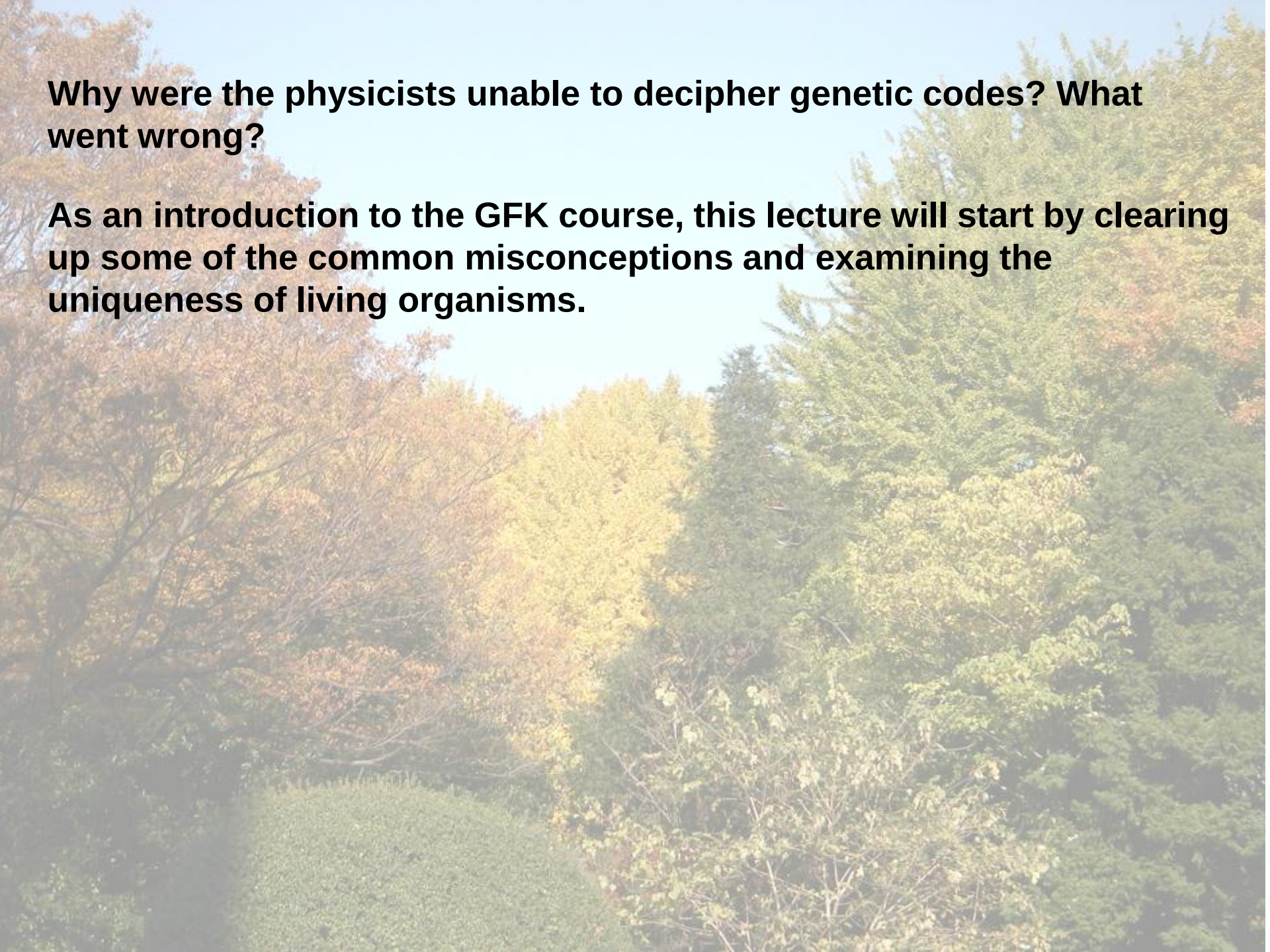
Some physicists believed that all living organisms were based on definite common principles, and that was a mistake.

Such misconceptions were apparent in their projections of DNA structures (genetic codes) and mechanisms of such codes.

Some physicists believed that in genetics, genes were transmitted steadily over hundreds of years and it was a system that created order from order as a counter to the increase in entropy.

How should this be when translating DNA into protein? The eminent physicist George Gamow conducted theoretical studies with other radical researchers, including leading physicists Max Delbrück and Richard Feynman.

But almost all of their many hypotheses were misguided. In the end, it was the biologists who managed to clarify how genetic codes should be deciphered by carrying out experiments with living organisms.



Why were the physicists unable to decipher genetic codes? What went wrong?

As an introduction to the GFK course, this lecture will start by clearing up some of the common misconceptions and examining the uniqueness of living organisms.

One of the ideas that many people fail to understand properly is the concept of evolution.

It seems that quite a few people feel that evolution means improvement or optimization, or basically making something somehow better than before.

A good example is when we talk about the evolution of cell phones.

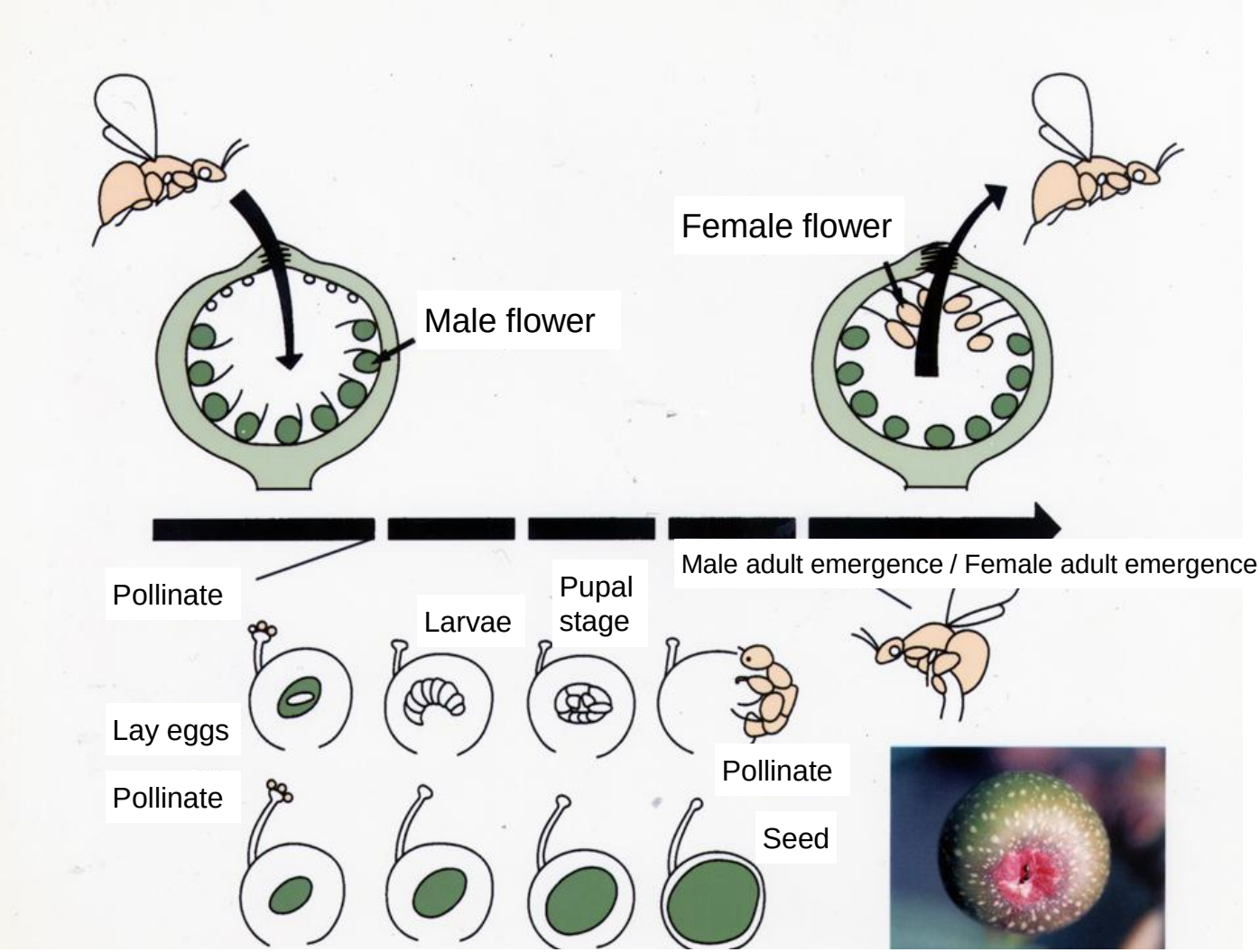
The word “evolution” is commonly used in this context in daily life, but this is not actually evolution. Hence, evolution is misunderstood by many people.

There is another deep-rooted misconception that has contributed to this general misunderstanding.

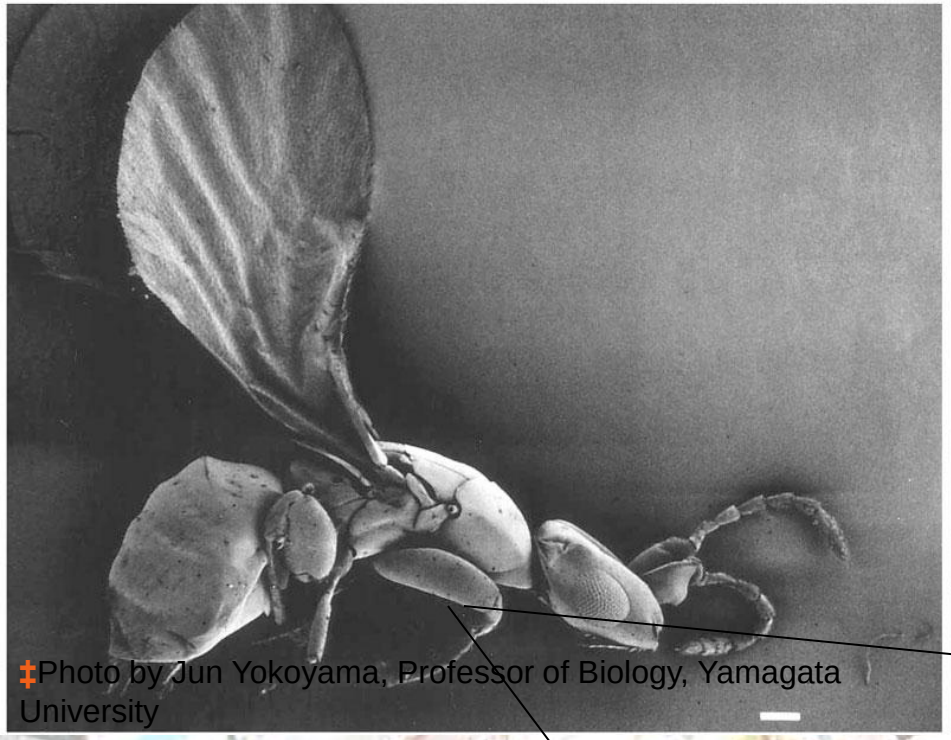
This is the irrational belief that living organisms are wonderful. “How could such a refined system or sophisticated structure be formed?” This simple question has clouded the judgment of many people. Jean Henri Fabre, for example, who lived in the same age as Charles Darwin, was trapped by this idea.

Fabre stubbornly refused to recognize the theory of evolution in his work. His refusal involved his love for insects – they simply looked so sophisticated in structure, and insects do indeed have fantastic bodies.

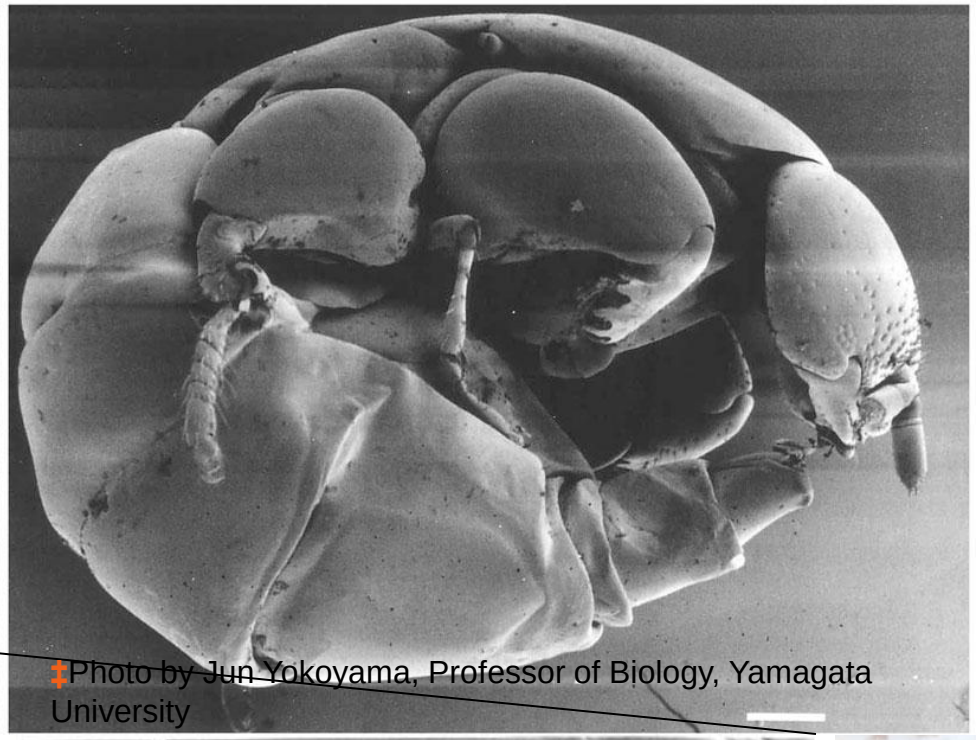
For example, the fig wasp manages to enter and pollinate a fig by squeezing its way into the flower…



‡ Drawings by Professor Jun Yokoyama; Source: Hirokazu Tsukaya, *Shokubutsu no Kokoro*, Iwanami Shinsho, 2001



‡Photo by Jun Yokoyama, Professor of Biology, Yamagata University



‡Photo by Jun Yokoyama, Professor of Biology, Yamagata University

Their legs even have pockets to prevent pollen from dropping!

‡Ryoichi Arai et al., 1994, The Japan Academy, November 29-30

(Yokoyama, 1995)

Then there are other insects that have taken things to the extreme in trying to attract females, resulting in bizarre forms.

Whatever the case, the idea that living organisms are wonderful and sophisticated beyond human intelligence and the perception that evolution must be about something becoming better are inextricably linked misconceptions that we must watch out for.

At the core of the theory of evolution is the idea that evolution is the result of coincidence, and this is often misunderstood.

People who cannot accept the theory of evolution often share the common misconception that living organisms are too wonderful and sophisticated to be the result of coincidence.

It is here where people start to lose their way – most often being those who turn to Christian fundamentalism.
These are people who believe that living organisms are not the result of coincidence but the creation of God. The intelligent design theory, which is gaining more followers mainly in the United States, is also based on the same idea. It simply replaces the word "God" with "designer."

Many so-called philosophers are also reluctant to accept the concepts of "coincidence" or "evolution."

"This is another point that sparks debate, but in short, they assert there just happened to be circadian rhythm reactions, and these rhythms just happened to be more favorable to living organisms than other rhythms, making it possible for them to survive. I do understand that if they were to answer in any other way, they would have to presume that proteins or cyanobacteria were somehow capable of sensing the earth's rotation, but I cannot help feeling somewhat unconvinced, and a question mark keeps flickering in my mind.

I feel the theory that evolution is a result of coincidence tends to paralyze thought."

"UT ODYSSEY," Yasuo Kobayashi, *UP Magazine*, September 2008

Yasuo Kobayashi is Professor of Culture and Representation, Interdisciplinary Cultural Studies, at the Graduate School of Arts and Sciences of the University of Tokyo.

Yasuo Kobayashi is not the only one.
Quite a few self-professed philosophers try to bring a higher power into the picture of evolution.

"Because Darwin's theory of evolution drew criticism that it was an ideology with a progressive view of history, it is said that the word "evolution" was replaced with "change." Nevertheless, the human desire to explain that "change," to connect and explain the points in time, of past and present, in sequence, remains unchanged. The diversities and wonders of life, we want to explain them all. However, I still fail to understand the concept of mutation that seems to have popped up in an attempt to explain the unexplainable. What I want to understand is exactly what this mutation is and why it occurs.

In terms of being unable to understand or explain the reason why, perhaps it could be called an act of God. Mutation is another name for God's doing."

(Akiko Ikeda, "Ningen Jishin (The Human Self)" 126, *Weekly Shincho* November 13, 2005)

Akiko Ikeda sees the cause of mutation (what we would call mutagen) as another name for God's doing, and persists in tying it to God. On the other hand, Yasuo Kobayashi's work tries to bring in the idea of complex numbers instead of God. For Kobayashi, complex numbers are symbols of a higher power or a higher power itself. However, this is simply another example of word substitution – God = designer = complex numbers. Being caught in theological determinism is a common error.

Fortunately, the intelligent design movement has not spread in Japan (at least on the surface) where people are relatively indifferent to religion,* though it has become quite widespread in the United States.

*Incidentally (I frequently use * notes, influenced by the work of Professor Sudo, physicist and interpreter of the GFK lecture), there is a surprisingly large number of intellectuals in Japan who feel somehow guilty that the Japanese people are less religious compared to Americans, and they find themselves turning to new religions. A prominent and unfortunate example of this is the AUM cult incident. But in actual fact, as a country develops and gains economic power, whether East or West, it is a common trend for people to become less religious and Japan is not a unique case. Rather, it may be said that the United States is an unusual case with its strong dependency on Christianity as a developed country.

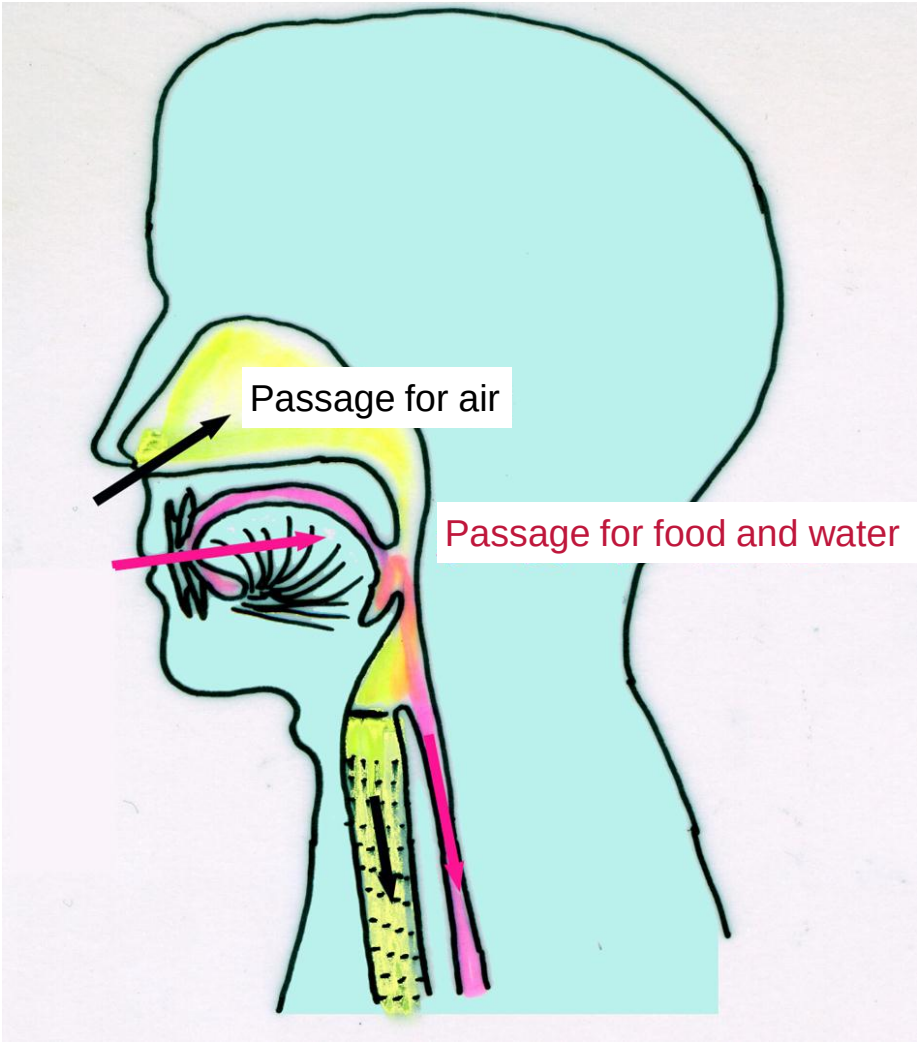
Furthermore, for people in search of religion, there are options other than monotheistic religions like Christianity or Islam. But if you are used to a discipline like physics, which searches for absolute unified principles, a monotheistic religion may seem more appealing. The opposite may also be true.

Here I wish to clear up the misconception that living organisms are too sophisticated to be creations of a series of coincidences.

The examples that will be discussed are some of the most well known and easy to understand.
To find similar examples, try searching a set of keywords of "design mistake" and "human body" on the internet.
There are hilarious sites that were clearly created by young students.

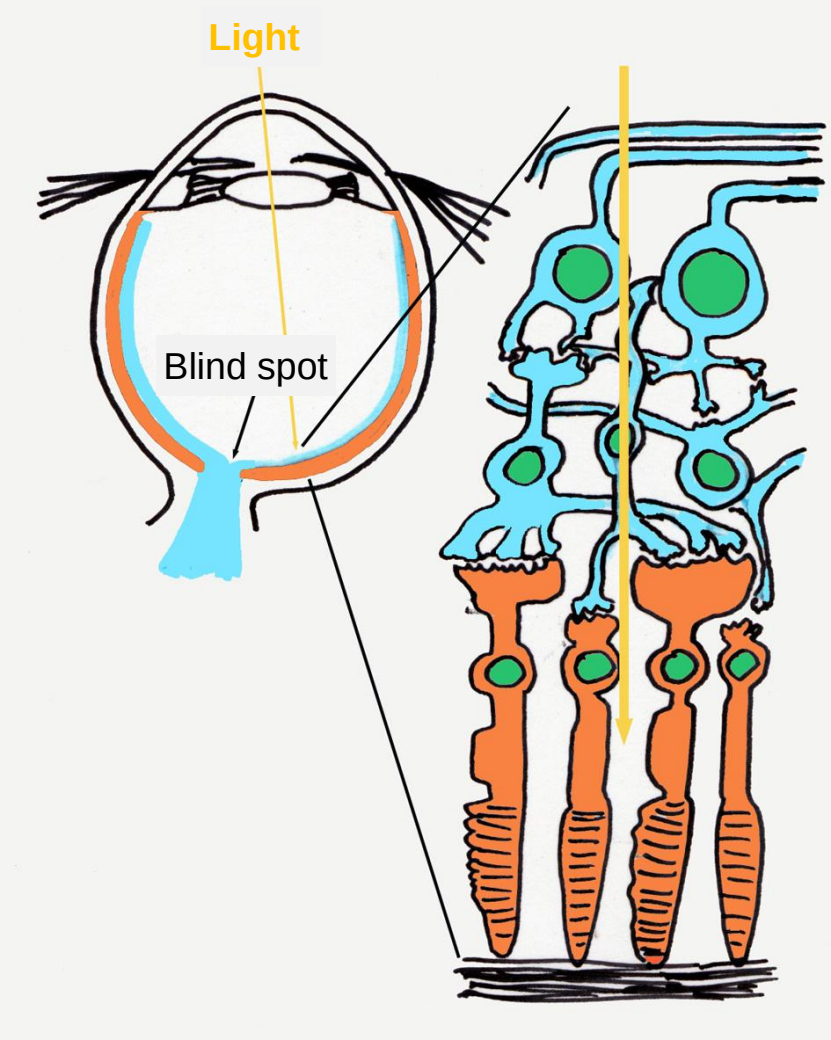
If the following biological structures had been designed by a God, or a designer, or complex numbers, you might want to say a thing or two about the rationality of their design.

Why are the respiratory tract and esophagus designed this way?



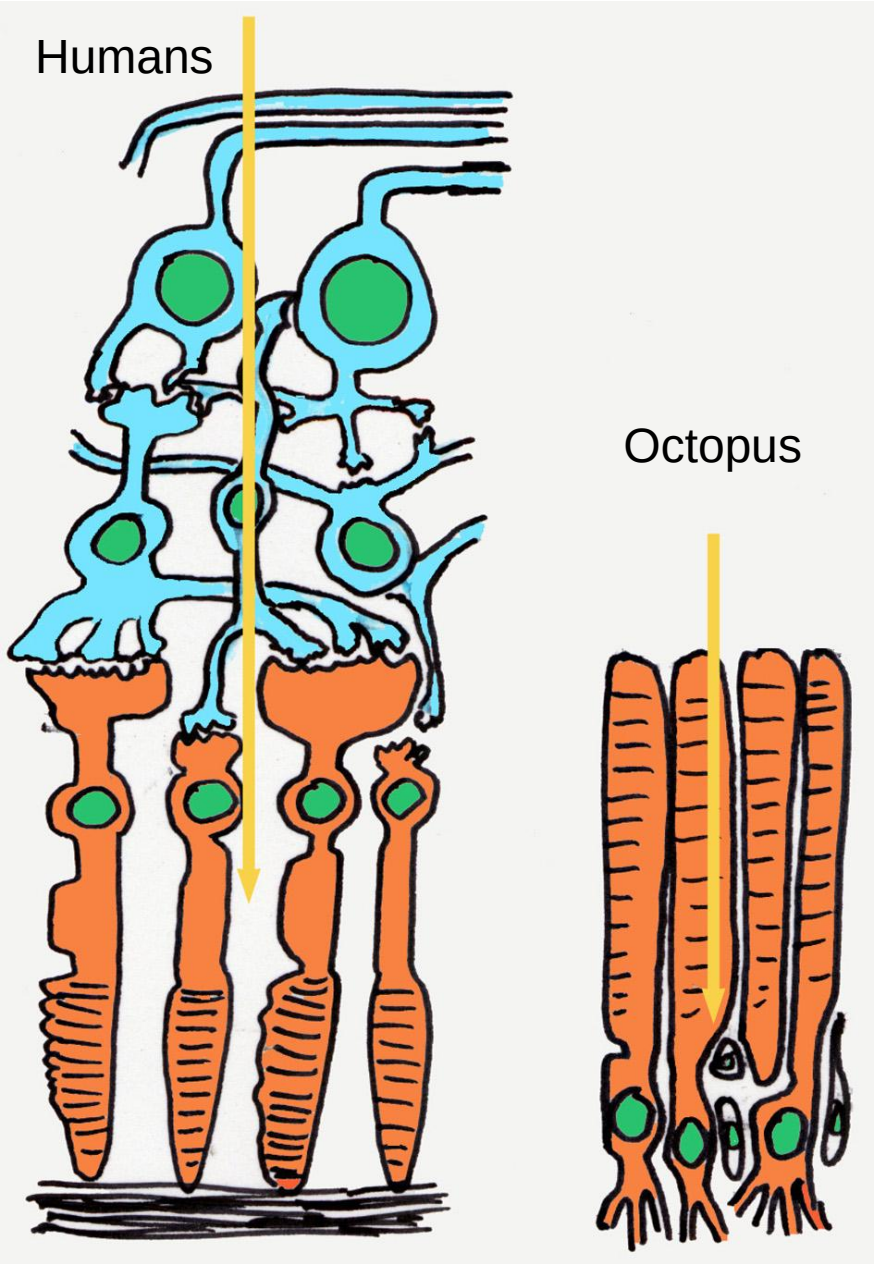
Better designed valves or plumbing could prevent people from choking on mochi rice cakes, avoiding calls for ambulances and doctors over the New Year holidays.

Why are the retina and optic nerve wired to block out light?



If only the optic nerve had been designed to pass behind the retina, there would be no blind spot and nothing to cut off the light coming in. We may have enjoyed better resolution.

Incidentally, octopus and squid keep their optic nerves separate, so the retina is in an ideal position and direction.



Other things that are often mentioned:

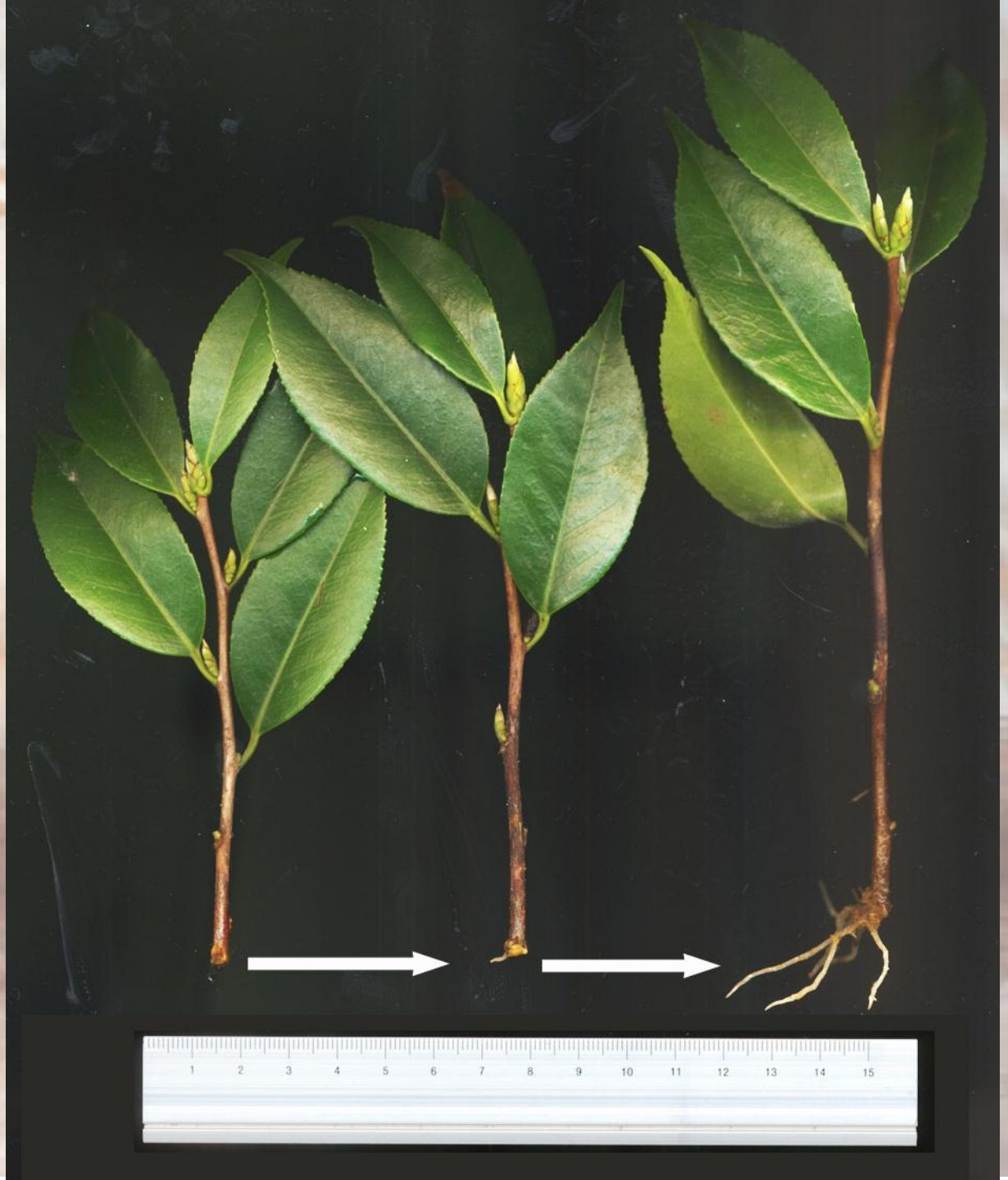
1) Since the human body was originally designed for four-legged locomotion, evolving to walk upright has put structural stress on the lower back. The body should have been redesigned to suit bipedal locomotion. Lack of the redesign process has resulted in back pain for many people.

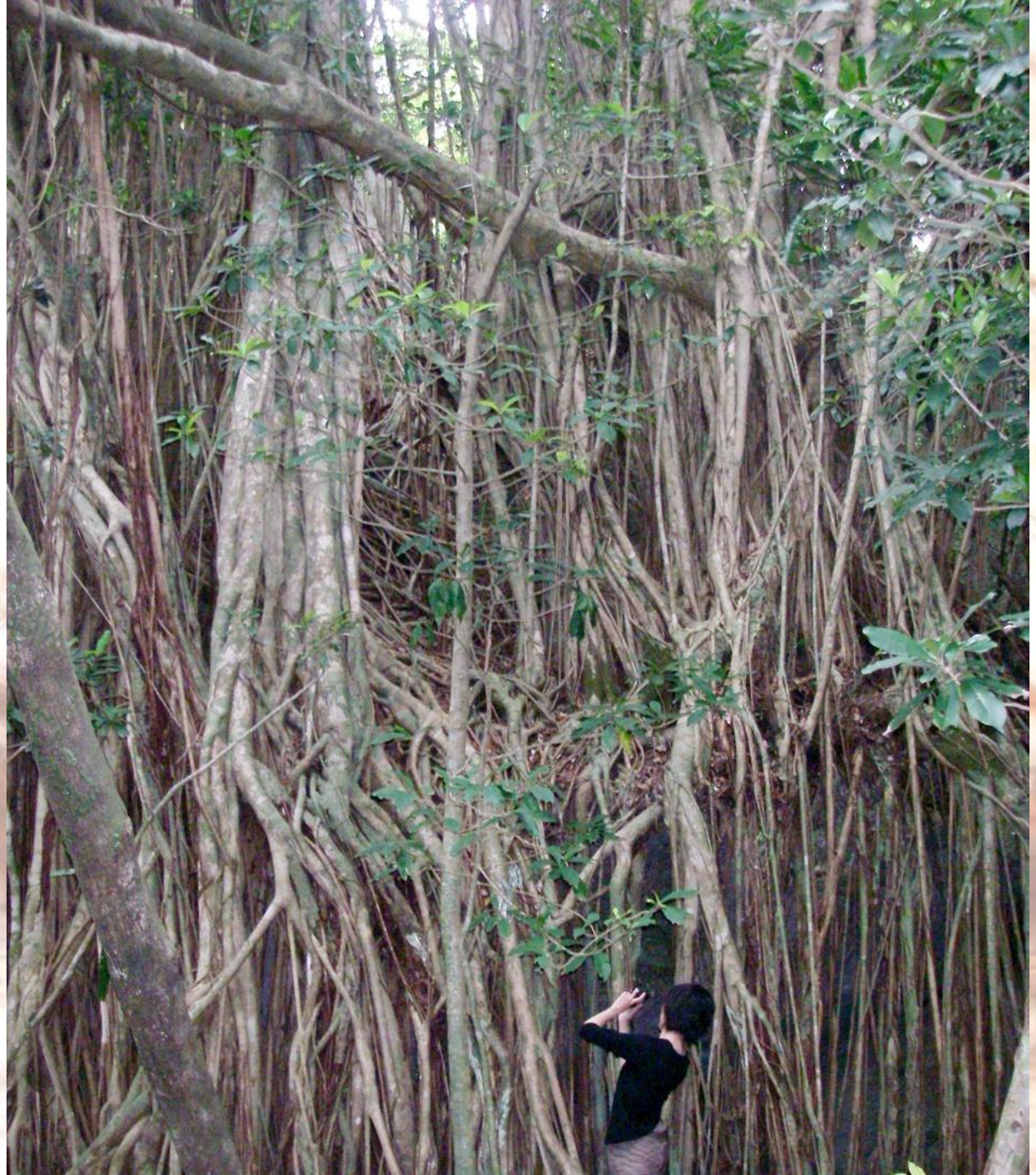
2) The human skull has evolved to such an extraordinary size that now, even at the fetal stage, it can just barely pass through the female pelvis at birth. The female pelvis at least should have been restructured to allow larger heads to pass through.

3) As well, many people on the earlier mentioned website have pointed out the pinky toe, apparently because people often stub their pinky toes on furniture.

Since my field of expertise is botany, let's see how a plant sprouts roots.

Plants casually sprout roots from here or there, and let them branch out at random.

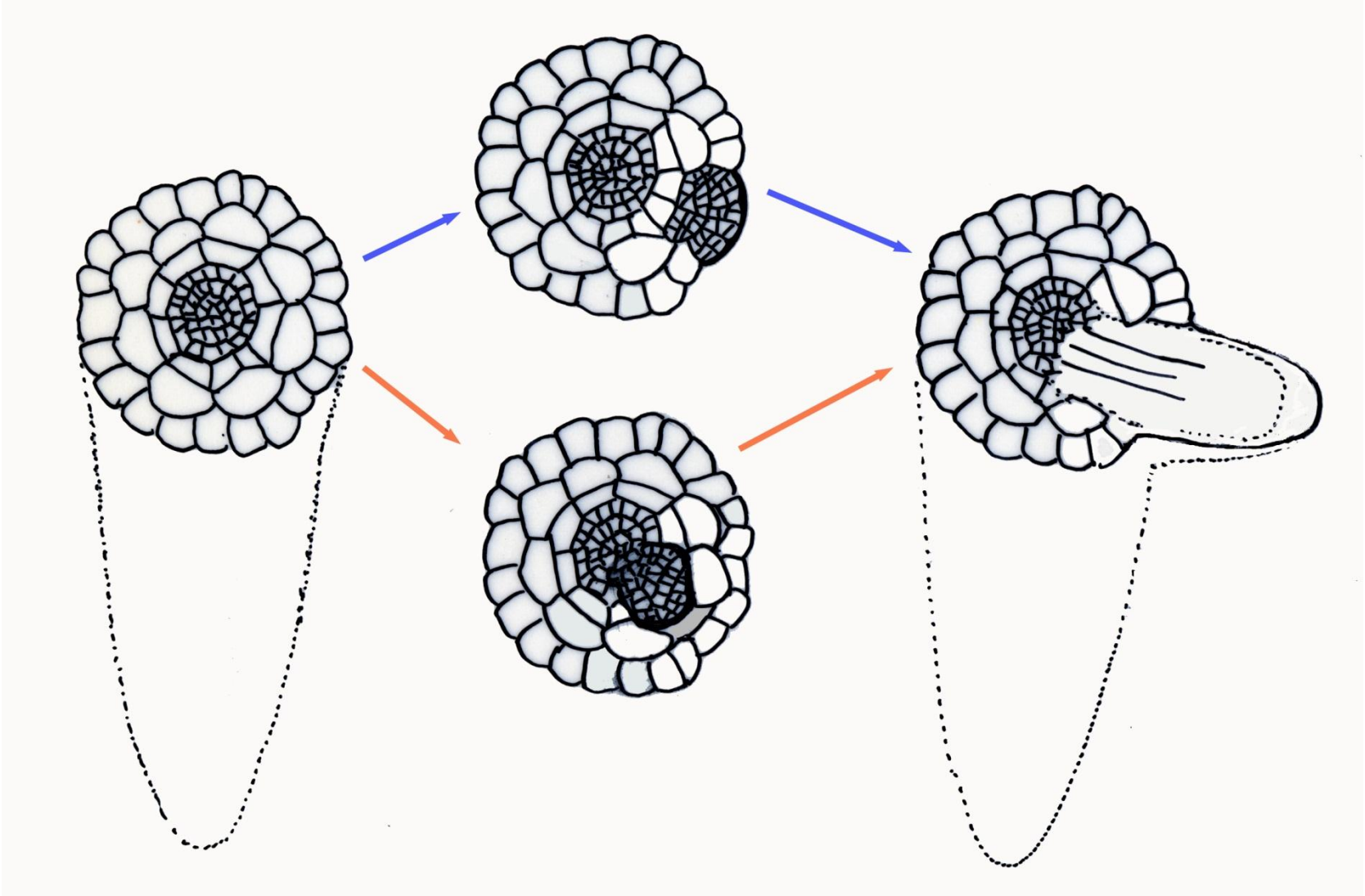




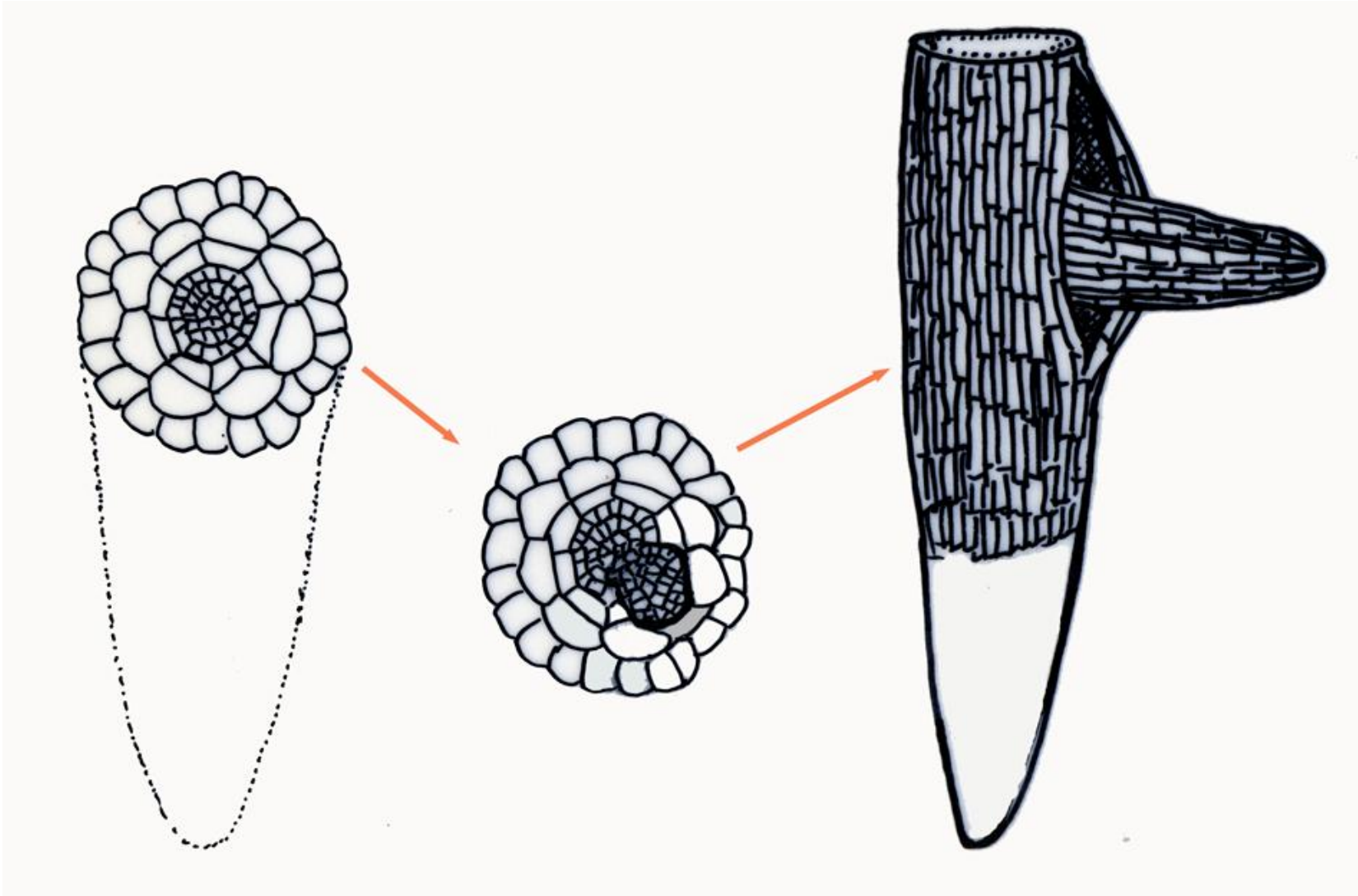
In some cases, they may end up like this ….

These are aerial roots of the banyan tree.
(Photo: Yakushima field trip for 4th year students of the Department of Biological Studies, School of Science)

Question: From where do cells divide when a root decides to branch out?



Answer: Such a crazy design. Each time a root branches out, or an adventitious root sprouts out of the stem or leaves, it leaves a crack in the plant's body. Surely this leaves the plant vulnerable to disease and insect damage?



Now, some physicists and quite a few philosophers are believers in the “theory of everything” – that everything can be expressed in one absolute and simple mathematical form.

They probably think the theory of everything should eventually apply to describing living organisms. If so, it would render diversity in organisms meaningless.

For instance, in 1954 when Einstein was asked how he would feel if he discovered that the ultimate rule of nature was not simple, he replied he would not be interested in such a rule.

But does the theory of everything really exist?

Sheldon Glashow said that physicists in the past had done well in seeking the process of simplification and unification, but there is no reason for things to become simpler. According to Glashow, they could actually become more chaotic and more complicated.

Take for example the Kobayashi-Masukawa Theory, which asserted the existence of six types of quarks. The theory was initially ignored for “increasing the number of elements too easily,” but it eventually proved correct and won a Nobel Prize nomination in 2008.

So, is it necessary for the ultimate theory of nature to be simple?

Another argument that has spread is the anthropic principle, which reasons that the universe must be compatible with human life that observes it, because there are too many physical constants in the universe that seem favorable to our existence.

But in recent years we have seen the emergence of the idea that the universe is not just one but rich in variety, and that our universe just happens to have such properties.

Although these concepts of diversity or coincidence are quite natural for biologists, they seem hard for some physicists and philosophers to accept.

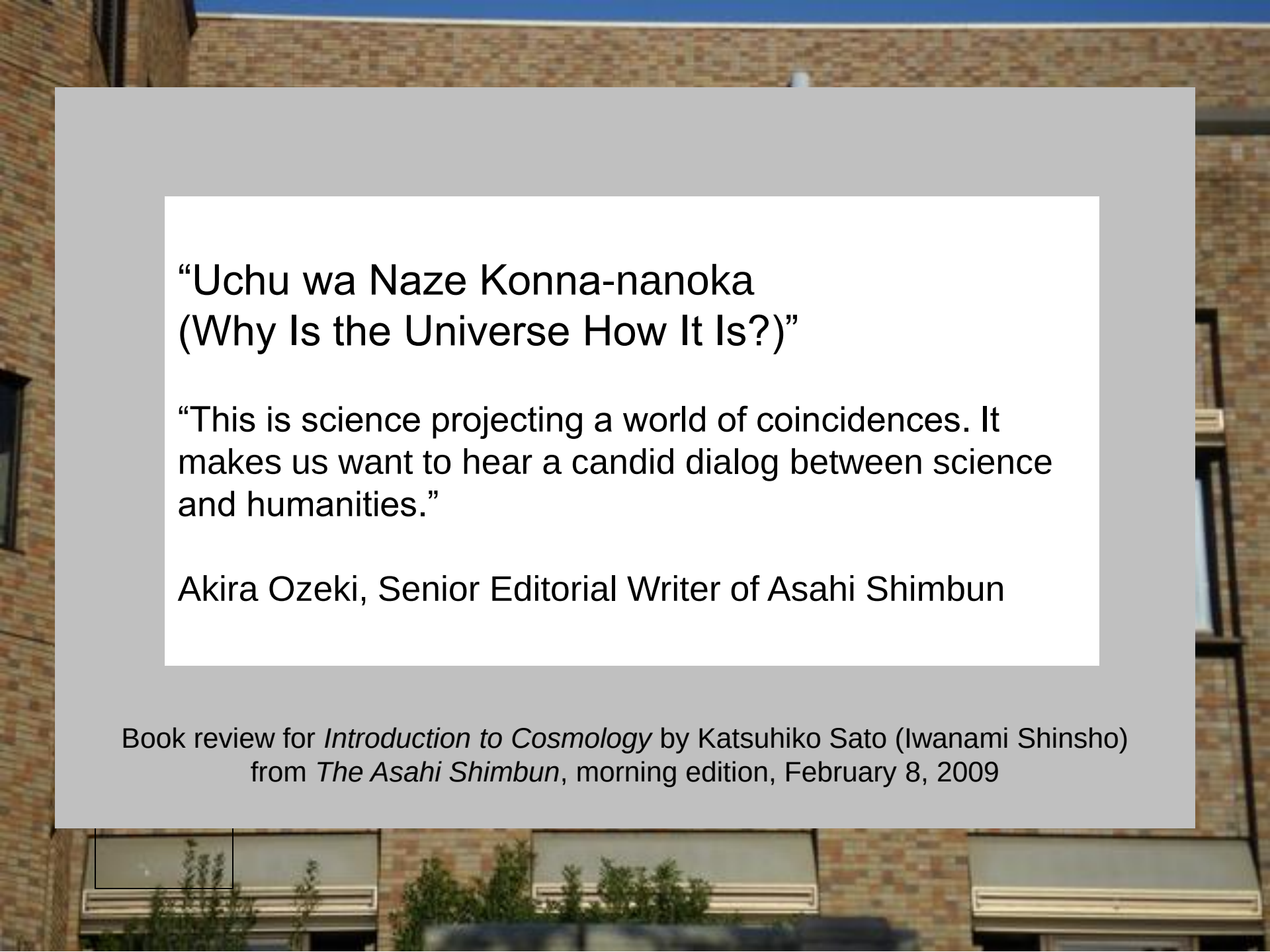
Incidentally, when ideas such as the theory of everything or the anthropic principle are taken to the extreme (or caricatured), we then reach the world of science fiction like *Distress* (written by Greg Egan, translated by Makoto Yamagishi).

If you think about it, you will probably see the inherent danger: how easy it is for the search for one absolute theory of everything to transform into the worship of an absolute God. This is probably why so many of the physics crowd became absorbed in questionable religions and cults.

Moreover, there is a physicist who claims that Western science has come up against a brick wall and that we need something new, something that incorporates Eastern philosophy. (He is no pseudo-scholar; he is a veteran physicist and one of the top scientists in his discipline in Japan.)

But from the biologist's point of view this is simply a misconception. It only suggests that the science the physicist had been pursuing was similar to religion, and that the direction he will take from now on is the real science that biologists have long been dealing with.

Surprisingly, however, it seems the public are not aware of this point. The Asahi Shimbun Newspaper recently published the following article…



“Uchu wa Naze Konna-nanoka
(Why Is the Universe How It Is?)”

“This is science projecting a world of coincidences. It makes us want to hear a candid dialog between science and humanities.”

Akira Ozeki, Senior Editorial Writer of Asahi Shimbun

Book review for *Introduction to Cosmology* by Katsuhiko Sato (Iwanami Shinsho)
from *The Asahi Shimbun*, morning edition, February 8, 2009

“Science projecting a world of coincidences”?!
“Makes us want to hear a candid dialog between science and humanities”?

Science = world of inevitability?
Humanities = world of coincidence?

I say No.

At least the brain that thinks about science or the continuous evolution that has made it possible for our minds to think of science is the result of a series of coincidences, and biologists who seek the path of evolution, or strive to learn more about the results of evolution, believe that coincidence is everything. From a biologist’s point of view, the idea that everything in the universe is born from inevitability appears similar to a religious view or perception that has been unconsciously corrupted by the story that everything was created by a single God.

Incidentally, Dr. Katsuhiko Sato, Professor Emeritus of the University of Tokyo and author of the reviewed book, once mentioned that the biologist's view of science seemed to differ from his. (*NIKKEI SCIENCE*, April 2004)

Sato: I'm not sure if this answers your question, but I feel that different areas of science can have very different cultures.
Sena: Could you elaborate on that?
Sato: Once I was at a meeting to discuss preparations for the opening of a new science museum and people started talking about the concept of science. I said I was trying to pursue truth to solve cosmic questions, and a biologist told me there was no such thing as truth and they were simply studying the mechanisms or systems of nature. It was as if he were accusing me of being a pseudo-scientist by daring talk about truth, and I remember feeling taken aback by this reaction.

Sato: But we physicists quite simply believe in it. We believe there is a truth in this world, and that the world revolves around this truth. Though, of course, I don't believe this ultimate truth would let us understand everything in the world.
In terms of cosmology, the laws of physics are the warp and the various mathematical phenomena such as quantum fluctuations and chaos are the woof. This incredible world of ours exists in the fluctuations between inevitability and coincidence. But I still believe there is a truth in this world and this knowledge will let us recognize the world. That is how a theoretical physicist is.

Recommended readings from today's lecture: April 13, 2011

Hirokazu Tsukaya, *Shokubutsu no Kokoro (Soul of Plants)*, Iwanami Shinsho, 2001
It may be a mistake to view plants in the same way as we view humans, but it is also a mistake to treat them as something completely different from humans. If you see that human relationships are quite similar to plants after reading this book, then my job is done. This idea is the underlying thought throughout my lectures for this GFK course. Available as a Shinsho book at ¥735.

Yasushi Sudo, *Jinsei Ippan ni Sotairon (Relativity in General Life)*, University of Tokyo Press, 2010
This book is a signature piece by Professor Sudo, interpreter of this GFK course; it is a compilation of his essays randomly published in the monthly PR magazine *UP* from the University of Tokyo Press (pronounced "U-P," often found next to the register at the co-op book shop). This book gives a good idea of how physicists are and what characteristics they possess. A must-read for this GFK course. As with the book below, available at ¥2,520.

Hirokazu Tsukaya, *Kawaru Shokubutsugaku Hirogaru Shokubutsugaku (Changing Botany)*, University of Tokyo Press, 2006
A book for students who wish to study botany someday. Botany has changed completely during this decade. This book summarizes the overall flow and background of studies in a readable manner. The studies that are popular now are already old. If you want to study, you need to study something that no one else has done. I have made the book affordable by reducing the royalties for the first edition. Relatively cheap for a University of Tokyo Press textbook, available at ¥2,520.

Greg Egan, *Distress*, translated by Makoto Yamagishi, Sogen SF Bunko
If you are a science fiction fan, you may have already read this book. Since the passages in last part are constrained by the nature of the theory of everything presumed in the book, the reviews seem to be divided over how the story ends. Nevertheless, Sisyphus, worn by the protagonist bio-tech journalist, is an item that I would like to have. Hopefully it will become available in the near future? The book is available at ¥1,365.