Simple explanation of the Carbon-Based Evolutionary Theory (CBET)

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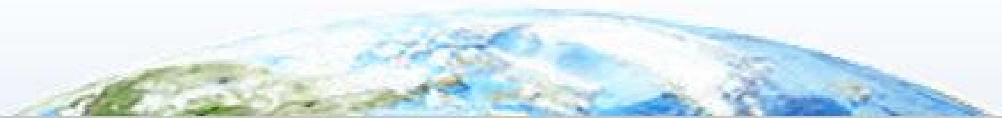


1 **History & background of the CBET**

2 The primary driving force of evolution

3 The mechanisms of evolution

4 Reliability & significance of the CBET

5 Questions & answers

6 Generalization of the CBET

The infant version of the CBET was published in 2000–2001 as one paper, one book, and one PhD dissertation

Springer Link

Discussion | Published: March 2000

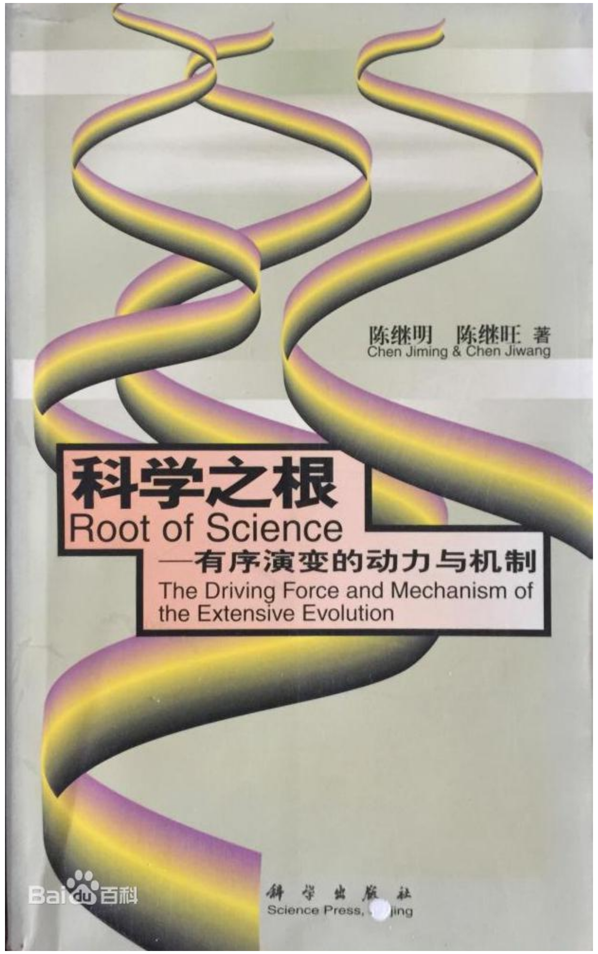
A new evolutionary theory deduced mathematically from entropy amplification

Jiming Chen

Chinese Science Bulletin **45**, 91–96(2000) | Cite this article

Abstract

A new evolutionary theory which is able to unite the present evolutionary debates is deduced mathematically from the principle of entropy amplification. It suggests that the extensive evolution is driven by the amplification of entropy, or microscopic diversity, and the biological evolution is driven by the amplification of biodiversity. Forming high hierarchies is the most important way for the amplification and brings out spontaneously three kinds of selection. This theory has some positive cultural meanings.



Doctorial Dissertation

Molecular Evolution of Influenza B Virus HA1 region & Tentative Discussions on Biological Macroscopic Evolution

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May, 2001

Afterward we spent around 20 years greatly optimizing and simplifying it

Major steps of the evolution of the CBET

1. Establishment of the mathematical and thermodynamic bases of this theory originally targeting the evolution of the universe in 1998-2000
2. Investigation of the evolution of multiple virus species and application of this theory to the evolution on the surface of the Earth in 2001-2015
3. Establishment of the concept of carbon-based entity and the simple expression of the second law of thermodynamics in 2018
4. Elucidation of the mechanisms how low-hierarchy CBEs evolved to high-hierarchy CBEs in general in 5/2020-6/2021
5. Elucidation of the mechanisms how low-hierarchy CBEs evolved to high-hierarchy CBEs step by step with chemistry in 2/2021-7/2021

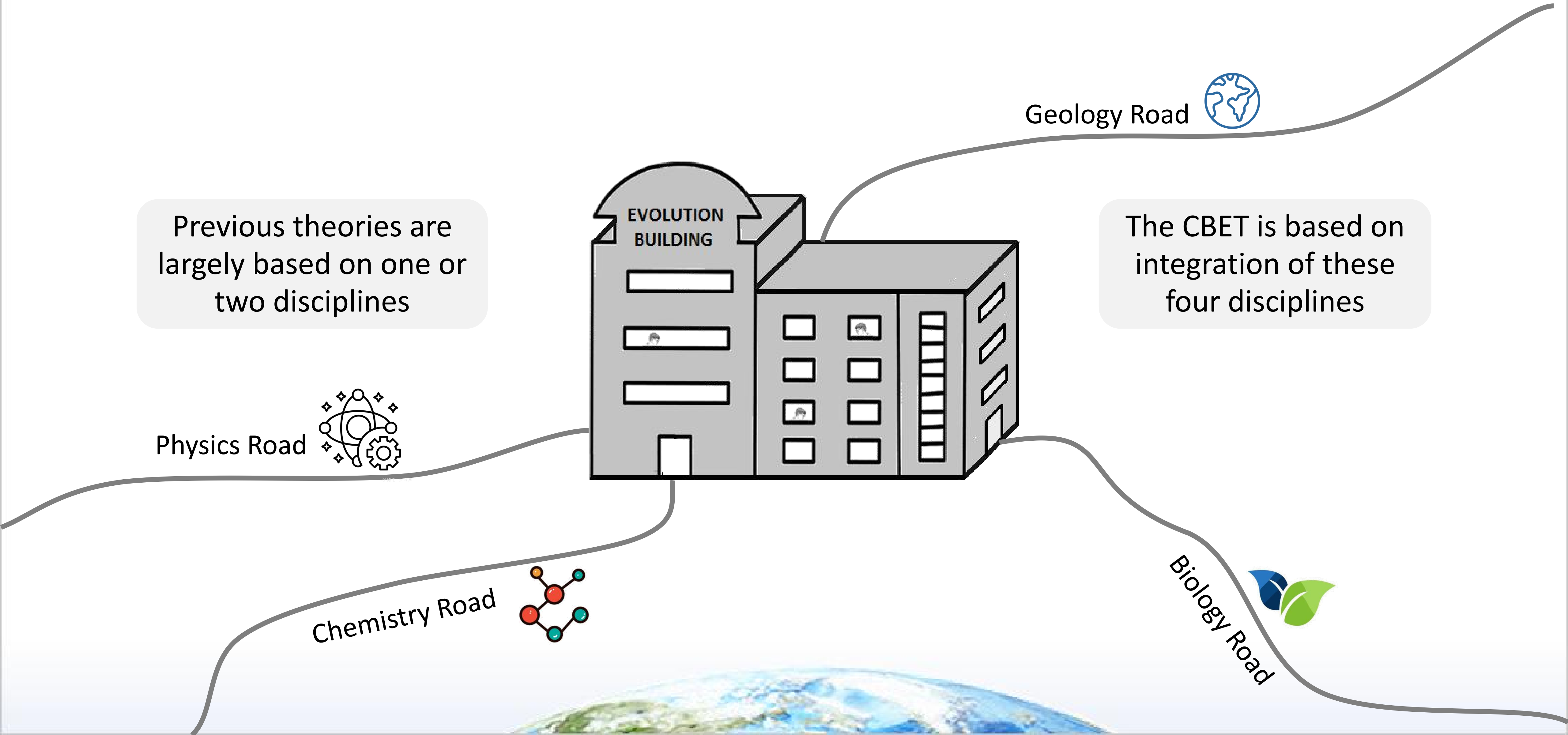
Five aims of the CBET

- To be a more scientific and comprehensive evolutionary theory
- To better explain multiple evolutionary issues
- To reveal the evolutionary basis of multiple social notions
- To be the first bridge linking physics, biology, and social sciences
- To upgrade previous mainstream evolutionary theories

How to achieve these aims

Previous theories are largely based on one or two disciplines

The CBET is based on integration of these four disciplines



Advantages of the multidisciplinary integration

Discipline	Non-replaceable function for evolution
Geology	Provides the environment and fossil evidence
Physics	Provides the temporal direction
Chemistry	Provides the molecular mechanism
Biology	Provides the genetic basis

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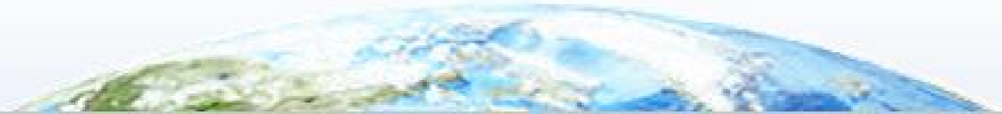
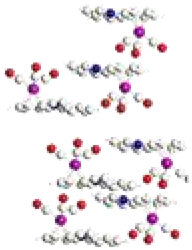
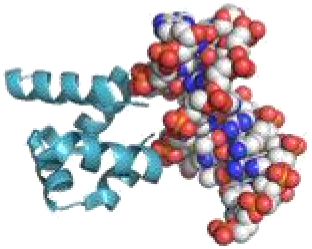
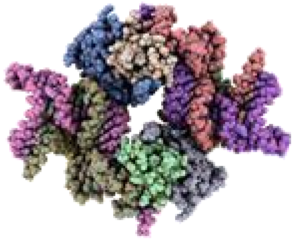
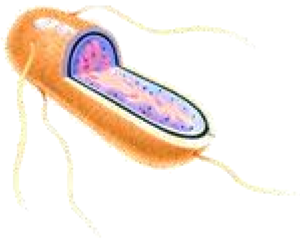
6 Generalization of the CBET



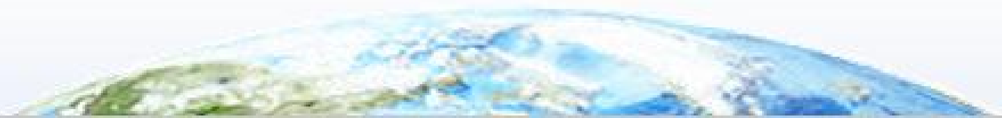
The leading actor in the CBET is CBEs

CBEs = carbon-based entities
= entities chemically containing carbon atoms
such as carbon dioxide, methane, amino acids, nucleotide, glucose, proteins, nucleic acids, lipids, organisms including bacteria, fungi, plants, animals, humans

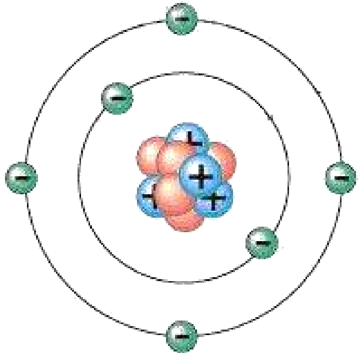





Advantage of CBEs in discussing evolutionary issues

- Evolution of CBEs covers life origin and life evolution
- CBEs are more readable, concrete, and specific than quanta, molecules, microscopic particles, matter, and systems
- CBEs are more inclusive than organic compounds, carbohydrates, organisms, genes, and populations



Carbon atoms are prone to share electrons with various atoms and form many flexible CBEs



Carbon atom

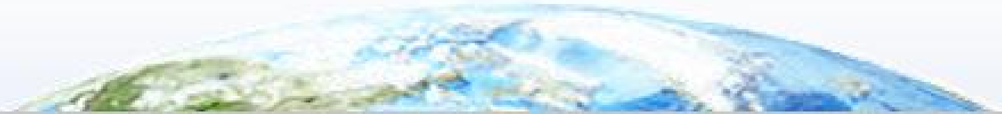
I am a CBE
I can change a lot
I can be very long
I can be very wonderful
Because I am good at sharing
Because I am flexible

CBEs can form multiple hierarchies

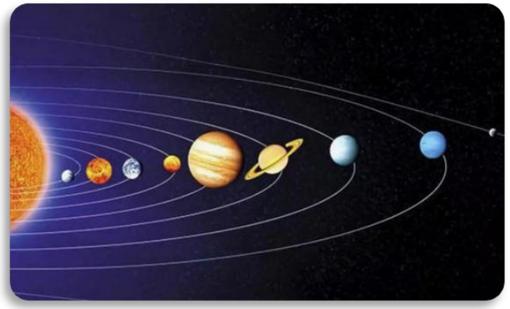
Hierarchy	Definition	Examples
H1-CBEs	Small molecules containing carbon atoms	Carbon dioxide, methane, and ethanol
H2-CBEs	Middle-sized organic molecules	Amino acids, nucleotides, and glucose
H3-CBEs	Organic macromolecules	Proteins, nucleic acids, and lipids
H4-CBEs	Unicellular organisms	Archaea, bacteria, and protozoa
H5-CBEs	Multicellular organisms	Grasses, trees, fishes, and birds
H6-CBEs	Animal societies	Ant societies, bee societies, human societies

There are no clear lines separating these hierarchies. For example, some peptides are between H2-CBEs and H3-CBEs

Higher-hierarchy CBEs (**HHCBEs**) and lower-hierarchy CBEs (**LHCBEs**) are compared with certain CBEs regarding their hierarchies



In geology: Many warm environments on the Earth



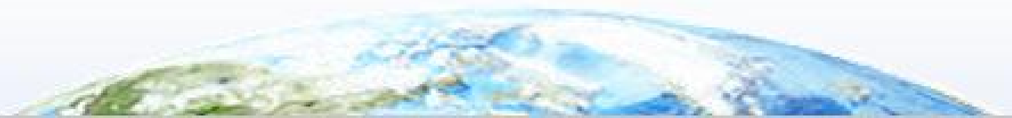
Due to the Sun

Due to geotherm

Due to biochemical energy

The Earth has much water and the atmosphere

which make warm environments more temperate, more widespread and last longer
through winds, rains, water flows, and evaporation



In physics: Two contrary tendencies on the Earth

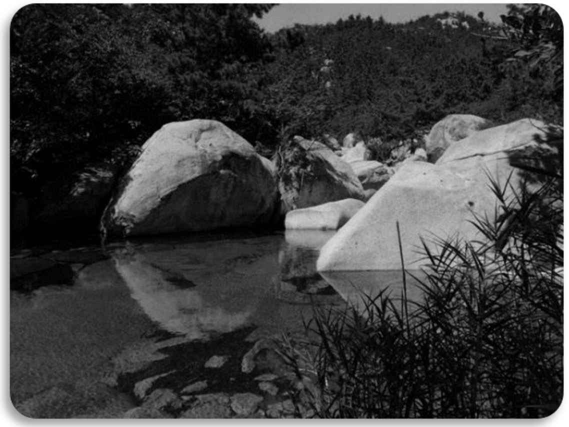
As per the second laws of thermodynamics

Heat can spontaneously flow from a hotter body to a colder body, and cannot spontaneously flow from a colder body to a hotter body

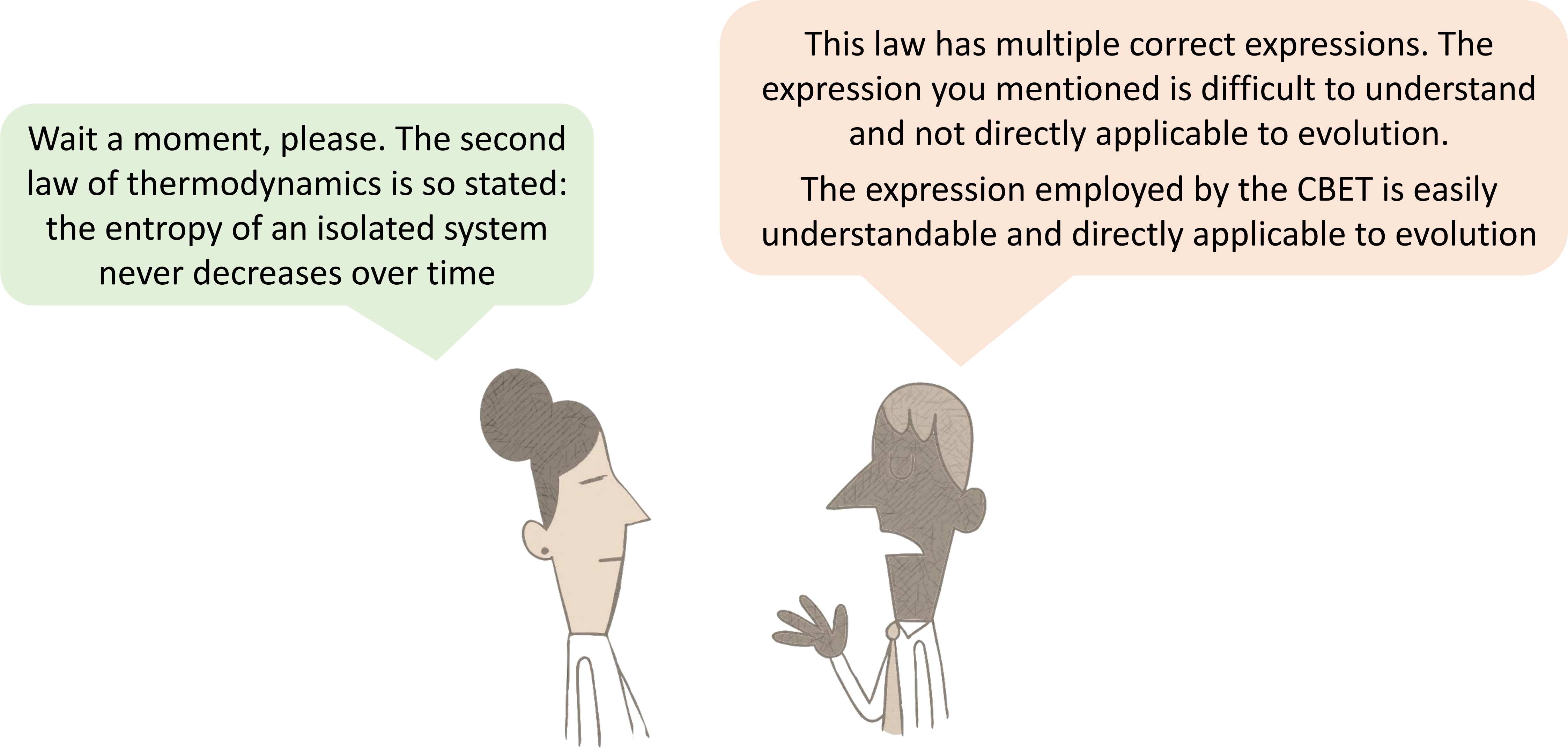
The heat absorbing tendency

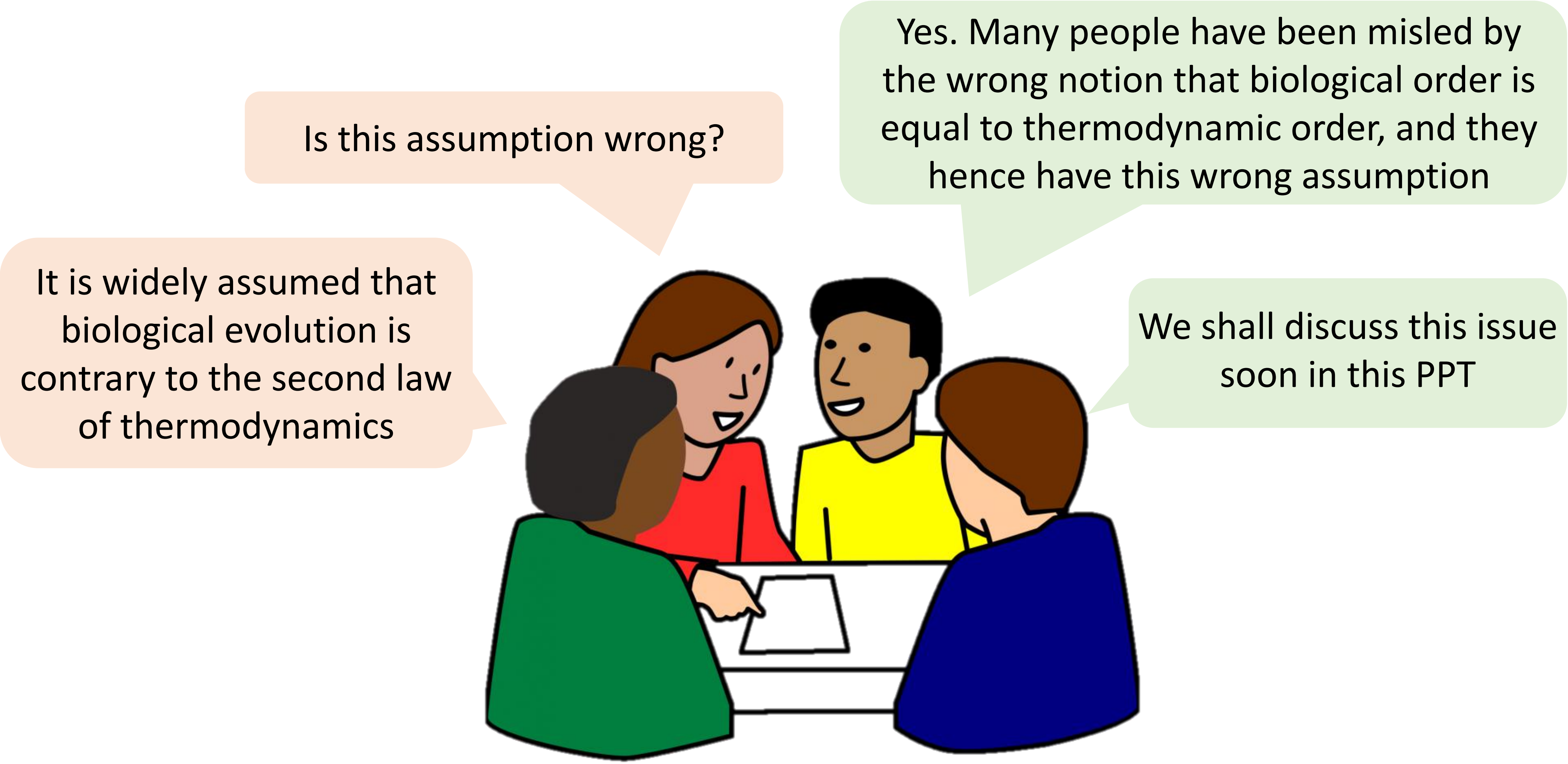
Many molecules in stones under the sunshine spontaneously have the tendency to absorb heat to move more rapidly

The heat releasing tendency



Many molecules in stones in the night spontaneously have the tendency to release heat to move less rapidly


Wait a moment, please. The second law of thermodynamics is so stated: the entropy of an isolated system never decreases over time
This law has multiple correct expressions. The expression you mentioned is difficult to understand and not directly applicable to evolution.
The expression employed by the CBET is easily understandable and directly applicable to evolution


It is widely assumed that biological evolution is contrary to the second law of thermodynamics
Is this assumption wrong?
Yes. Many people have been misled by the wrong notion that biological order is equal to thermodynamic order, and they hence have this wrong assumption
We shall discuss this issue soon in this PPT

In chemistry: Two contrary tendencies on the Earth

The organic synthesis tendency

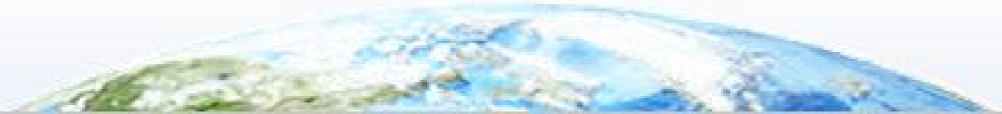
Carbon atoms are prone to form covalent bonds

after absorbing heat and moving relatively rapidly as per the second law of thermodynamics

The organic decomposition tendency

Organic molecules are prone to destroy their relatively fragile bonds
to release heat to the environment
after they have been activated by some relatively strong stimuli (e.g. fires)

Organic molecules can be decomposed only after they have been synthesized



The organic decomposition tendency

H3-CBEs —Release heat to the environment→ H2-CBEs —Release heat to the environment→ H1-CBEs

H2-CBEs (e.g. glucose, amino acids) and H3-CBEs (e.g. lipids, proteins) have the tendency to decompose to release heat to the environment after they have been activated by relatively strong stimuli (e.g. fires)

The organic synthesis tendency

H1-CBEs → (Absorb heat from warm environments) → H2-CBEs → (Absorb heat from warm environments) → H3-CBEs

H1-CBEs (e.g. CO_2) along with some other molecules (e.g. H_2O) have the tendency to absorb heat from warm environments to move relatively rapidly and form H2-CBEs (e.g. glucose)

H2-CBEs (e.g. amino acids) along with some other molecules have the tendency to absorb heat from warm environments to move relatively rapidly and form H3-CBEs (e.g. proteins)

Temperature and water are critical for organic syntheses triggered by the organic synthesis tendency

Too low temperature or too high temperate: no organic synthesis tendency

Water makes environments more temperate, last longer, and more widespread

Water participates in the organic syntheses as an important substrate

Water provides environments for the syntheses

Water flows facilitate molecules to meet each other for the syntheses

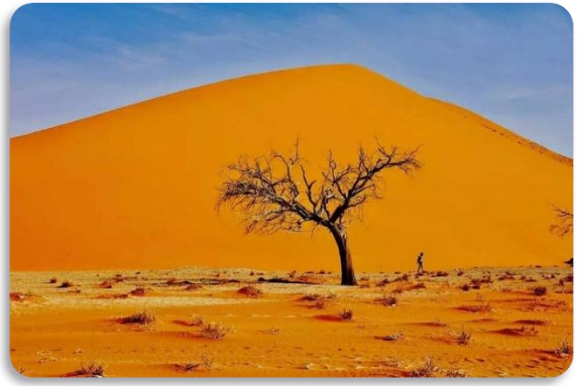
Water maintains the structures and functions of many enzymes for the syntheses

Warm humid areas

The organic synthesis tendency is obvious

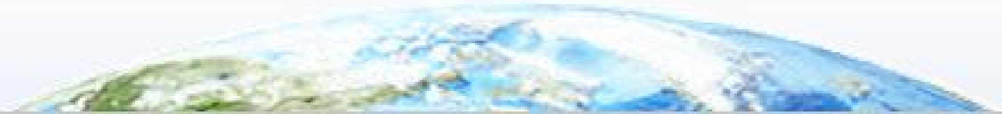
Cold areas

The organic synthesis tendency is inhibited

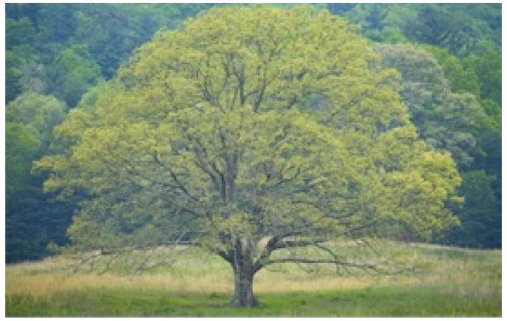


Tropic arid deserts

The organic synthesis tendency is inhibited

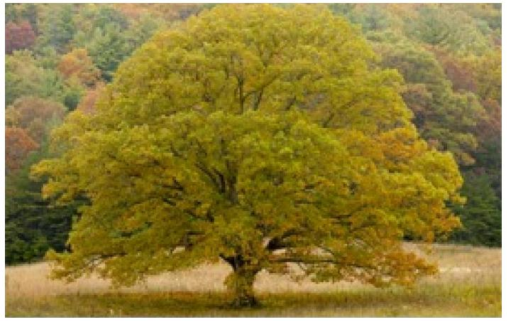


The organic synthesis tendency changes with seasons



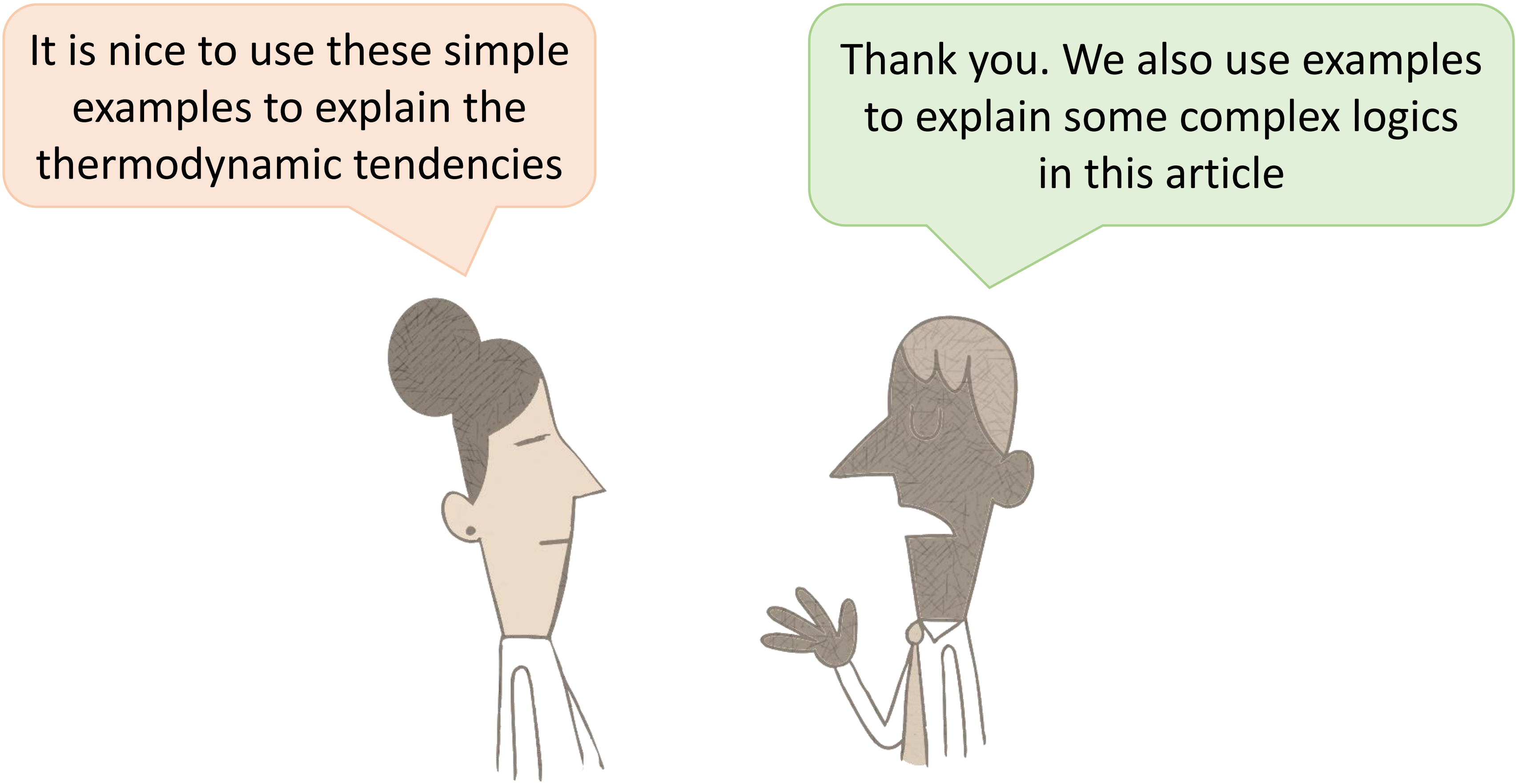
Spring
Organic synthesis begins dominating

Summer
Organic synthesis peaks

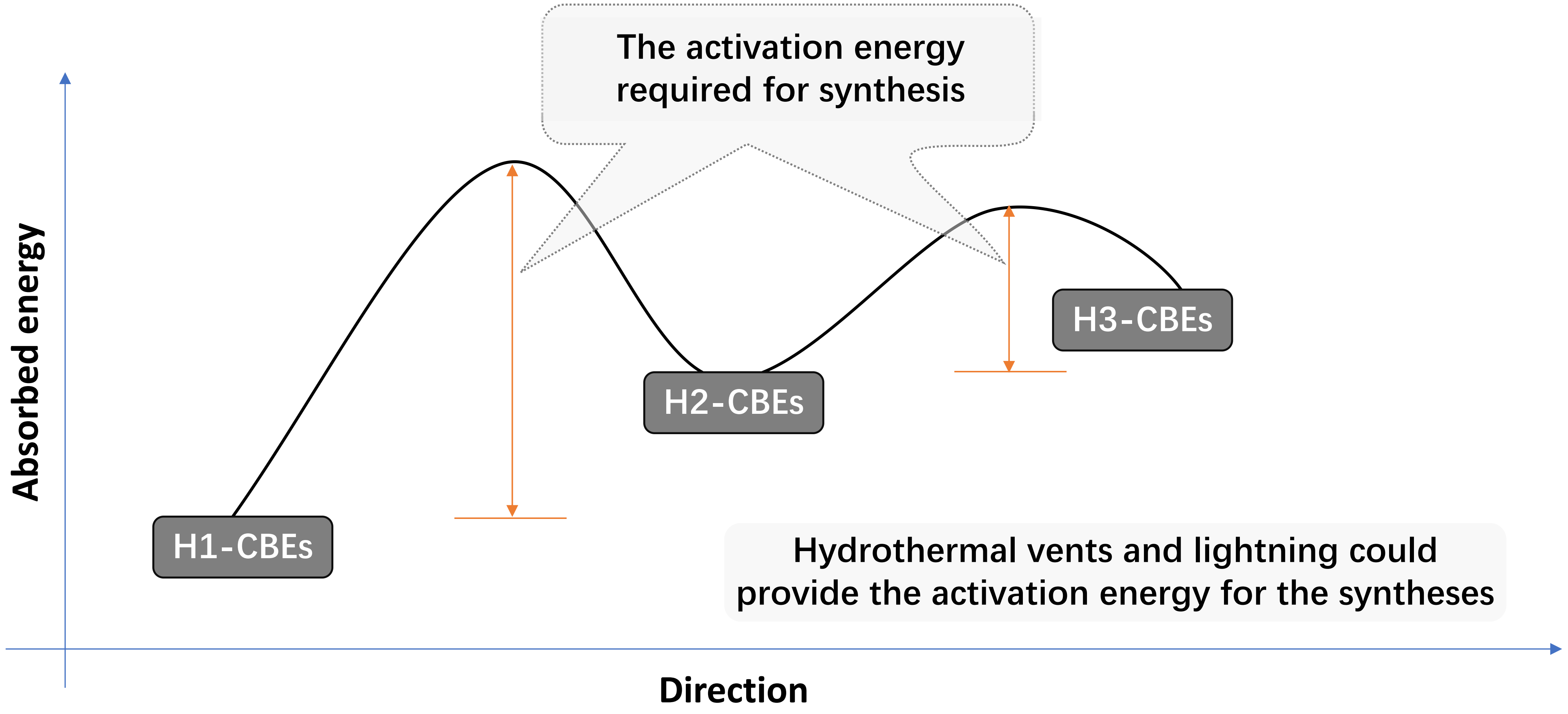


Autumn
Organic synthesis subsides

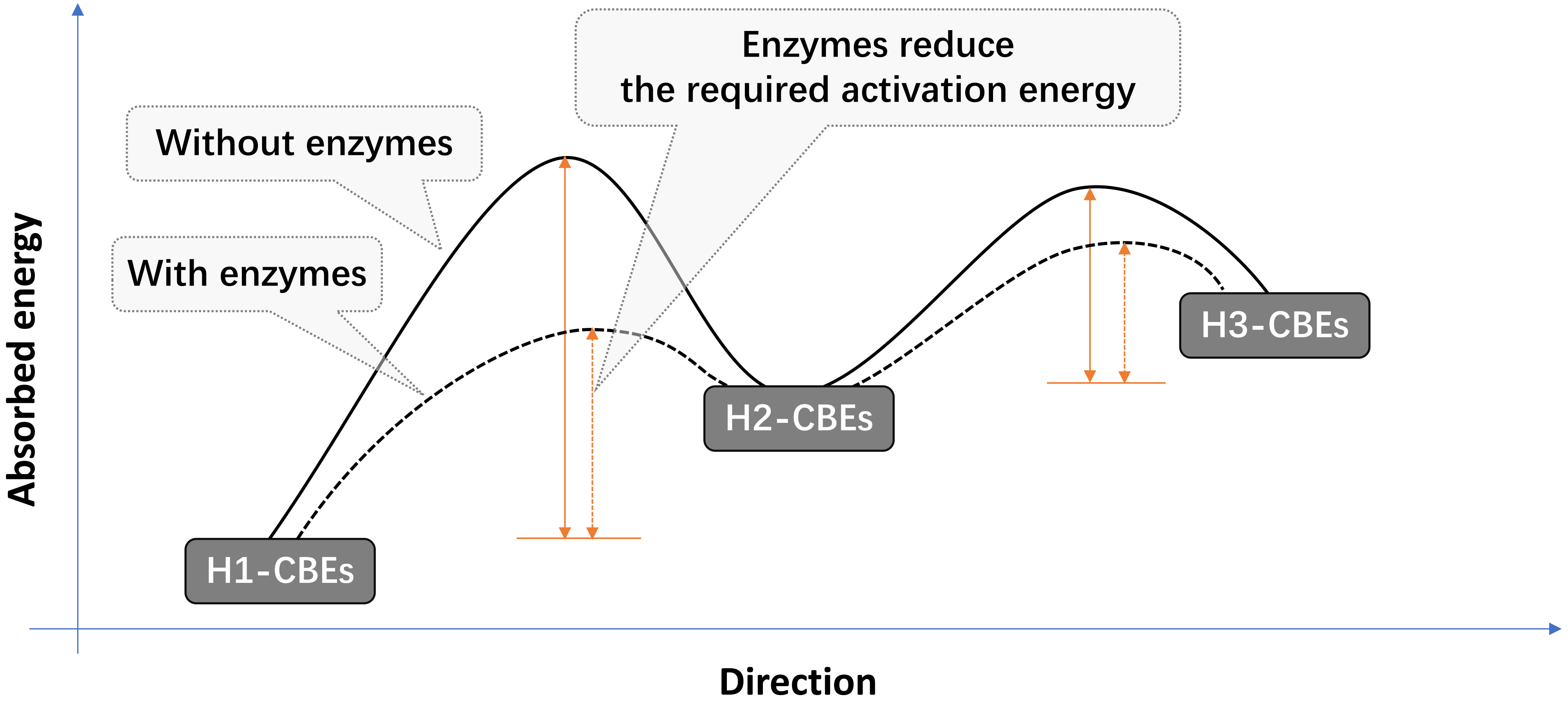
Winter
Organic synthesis is inhibited


It is nice to use these simple examples to explain the thermodynamic tendencies
Thank you. We also use examples to explain some complex logics in this article

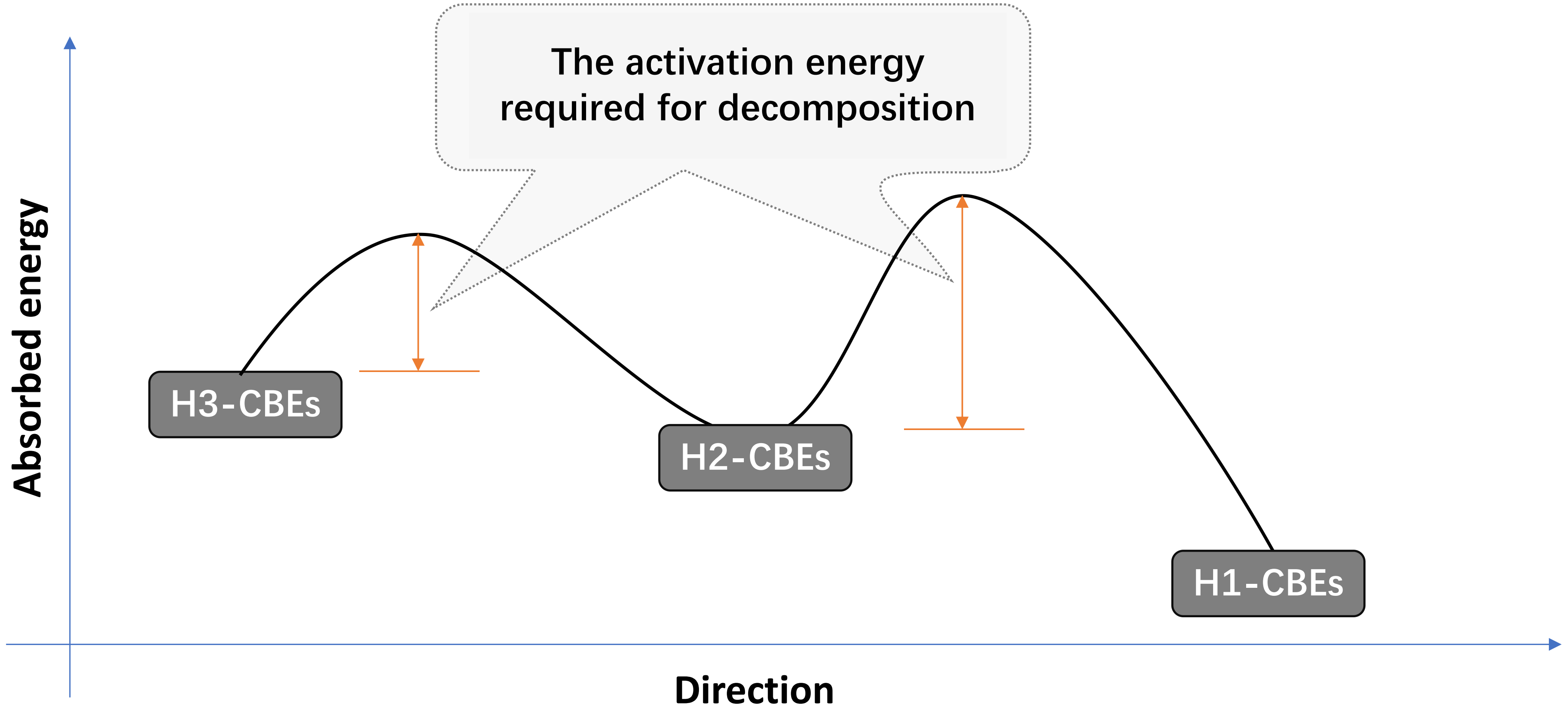
Without enzymes natural organic syntheses are very slow due to relatively high activation energy



Organic syntheses can be accelerated with enzymes

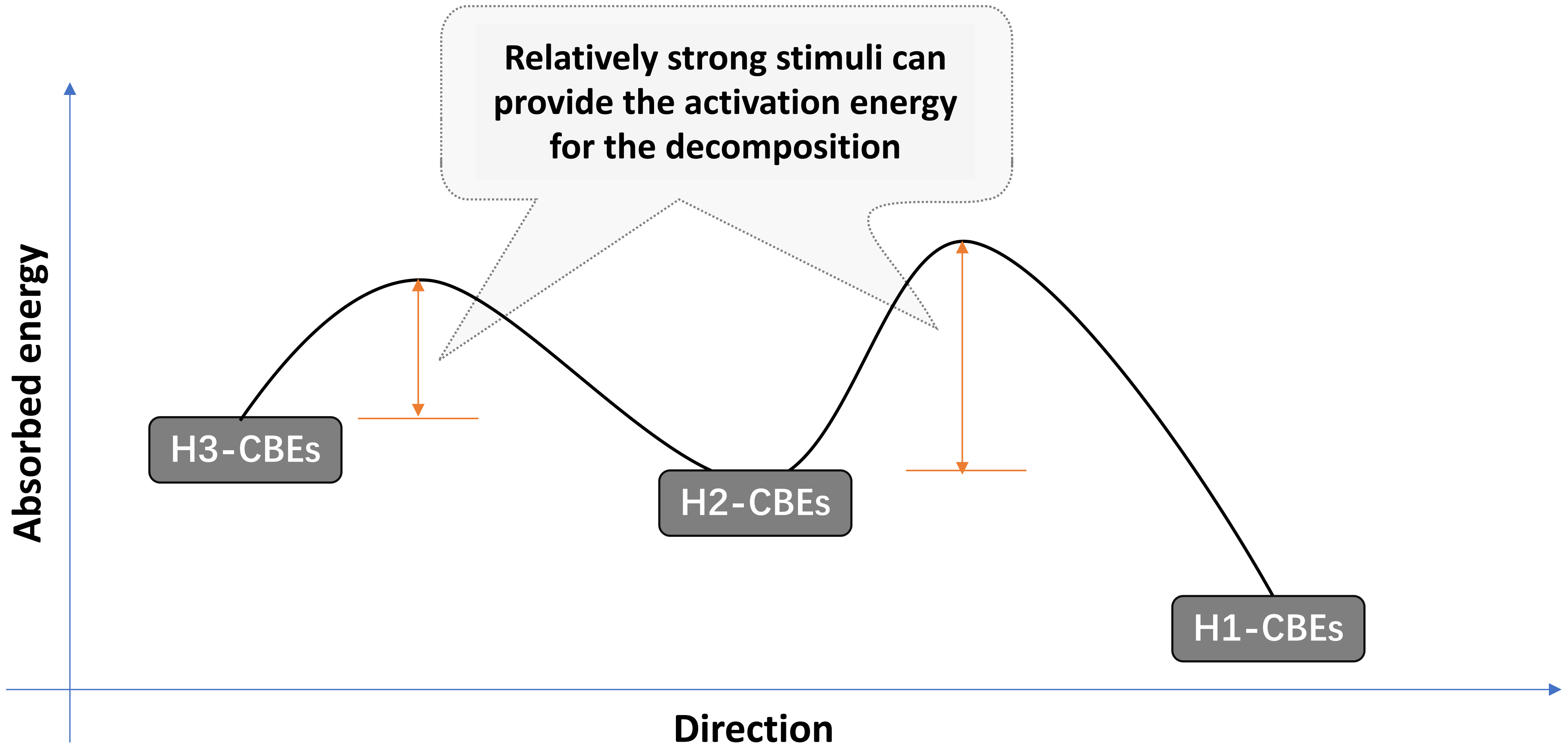


Likewise, natural organic decompositions are very slow in cold environments without enzymes and relatively strong stimuli



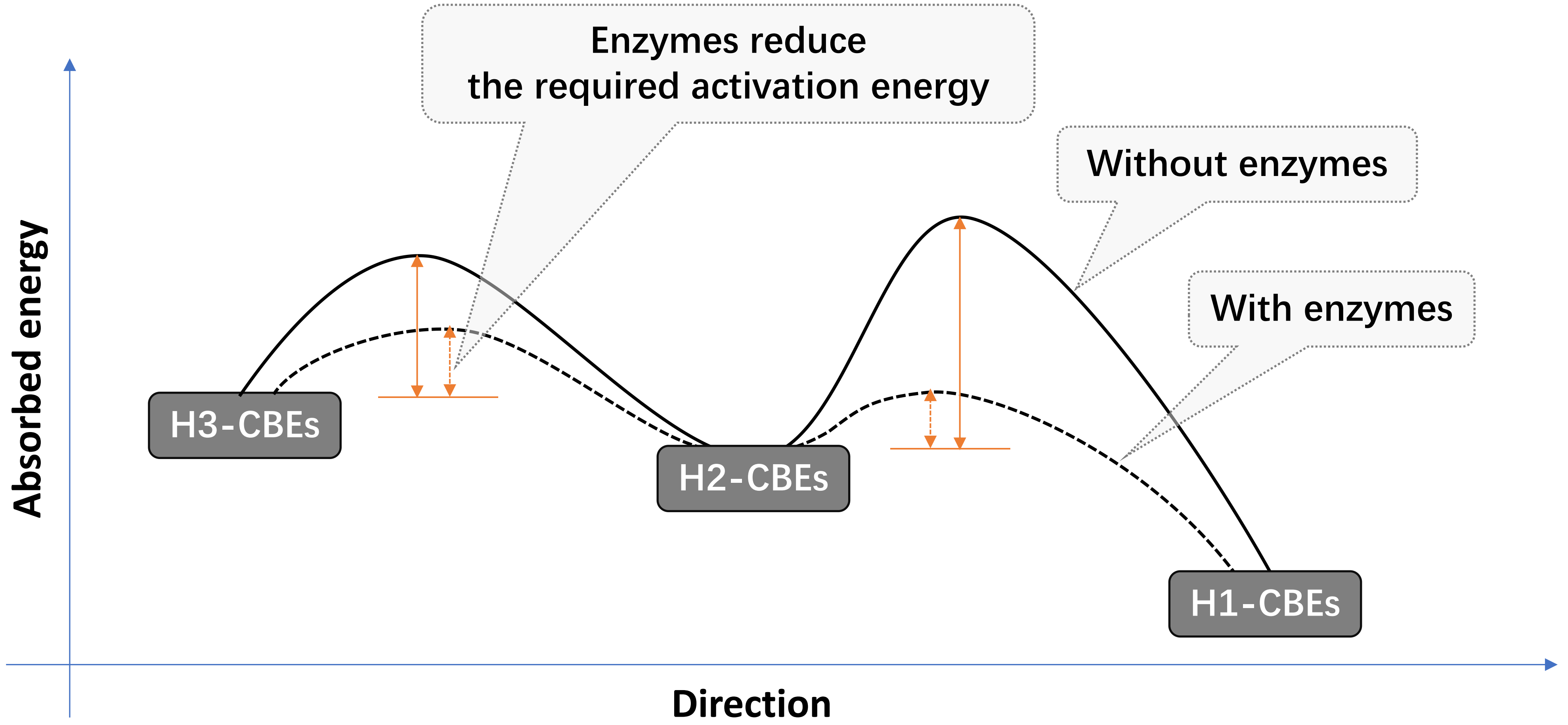
Cold environments without enzymes and relatively strong stimuli can inhibit organic decomposition

This principle is widely used to preserve food



Relatively strong stimuli can provide the activation energy for the decomposition
Absorbed energy
H3-CBEs
H2-CBEs
H1-CBEs
Direction

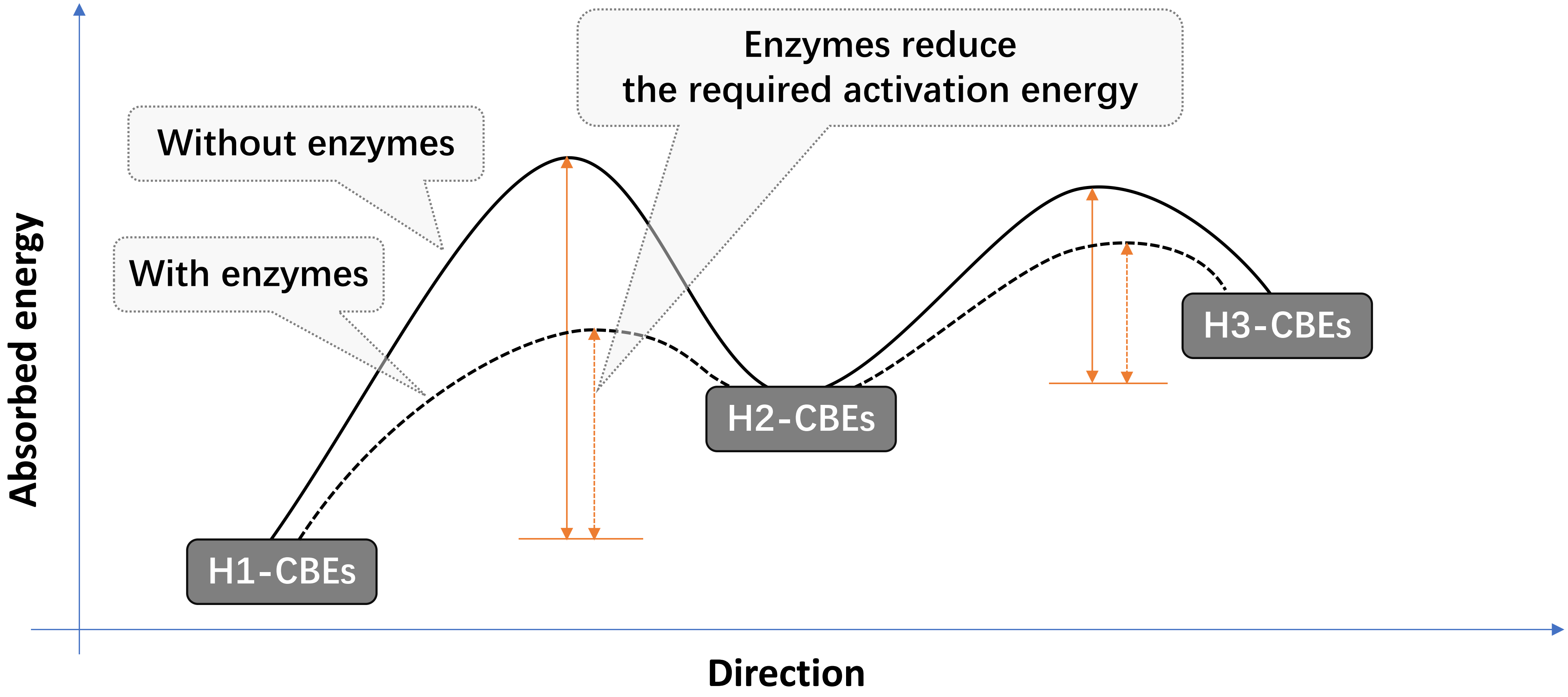
Organic decomposition reactions can be accelerated with enzymes



Without enzymes it requires strong stimuli to decompose organic molecules

Chickens use many enzymes to gently decompose organic molecules in the feed

Enzymes cannot change the reaction directions which are determined by thermodynamics

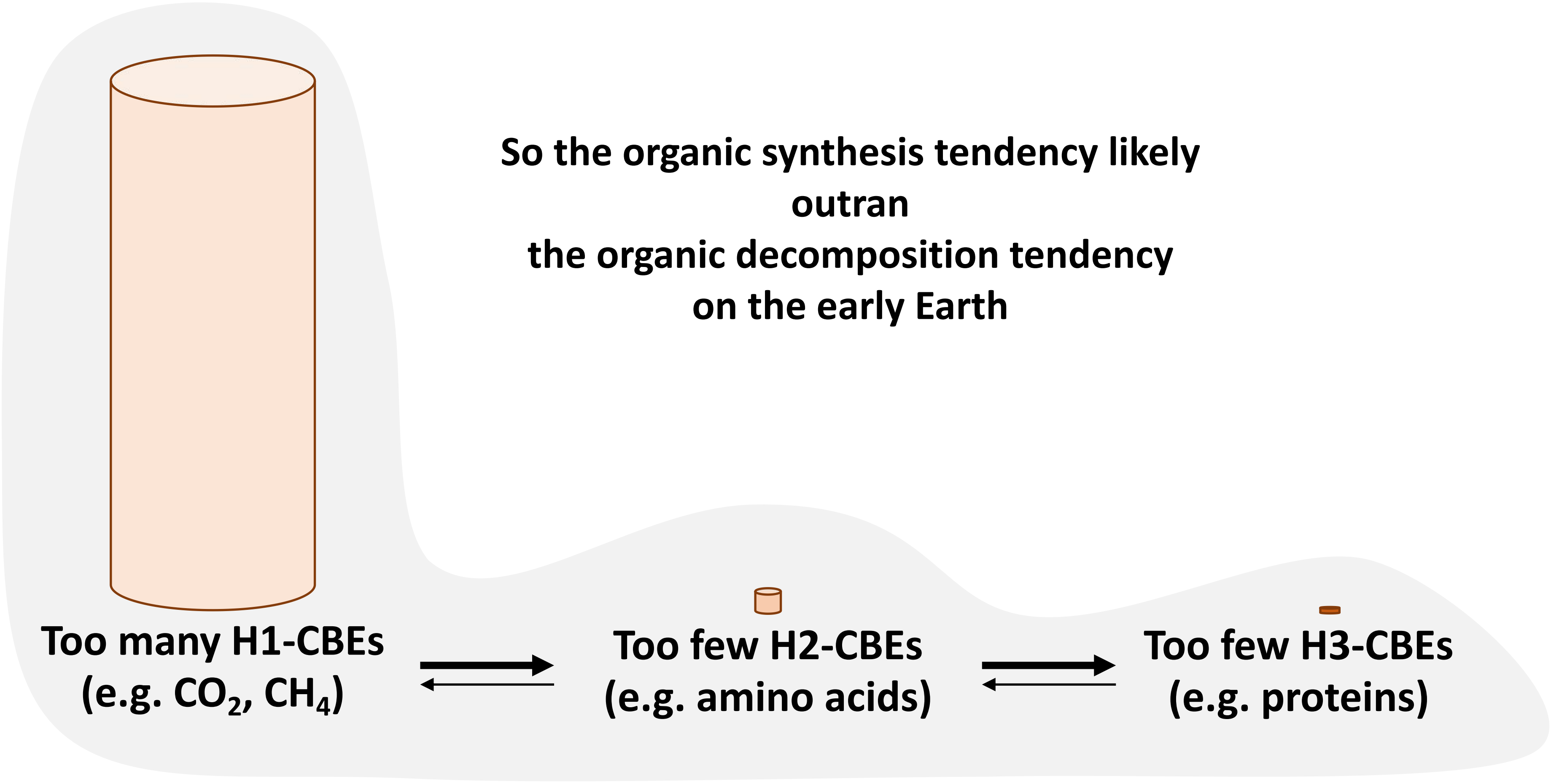


Each enzyme can only facilitate CERTAIN reactions

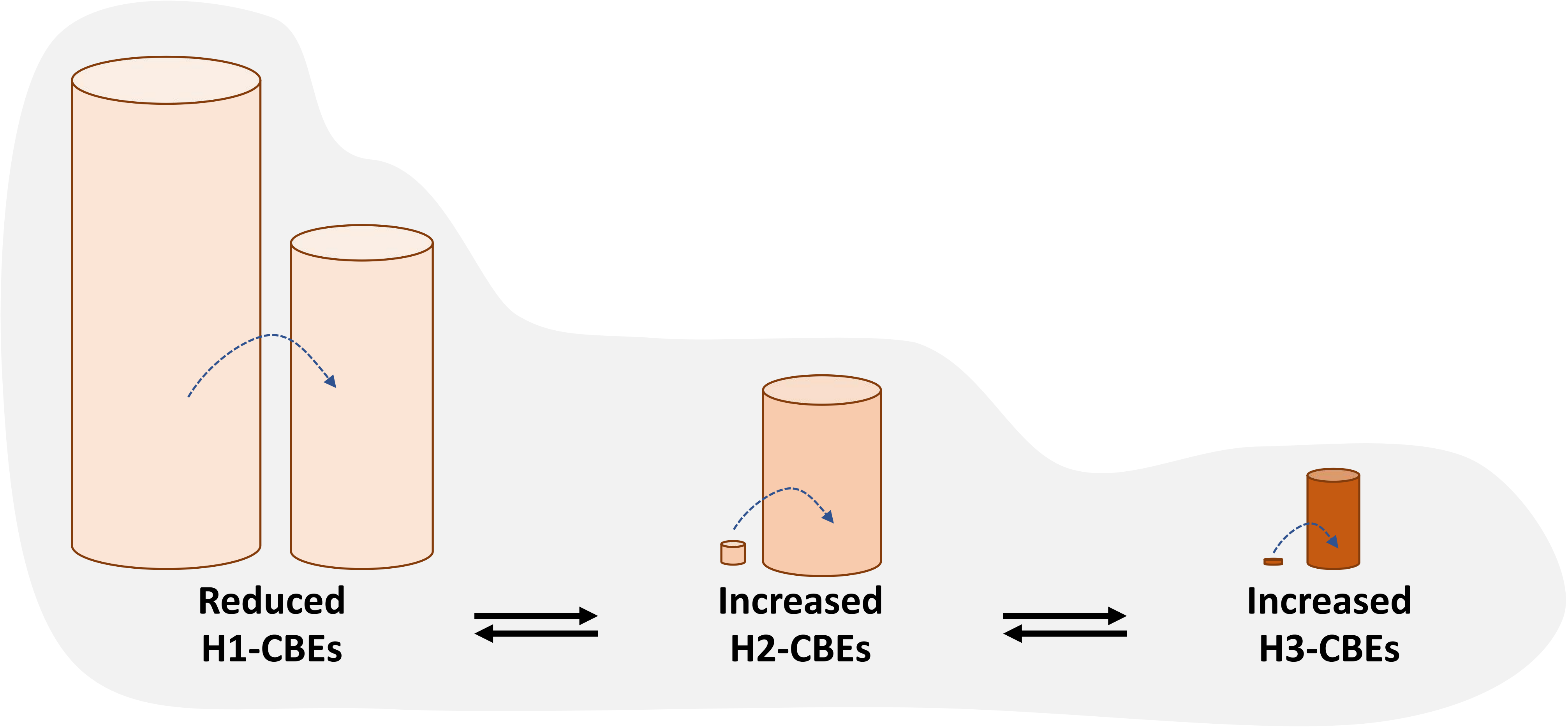
(The specificity of enzymes)

The early Earth was far from the balance regarding the two contrary tendencies

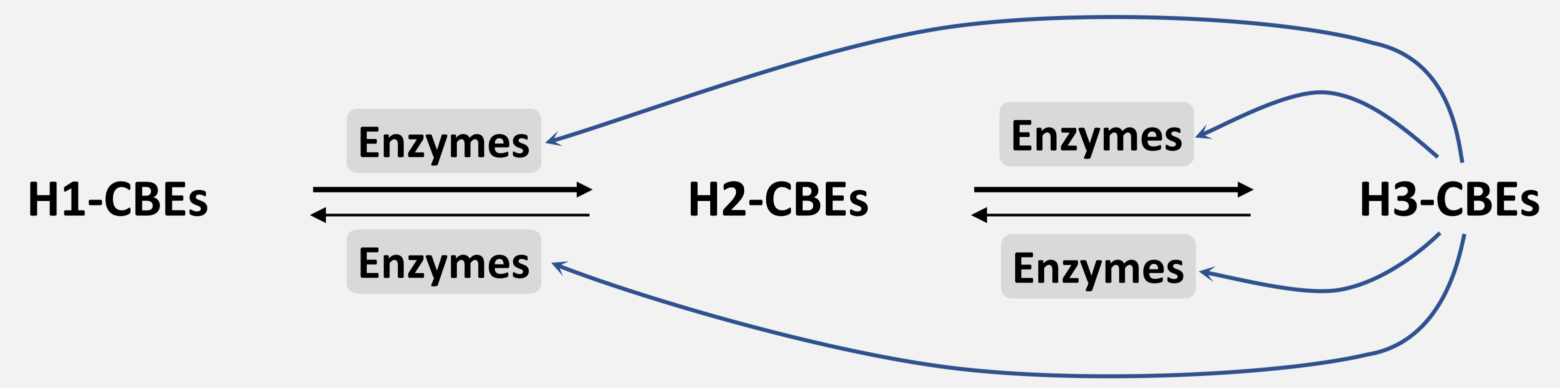
So the organic synthesis tendency likely
outran
the organic decomposition tendency
on the early Earth



Later, the two contrary tendencies on the Earth could maintain relative balance

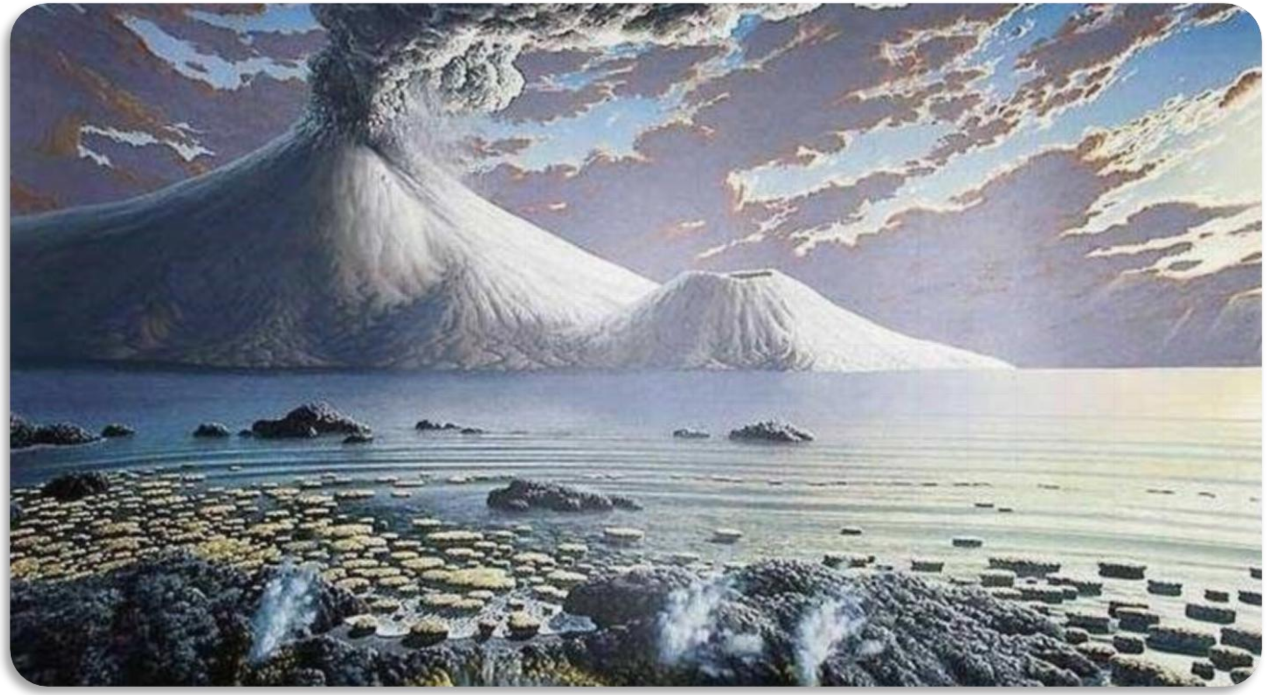


Some naturally synthesized H3-CBEs are enzymes which can accelerate some organic synthesis or decomposition reactions triggered by the above tendencies

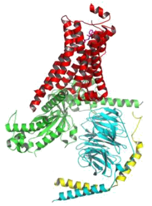


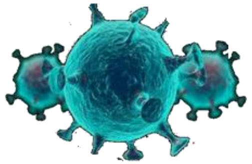
The Murchison meteorite that fell to the Earth in 1969 contains various organic molecules at relatively high concentrations

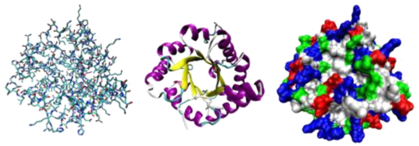
The meteorite suggests that billions of tons of organic molecules could have been synthesized before life origin with the aids of various enzymes

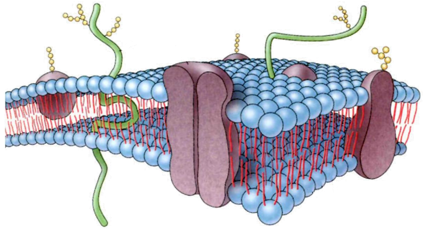


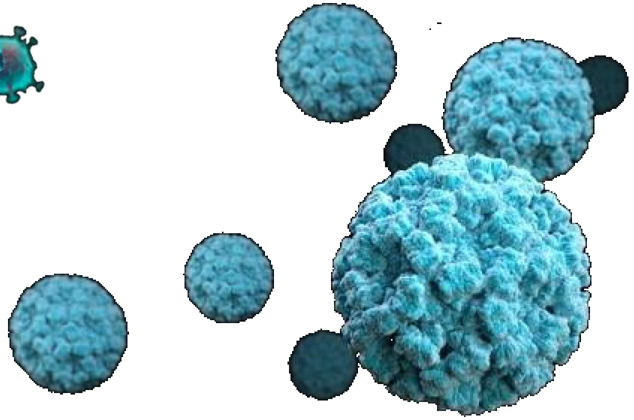
Various H2-CBEs and H3-CBEs spontaneously formed vast structures on the Earth

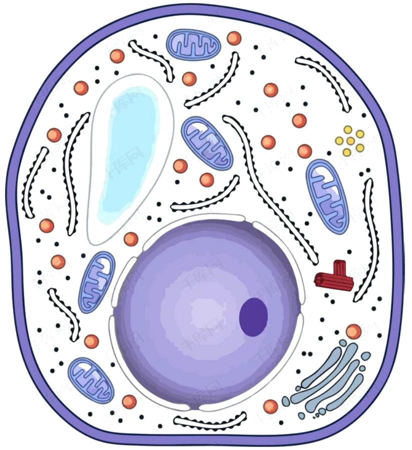


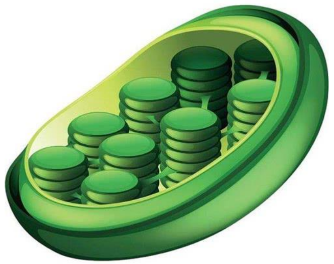


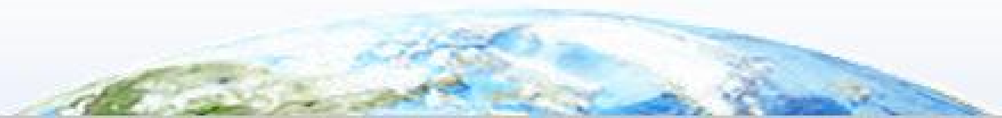






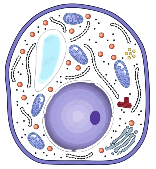




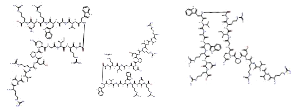


H4-CBEs (unicellular organisms) emerged at a very tiny possibility (life origin)

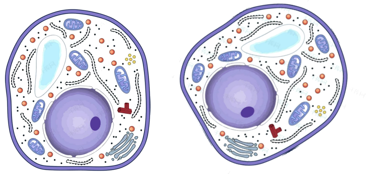
H4-CBEs had very complicated structures
So their emergence possibility is very tiny (e.g. once in a million years)



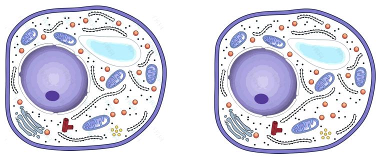
The very complicated structures of H4-CBEs enabled them to conduct various natural organic syntheses



The products or results of these various natural organic syntheses conducted by H4-CBEs were multiple copies of H4-CBEs



Reproduction of H4-CBEs led to increase in the amounts of H4-CBEs



"Selfish" synthesis of organic molecules in H4-CBEs

H4-CBEs had very complicated structures
So their emergence possibility is very tiny (e.g. once in a million years)

The very complicated structures of H4-CBEs enabled them to conduct various natural organic syntheses

Various enzymes aid these organic syntheses

"Selfish" synthesis

The products or results of these various natural organic syntheses conducted by H4-CBEs were multiple copies of H4-CBEs

Reproduction of H4-CBEs led to increase in the amounts of H4-CBEs

H4-CBEs conduct more and more organic syntheses with the aids of many enzymes via their reproduction

The organic synthesis tendency drives origin and reproduction of H4-CBEs

In thermodynamics and chemistry, many low-hierarchy CBEs in these environments tend to absorb heat, move relatively rapidly, and form larger organic molecules

Various organic molecules are naturally produced which can spontaneously form H4-CBEs at a very tiny possibility

The organic synthesis tendency drives the chemical evolution and origin of H4-CBEs

H4-CBEs can reproduce themselves due to their complicated structures if they obtain heat and composing matter from the environment

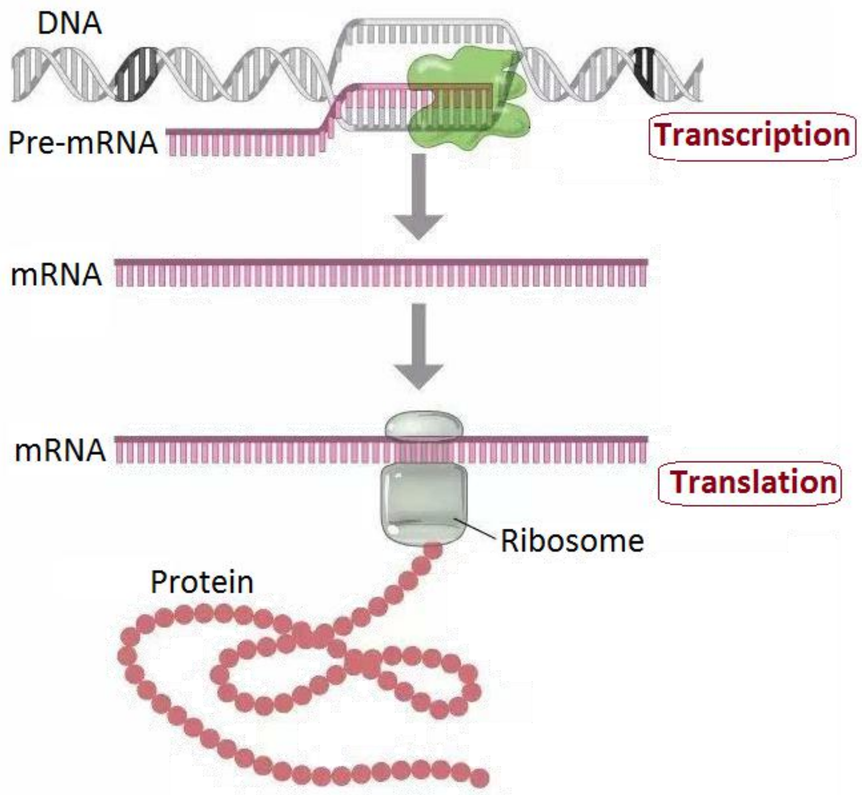
The organic synthesis tendency on the Earth provides H4-CBEs heat and composing matter for their reproduction

Reproduction of H4-CBEs meets the organic synthesis tendency because they efficiently synthesize various organic molecules

The organic synthesis tendency is the primary driving force for reproduction of H4-CBEs

If the Earth were too cold, it could not have the organic synthesis tendency, and CBEs could not increase their hierarchies, which means life could not originate and develop

In chemistry: H4-CBEs should have genomes which are made of certain H3-CBEs



Reproduction of H4-CBEs means many H3-CBEs are synthesized relatively precisely according to certain sequences

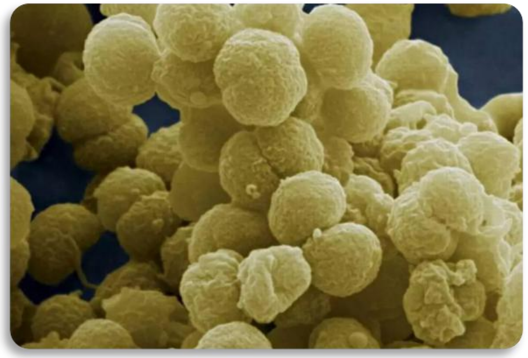
H4-CBEs should have genomes which are some H3-CBEs (i.e. organic macromolecules) encoding much information to direct syntheses of H3-CBEs as per certain sequences

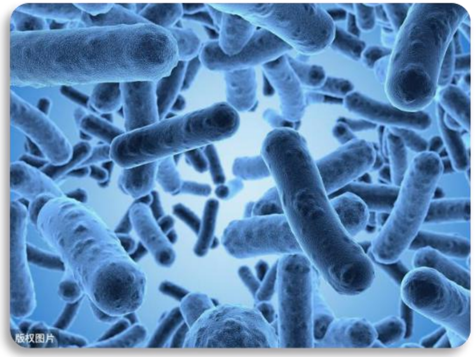
Otherwise, in chemistry, no H3-CBEs could be produced relatively precisely according to certain sequences

Reproduction of H4-CBEs with various changes

Although reproduction of H4-CBEs is relatively precise according to certain sequences, their offspring carry some changes, mainly because reproduction of genomes is with changes which are chemically unavoidable

Increase in the diversity of H4-CBEs





Emergence and development of H5-CBEs (multicellular organisms)

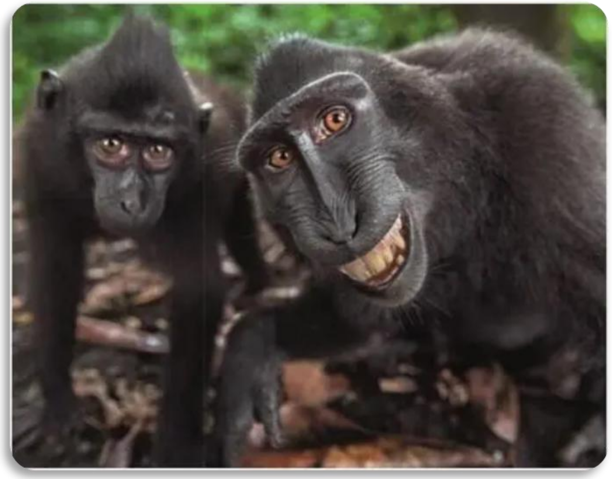
Some changes of H4-CBEs made some H4-CBEs become H5-CBEs at a very tiny possibility because H5-CBEs are much more complicated in structure than H4-CBEs

Although reproduction of H5-CBEs requires more heat and more composing matter, and H5-CBEs are more vulnerable than some H4-CBEs in some environments, some H5-CBEs (e.g. grasses and birds) could reproduce themselves and increase their amounts through collaboration of their cells in many environments and the support of the organic synthesis tendency on the Earth

Reproduction of H5-CBEs with various changes

Although reproduction of H5-CBEs is relatively precise according to certain sequences, their offspring all carry some inheritable changes in their genomes and some uninheritable changes

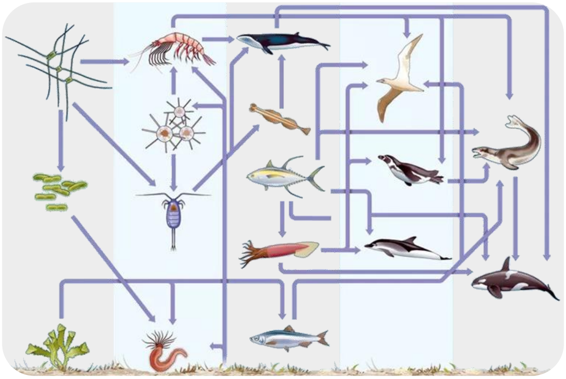
Increase in the diversity of H5-CBEs



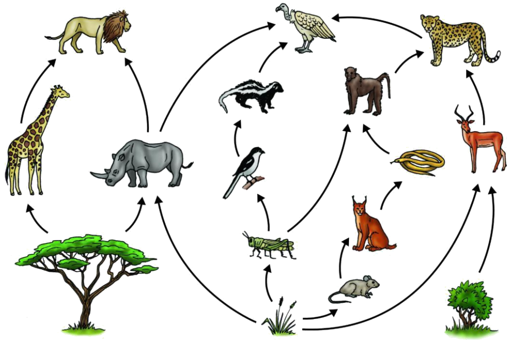
Emergence and development of <u>animals</u>

Increase in the amounts and diversity of H4-CBEs and H5-CBEs, which shall die or decompose, provides temperate heat and composing matter for development of other organisms

Emergence and development of decomposers (e.g. fungi), consumers (e.g. <u>animals</u>), and parasites (e.g. ascarid) in ecosystems



These roles aid to maintain the relative balance between the overall organic synthesis tendency and the overall organic decomposition tendency on the Earth



H1-CBEs ⇄ H2-CBEs ⇄ H3-CBEs

Emergence and development of H6-CBEs (animal societies)

Animals should protect themselves and obtain enough food which contains heat and composing matter

Animals fulfill these functions through various strategies based on their complicated structures

One strategy is that many animal individuals of the same species collaborate closely with each other and form animal societies

Some H6-CBEs (e.g. ant societies, bee societies) could maintain their existence through collaboration of their components and the support of the organic synthesis tendency on the Earth

It requires a long geological period to form an H6-CBE which is more complicated in structures than its ancestor

Five phases of evolution of CBEs embodied in current organisms

Phase	Definition	Examples	Note
1	Some H1-CBEs evolve to H2-CBEs	Carbon dioxide and water form glucose	Organic synthesis
2	Some H2-CBEs evolve to H3-CBEs	Amino acids form proteins; nucleotides form nucleic acids	Organic synthesis
3	Some H3-CBEs evolve to H4-CBEs	Proteins, nucleic acids, and various other molecules form fertilized eggs	These structures can reproduce themselves through organic synthesis
4	Some H4-CBEs evolve to H5-CBEs	Fertilized eggs form ants	
5	Some H5-CBEs evolve to H6-CBEs	Ants form ant societies	

These five phases all require organic synthesis driven by thermodynamics, and they all meet the organic synthesis tendency. Hence the organic synthesis tendency on the Earth is the primary driving force of these phases

In thermodynamics and chemistry, organisms live for organic synthesis

The organic decomposition tendency is also important

Organic molecules can be decomposed only after they have been formed and many organic molecules can be preserved for a relatively long time

The overall organic synthesis tendency likely outran the organic decomposition tendency on the early Earth

Repeated organic decomposition provides temperate heat and composing matter for repeated organic syntheses

Many organic decomposition reactions are accompanied with organic syntheses in many organisms for providing heat and/or composing matter

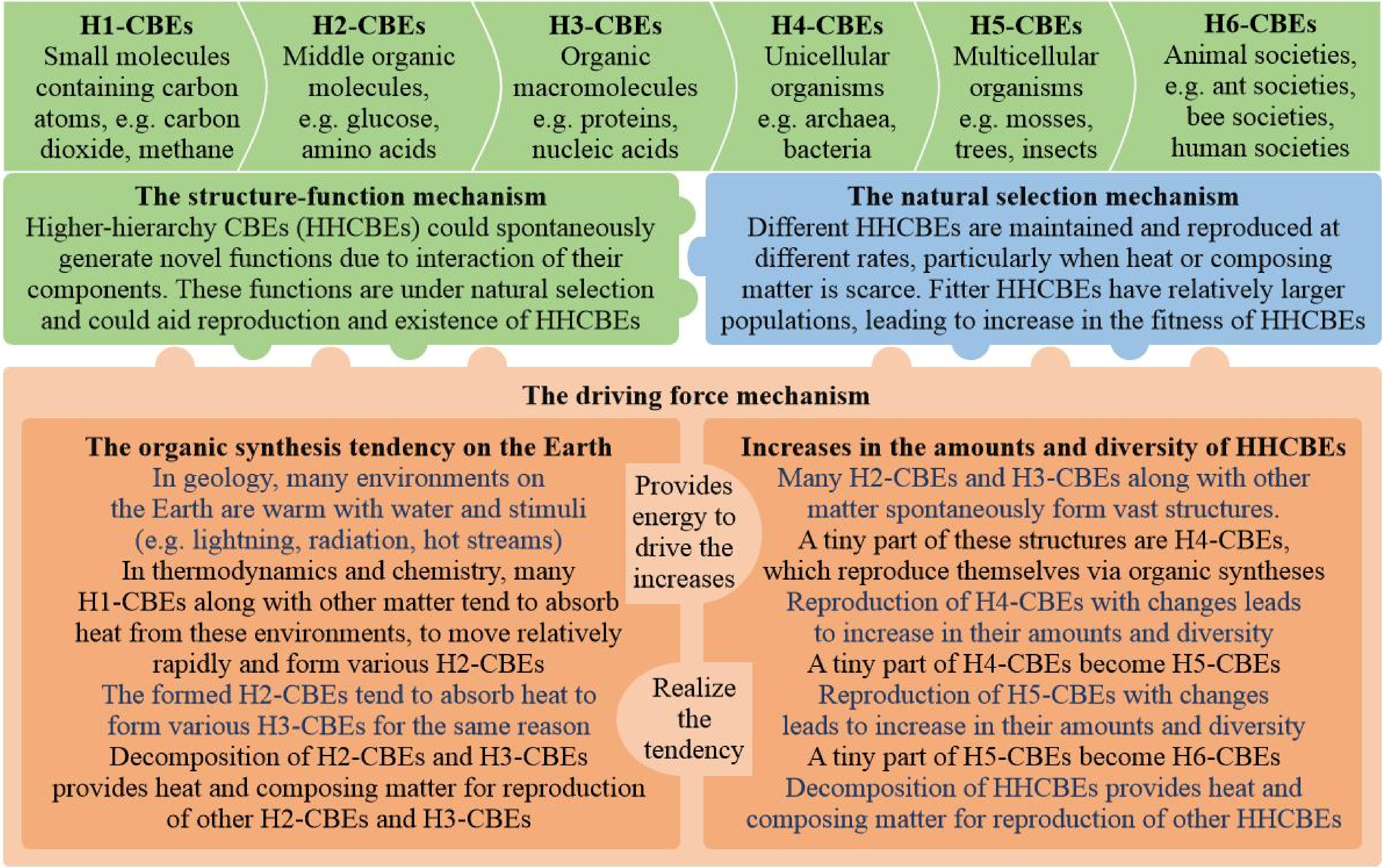
H1-CBEs $\rightleftarrows$ **H2-CBEs** $\rightleftarrows$ **H3-CBEs**

Three progressive mechanisms of evolution

The driving force mechanism leading to increase in hierarchy, structural complexity, and diversity of CBEs as per thermodynamics (see the above slides)

The structure-function mechanism which means that the CBEs with increased hierarchy and structural complexity spontaneously have novel complicated functions (e.g. amino acids can form green fluorescence protein which spontaneously emits fluorescence, although no amino acids can emit fluorescence)

The natural selection mechanism leading to increase in fitness of HHCBEs (see the following slides)


H1-CBEs
Small molecules containing carbon atoms, e.g. carbon dioxide, methane
H2-CBEs
Middle organic molecules, e.g. glucose, amino acids
H3-CBEs
Organic macromolecules e.g. proteins, nucleic acids
H4-CBEs
Unicellular organisms e.g. archaea, bacteria
H5-CBEs
Multicellular organisms e.g. mosses, trees, insects
H6-CBEs
Animal societies, e.g. ant societies, bee societies, human societies
The structure-function mechanism
Higher-hierarchy CBEs (HHCBEs) could spontaneously generate novel functions due to interaction of their components. These functions are under natural selection and could aid reproduction and existence of HHCBEs
The natural selection mechanism
Different HHCBEs are maintained and reproduced at different rates, particularly when heat or composing matter is scarce. Fitter HHCBEs have relatively larger populations, leading to increase in the fitness of HHCBEs
The driving force mechanism
The organic synthesis tendency on the Earth
In geology, many environments on the Earth are warm with water and stimuli (e.g. lightning, radiation, hot streams)
In thermodynamics and chemistry, many H1-CBEs along with other matter tend to absorb heat from these environments, to move relatively rapidly and form various H2-CBEs
The formed H2-CBEs tend to absorb heat to form various H3-CBEs for the same reason
Decomposition of H2-CBEs and H3-CBEs provides heat and composing matter for reproduction of other H2-CBEs and H3-CBEs
Provides energy to drive the increases
Realize the tendency
Increases in the amounts and diversity of HHCBEs
Many H2-CBEs and H3-CBEs along with other matter spontaneously form vast structures.
A tiny part of these structures are H4-CBEs, which reproduce themselves via organic syntheses
Reproduction of H4-CBEs with changes leads to increase in their amounts and diversity
A tiny part of H4-CBEs become H5-CBEs
Reproduction of H5-CBEs with changes leads to increase in their amounts and diversity
A tiny part of H5-CBEs become H6-CBEs
Decomposition of HHCBEs provides heat and composing matter for reproduction of other HHCBEs

Self-reproduction, non-random mutation, sexual reproduction, can all be realized through complicated structures

All these functions have to be under natural selection

Significance of self-reproduction in natural selection

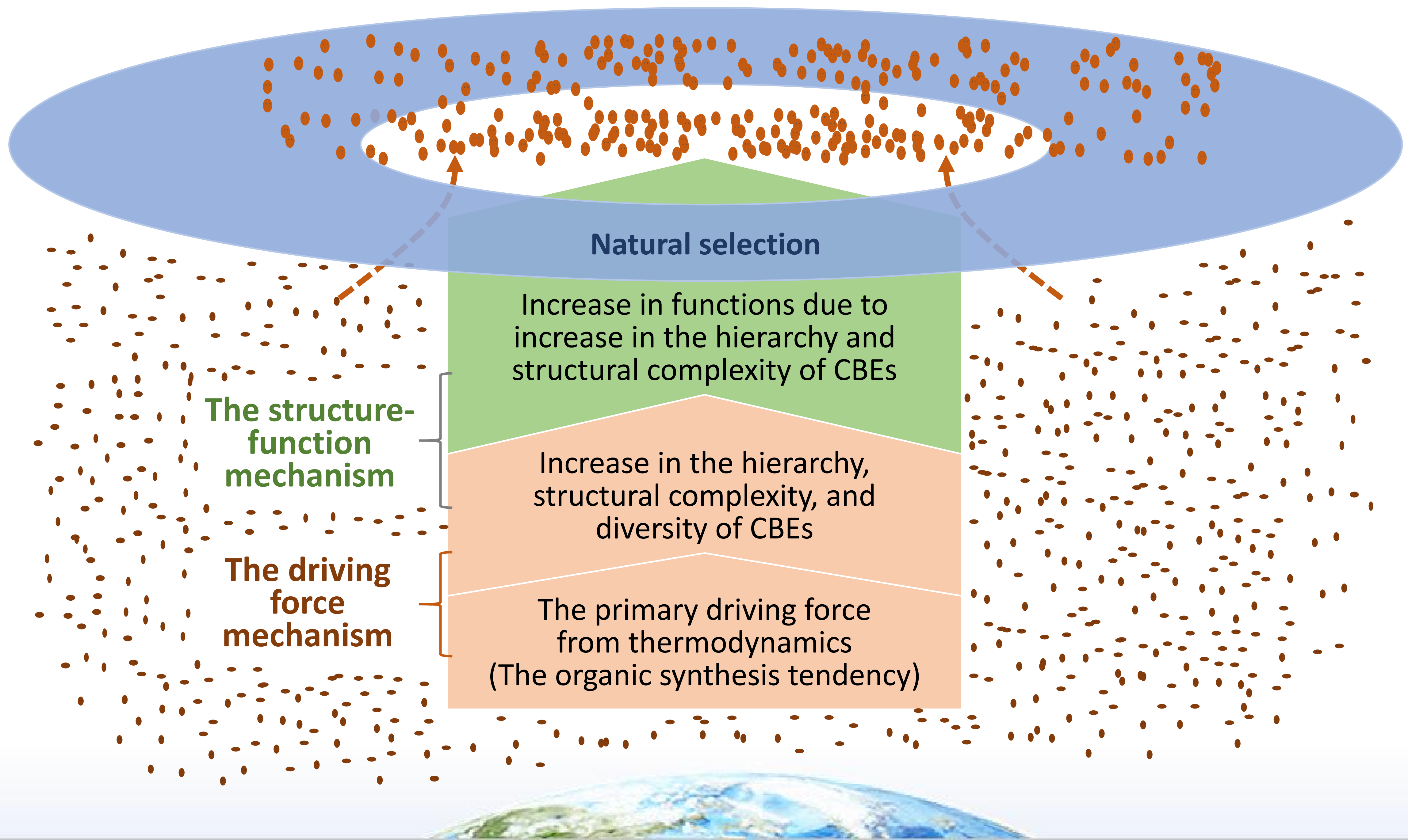
This function can directly increase the amounts of HHCBEs and maintain the advantages of HHCBEs in natural selection

Significance of non-random mutation in natural selection

This function facilitates to generate advantageous mutations and avoid disadvantageous mutations

Significance of sexual reproduction in natural selection

This function facilitates to generate numerous mutants which are useful to fit different environments, through recombination of genomic sequences, and this mutation strategy is less risky than nucleotide substitution because the recombined genomic sequences have passed long-term natural selection

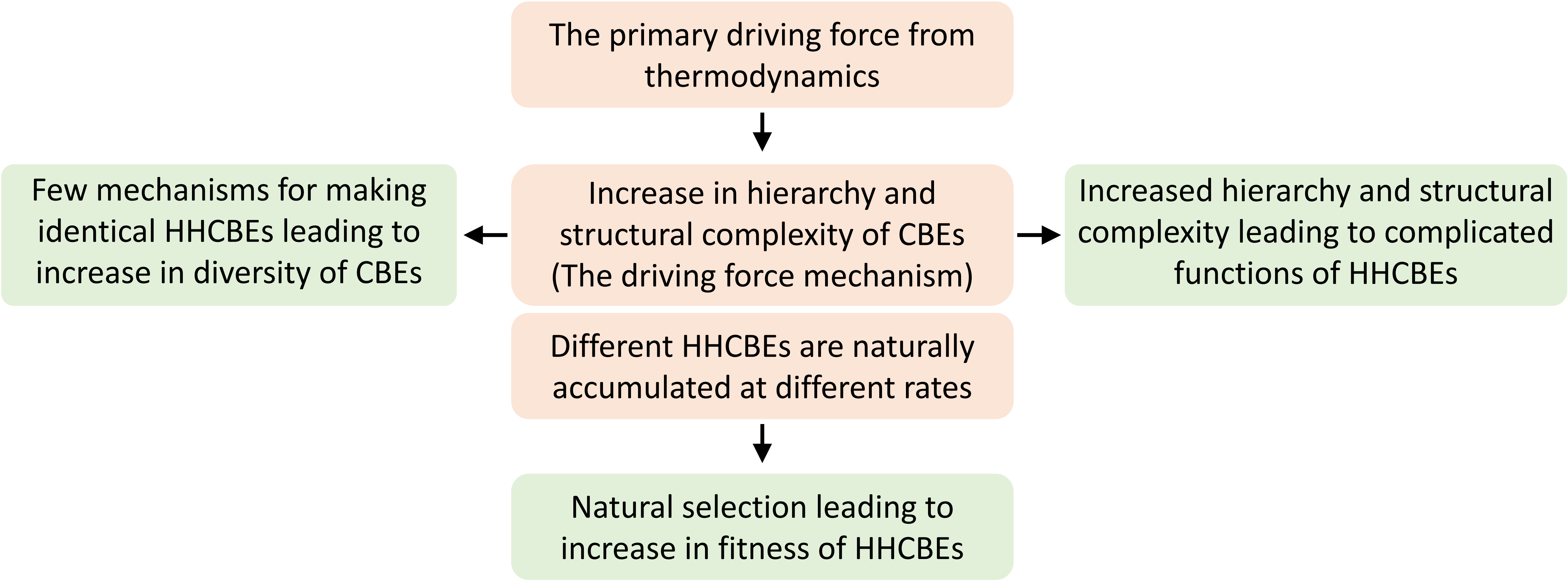


Natural selection
Increase in functions due to increase in the hierarchy and structural complexity of CBEs
The structure-function mechanism
Increase in the hierarchy, structural complexity, and diversity of CBEs
The driving force mechanism
The primary driving force from thermodynamics (The organic synthesis tendency)

Natural selection is a tautology with prerequisites

Fit HHCBEs survive, and those HHCBEs that have survived are fit HHCBEs Those HHCBEs having larger amounts are fitter HHCBEs, and fitter HHCBEs have larger amounts	The running champion is the one who runs the fastest, and the one who runs the fastest is the running champion
Natural selection does not exist without repeated regeneration of HHCBEs on the Earth	A running champion does not exist without a running race
Natural selection must exist with repeated regeneration of HHCBEs on the Earth	There mush be a champion if there is a running race
No mechanisms to make HHCBEs reproduced and maintained at the same rates	No mechanism to make every one run at the same speed
Repeated regeneration of HHCBEs and its driving force from thermodynamics are prerequisites of natural selection	A running race and its organization are prerequisites for existence of a champion

The primary driving force of evolution is the first leading role in evolution



Different from previous theories

In Darwin’s theory & the Modern Synthesis

Natural selection is claimed to be the driving force of evolution

Natural selection is claimed to be the first leading role in evolution

Natural selection is a tautology of weak roots because the theories do not explain why organisms repeatedly reproduce themselves

In the CBET

Natural selection stems from the primary driving force of evolution deduced from thermodynamics, and has hence solid roots

The primary driving force is the first leading role in evolution

Natural selection could be the secondary driving force directly affecting many traits of HHCBEs

Different from previous theories

Darwin's theory (Survival of the fittest)

Due to excessive reproduction and fierce competition

The mainstream evolutionary theory established in the 19th century

The Modern Synthesis (Survival of the fitter)

Gradual changes in gene frequencies as the individuals carrying adaptive mutations are more reproductively successful

The mainstream evolutionary theory established in the 20th century

The CBET (Survival of the fit)

Those HHCBEs fitter in general are more relatively successful in the combined effect of reproduction rates and longevity, which leads to increase in fitness (This is similar to the Modern Synthesis)

Those HHCBEs carrying changes advantageous, neutral, or disadvantageous in selection all survive if their overall fitness is adequate in suitable environments, which leads to increase in diversity of HHCBEs

Those HHCBEs carrying advantageous changes could be eliminated if their overall fitness becomes inadequate in harsh environments, e.g. mass extinction due to asteroid impacts

Besides reproduction rates, the CBET highlights the longevity of HHCBEs

Different from previous theories

Darwin's theory (Survival of the fittest)

Due to excessive reproduction and fierce competition

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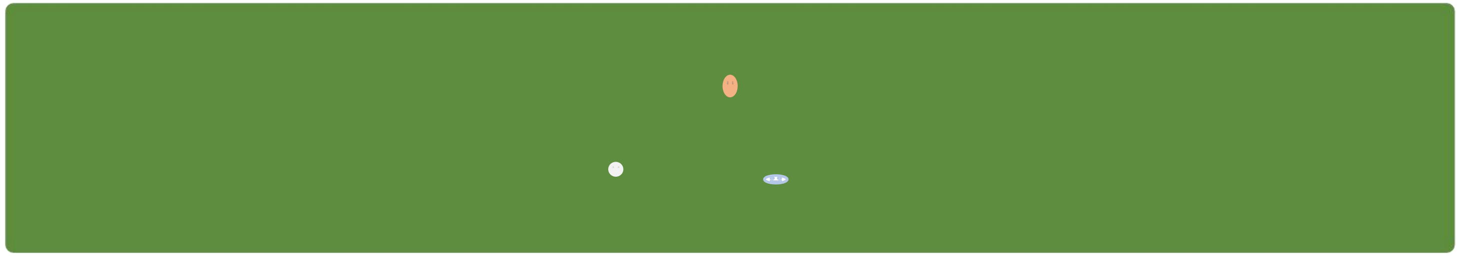
Positive selection: promoting accumulation of advantageous changes

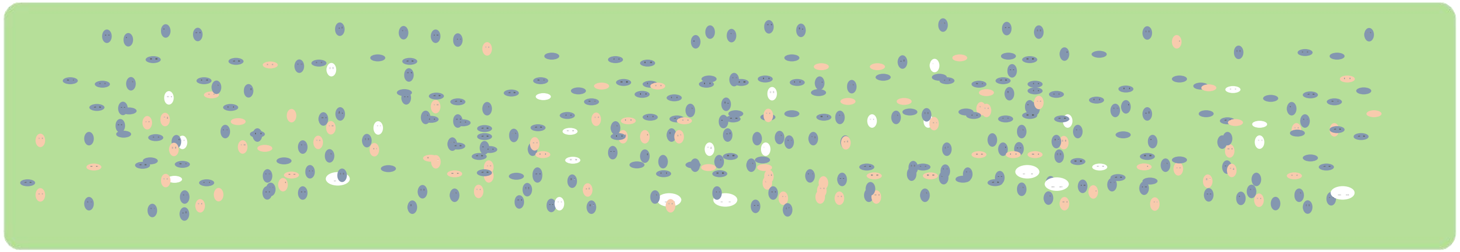
- Competition
- Mild competition
- Fierce competition

Negative selection: inhibiting existence of disadvantageous changes

- Competition
- Mild competition
- Fierce competition



When the environment is far from saturated with certain HHCBEs
the competition for heat or composing matter is mild
Those HHCBEs with less fitness could be fit, survive, and increase their amounts



When the environment is saturated with certain HHCBEs
the competition becomes fierce, and the less fit HHCBEs are gradually replaced by the fitter HHCBEs, leading to increase in fitness of the HHCBEs

When the environment becomes very harsh
The competition for heat or composing matter is very fierce
leading to mass elimination of the HHCBEs sometimes including the fittest HHCBEs

Different from previous theories

In Darwin’s theory & the Modern Synthesis

Natural selection usually targets only inheritable changes

Genetic mutations occur at random

In the CBET

Genetic mutations, epigenetic changes, and uninheritable changes (e.g. vaccination) all influence the overall fitness of HHCBEs, and are thus all under natural selection

Some genetic changes (e.g. those regarding antibody diversity) are not random due to complicated functions of organisms

Different from previous theories

In Darwin's theory & the Modern Synthesis

Natural selection is usually based on the fitness of a single aspect

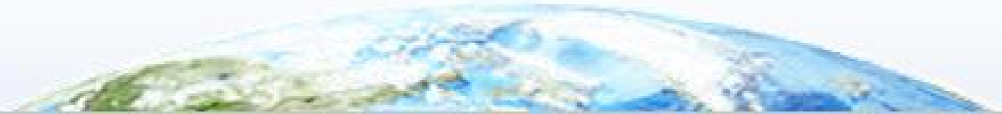
A biological trait (e.g. long necks of giraffes, altruism) is usually assumed to be advantageous in natural selection

In the CBET

Natural selection is based on the overall fitness

A biological trait (e.g. long necks of giraffes) may be neutral, advantageous, or disadvantageous in natural selection in general

A biological trait may be advantageous in some aspects, and disadvantageous in other aspects (e.g. long necks of giraffes are useful for finding predators, but add burdens to bones and hearts), so the trait may be under positive selection in some aspects and under negative selection in some other aspects



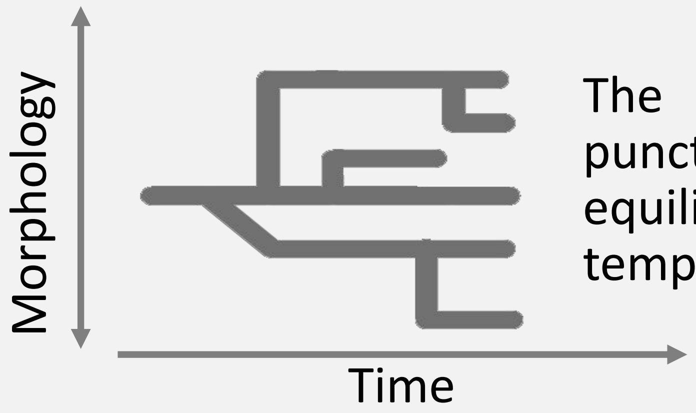
The CBET reveals a novel mechanism for sympatric speciation

Previously, no mechanism for sympatric speciation targeting the same ecological niches of the same area was proposed

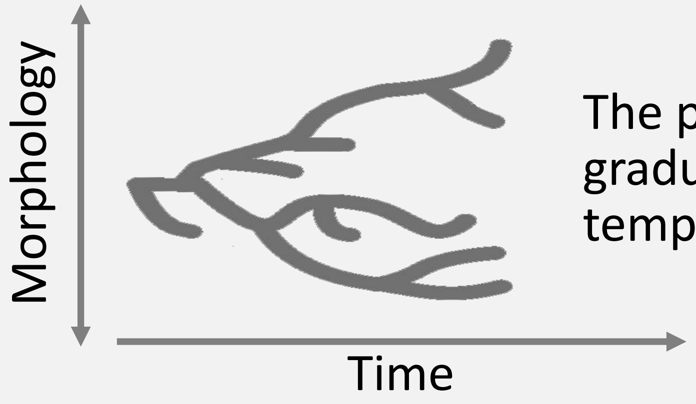
In the CBET, organisms with different combinations of traits can speciate in the same ecological niche in the same area because they all have adequate overall fitness particularly when the mutants have small populations

Antelopes and buffaloes have different advantages and disadvantages, and they both have adequate fitness throughout the history, and thus they could speciate in the same niches of the same area

The CBET suggests a novel mechanism for punctuated equilibrium



The punctuated equilibrium tempo



The phyletic gradulism tempo

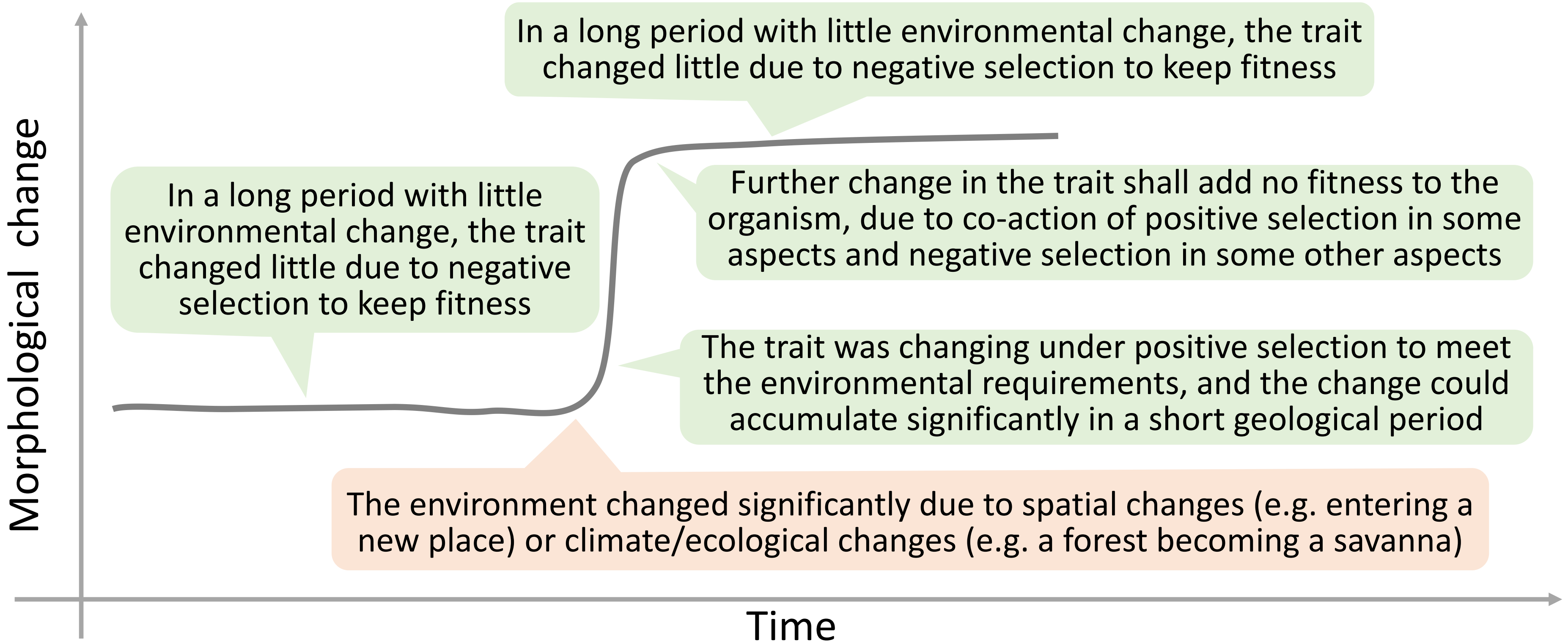
Punctuated equilibrium

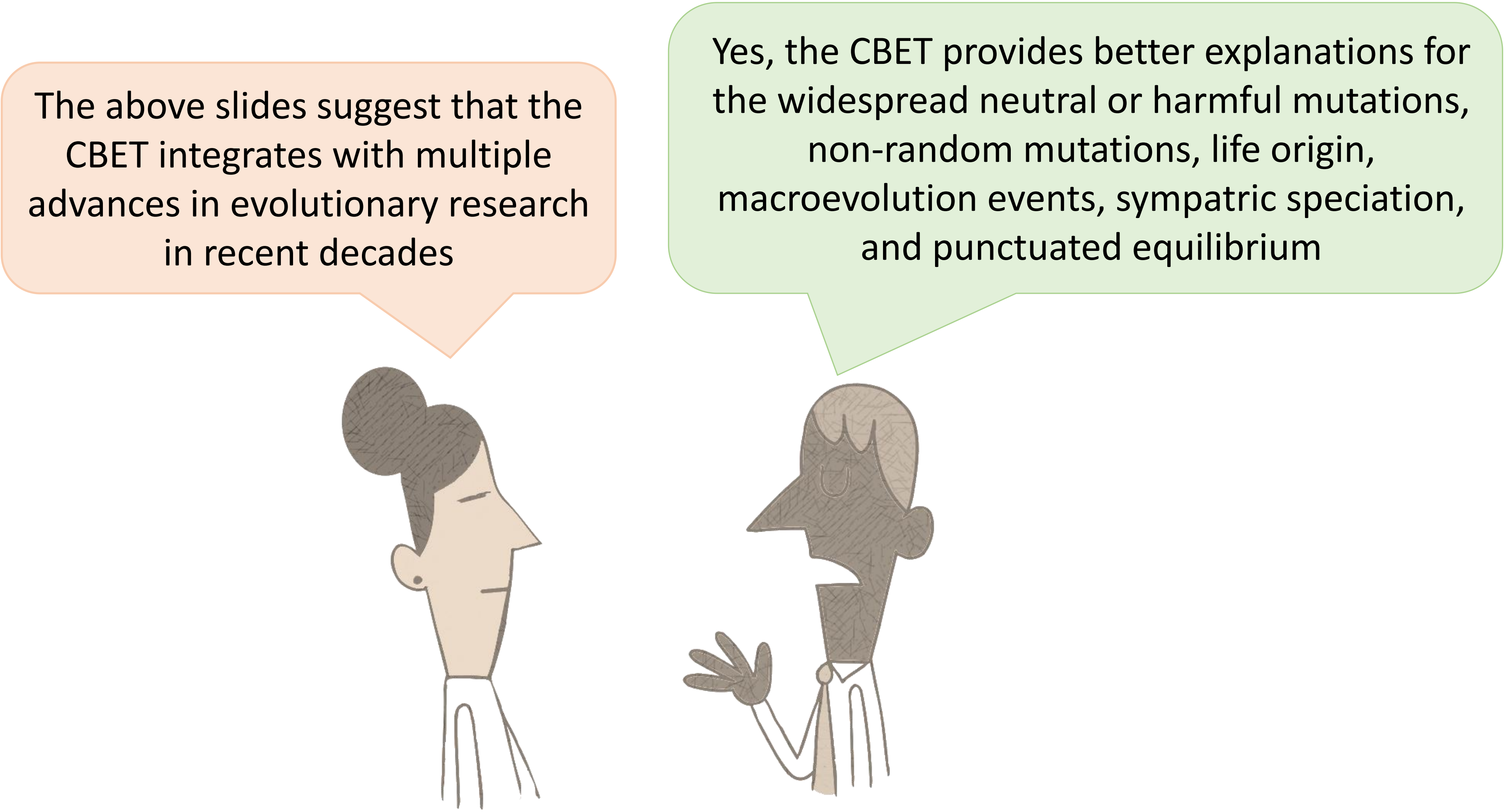
Little change in long geological periods and significant changes in short geological periods, as demonstrated by fossils of many species

Previously, only geographical isolation was employed to explain punctuated equilibrium in an elusive way

The CBET suggests a novel mechanism for punctuated equilibrium

Co-action of positive selection and negative selection
on the same trait as per spatial or climate/ecological changes




The above slides suggest that the CBET integrates with multiple advances in evolutionary research in recent decades
Yes, the CBET provides better explanations for the widespread neutral or harmful mutations, non-random mutations, life origin, macroevolution events, sympatric speciation, and punctuated equilibrium

The primary driving force and natural selection in the CBET provides better explanations for macroevolution events

Events	Explanations of the CBET	Previous explanations
Life origin	The organic synthesis tendency (OST) on the Earth generated various organic molecules which spontaneously formed life structures at a very tiny possibility; life structures are more difficult than deaths, but they can reproduce and maintain themselves with their inner collaboration and the outside support of the OST	Life origin has been explained with elusive concepts (e.g. negative entropy or dissipation systems)
Some unicellular organisms evolved to multicellular organisms	Many niches could be better employed for organic syntheses by multicellular organisms for their reproduction; multicellular organisms could have adequate fitness even if they could be less fit than unicellular organisms	The reasons are unknown, because unicellular organisms could be fitter than multicellular organisms in many environments
Some ectotherm animals evolved to warm-blooded animals	Many biomaterials could be better employed for organic syntheses by warm-blooded animals for their reproduction; warm-blooded animals could have adequate fitness even if they could be less fit than ectotherm animals	The reasons are unknown, because ectotherm animals could be fitter than warm-blooded animals in many environments

The CBET highlights collaboration, altruism, obeying rules, and restriction of freedom

- Many small molecules spontaneously collaborate with each other, “sacrifice” their freedom, and obey some rules to form large organic molecules (e.g. amino acids form proteins)
- Many molecules inside cells spontaneously collaborate with each other, “sacrifice” their freedom, and obey some rules to support the replication and functions of nucleic acids
- Many immune cells in multicellular organisms spontaneously collaborate with each other, “sacrifice” their freedom, and obey some rules to support the production and functions of other cells
- Many individuals in animal societies spontaneously collaborate with each other, “sacrifice” their freedom, and obey some rules to support the birth and functions of other individuals

→

Collaboration, altruism(a special collaboration supporting the production and functions of other entities), obeying rules, and restriction of freedom constitute fitness of HHCBEs and are important throughout evolution

The CBET highlights proper extension of freedom

- Many atoms can hardly move in large molecules (little freedom)
- Many molecules can move around inside cells (freedom increased a little)
- Many cells can move in multicellular organisms (freedom further increased)
- Many animal individuals can move in certain areas (freedom increased obviously)

Influence of evolution on evolution

Phase	Definition	Examples	Examples of influence of evolution on evolution
1	Some H1-CBEs evolve to H2-CBEs	Carbon dioxide and water form glucose	Producing molecules for forming HHCBEs Producing molecules (e.g. ATP) for transferring heat
2	Some H2-CBEs evolve to H3-CBEs	Amino acids form proteins; nucleotides form nucleic acids	Accumulating various enzymes which accelerate natural organic syntheses Producing important molecules for forming organisms
3	Some H3-CBEs evolve to H4-CBEs	Various molecules form fertilized eggs	a. Organisms provide energy and organic matter for driving the evolution of other organisms b. Organisms change the environment and provide novel selection pressures for organisms c. Sexual selection directly influence some traits of many animals d. Human evolution has great and extensive influences on evolution of many species
4	Some H4-CBEs evolve to H5-CBEs	Fertilized eggs form ants	
5	Some H5-CBEs evolve to H6-CBEs	Ants form ant societies	

1 History & background of the CBET

2 The primary driving force of evolution

3 The mechanisms of evolution

4 Reliability & significance of the CBET

5 Questions & answers

6 Generalization of the CBET

Reliability of the CBET

It is deduced mainly from the classical laws of thermodynamics using some factors well known to be crucial for evolution

I support the CBET because its conclusion is not strange, but rational and comprehensible

The CBET is not built on novel laws, novel observations, or novel experiments

No one has found that any biological reaction does not comply with the classical laws of thermodynamics

Reliability of the CBET

Many evolutionary phenomena are explained better by the CBET than by previous theories. This strongly supports the CBET

Yes. The CBET provides better explanations for life origin, macroevolution, prevalent neutral mutations, widespread disadvantageous mutations (e.g. thalassemia mutations), non-random mutations, effects of uninheritable traits on fitness, sympatric speciation, punctuated equilibrium, altruism, etc.

The CBET is supported by numerous facts

Mm…, I have not found any biological fact which is against the CBET

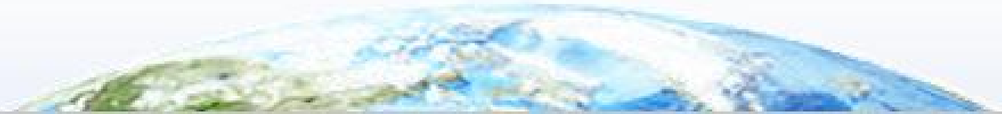
Significance of the CBET in thermodynamics/physics

Previous theories in thermodynamics regarding evolution

Did not highlight the specific thermodynamic features of the Earth which are well known to be important for evolution

Did not combine chemistry of CBEs and laws of thermodynamics to explain evolution in a direct and understandable way

The CBET could be the first evolutionary theory revealing the driving force and mechanisms of evolution from the chemical effect of classical laws of thermodynamics on CBEs using easily understandable words



Significance of the CBET for thermodynamics/physics

Previous theories in thermodynamics regarding evolution

Difficult to understand, controversial, or even wrong
mainly because scientists were misled by
the wrong notion that biological order is equal to thermodynamic order

Biological order increases slowly via long-term natural selection
Thermodynamic order increases rapidly via releasing heat to the surroundings

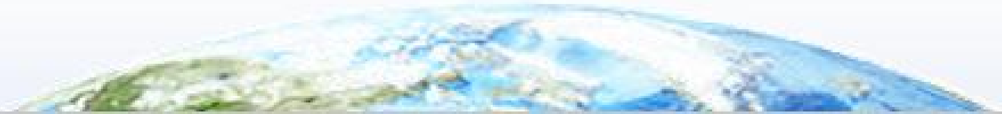
Biological order requires movements of microscopic particles
Thermodynamic order requires microscopic particles to be static
(Cold perfect crystals have low entropy and high thermodynamic order)
(Detailed later in this PPT file)

Significance of the CBET for biology

The CBET reveals for the first time the driving force of evolution, which is the chemical effect of the thermodynamic features of the Earth on CBEs, the first leading role in evolution, and the prerequisite of natural selection

The CBET reinterprets natural selection, provides better explanations for multiple evolutionary issues, and integrates with multiple advances in biology

The CBET is hence more scientific and comprehensive from a broader perspective with multi-disciplinary integration



Significance of the CBET for social development

Previous evolutionary theories

Highlight selfishness, competition, and elimination of those less fit in certain traits, which have been employed to justify authoritarianism, racism, fascism, and Nazism

The CBET

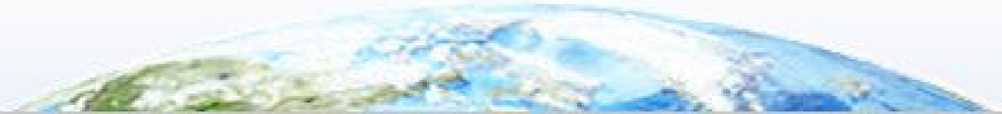
Not only highlights selfishness, fitness, and competition, but also highlights respecting diversity, collaborating with, obeying rules, and extending freedom

Significance of the CBET for social development

Previous evolutionary theories
Highlight heritable genetic effects

The CBET
Highlights heritable genetic effects and the effects of uninheritable endeavor (e.g. education & vaccination) to increase the overall fitness

The CBET could be the first evolutionary theory revealing the basis of various important notions for harmonious social development

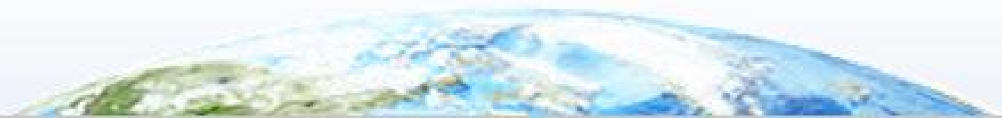


The CBET could be the first bridge directly linking physics and biology and social sciences

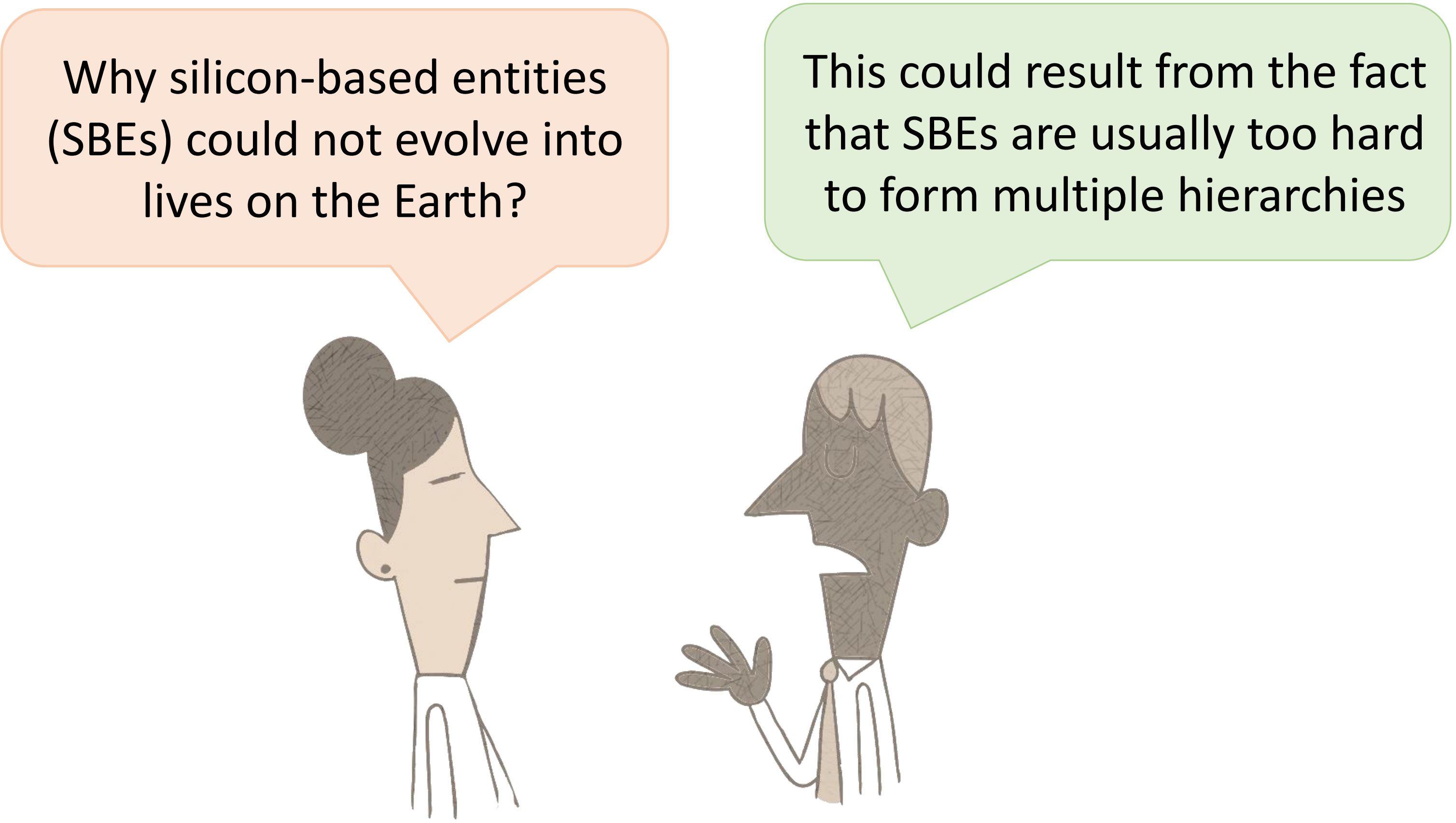
Physics
Laws of thermodynamics

Biology
Origin and evolution of Life

Social sciences
Development of society



Questions & Answers



Questions & Answers

What are the differences between the CBET and the DST?

The CBET directly answers evolutionary questions, while the DST only indirectly talks about evolution

The dissipative structure theory (DST) has been employed to explain some evolutionary issues

The CBET is easy to understand, while the DST is difficult to understand

Questions & Answers

Will life surely emerge on a planet (e.g. Mars or Earth)?

The CBET reveals the driving force, mechanisms, possibility, and tempos about evolution. But it does not explain the certainty of evolution

Life emerges on a planet at a very tiny possibility, and so far life has been found only on the Earth

The Earth is a very rare planet with temperate climate and much water, providing a very rare and very big suitable thermodynamic environment for life origin

Questions & Answers

It has been widely claimed that biological evolution is contrary to entropy increase, or contrary to the second law of thermodynamics

Why does the CBET claim that biological evolution stems from the second law of thermodynamics?

This is a very important question. It is also very difficult because entropy is an elusive concept

Please let me use some slides to tell you some interesting stories on this topic

Classical laws of thermodynamics

- The first law of thermodynamics: increase in internal energy of a closed system is equal to the work the surroundings gives to the system plus the heat the surroundings gives to the system

- The second law of thermodynamics: heat can spontaneously flow from a hotter body to a colder body, and cannot spontaneously flow from a colder body to a hotter body; or to say, the entropy of an isolated system never decreases over time

- The third law of thermodynamics: the entropy of a system approaches a constant value as its temperature approaches absolute zero, and the entropies of perfect crystals at absolute zero temperature are zero

Classical laws of thermodynamics

- The first law of thermodynamics: increa… …stem is equal to the work the surroundings give… surroundings gives to the system

This simple expression regarding heat flowing is employed by the CBET

- The second law of thermodynamics: heat can spontaneously flow from a hotter body to a colder body, and cannot spontaneously flow from a colder body to a hotter body; or to say, the entropy of an isolated system never decreases over time

The CBET, with the aim to provide easily comprehensible explanations, avoids this difficult expression which is not required for deduction of the CBET

- The third law of thermodyna… value as its temperature app… crystals at absolute zero temperature are zero

Two basic formulas about entropy

$dS \geq \delta Q/T$ (Clausius inequality)

(dS, changes of entropy; δQ, absorbed heat; T, absolute temperature)

Suggesting that a closed system increases its entropy via absorbing heat from the surroundings

$S = k \times Ln\Omega$ (Boltzmann formula)

(S, entropy; k, a constant; Ω, microstates)

Suggesting that the entropy of a system is only determined by its microstates which are related to the physical and chemical states of the system, and increase of microstates of a system shall increase the entropy of the system

Scientifically, all concepts derived from entropy should be consistent with these two original formulas

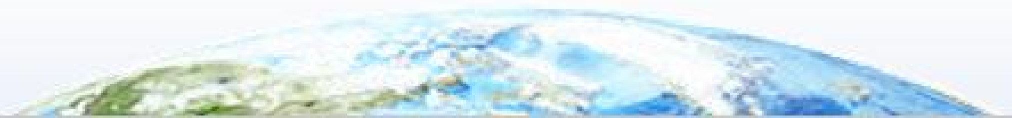
As per these two formulas, when the stone absorbs heat

1. Its temperature becomes higher
2. Its molecular movement becomes faster
3. It has less order at the microscopic level in thermodynamics
4. It has more chaos at the microscopic level in thermodynamics
5. Its microstates increase, which means each microscopic particle in the stone has more possible states
6. Its entropy increases

The above sentences tell the SAME thing from six aspects

So we can understand the last two difficult sentences from the first four simple sentences

More entropy = More microstates = The microscopic particles become less static
= Less thermodynamic order = More thermodynamic chaos



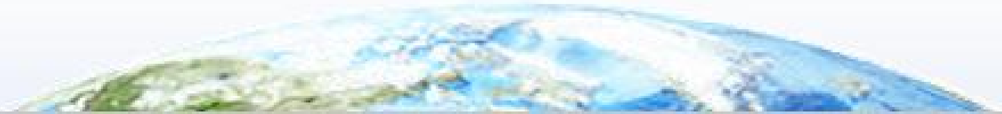
When this seal is dying in the ice

Its entropy is declining because the seal is releasing heat ($dS \geq \delta Q/T$)

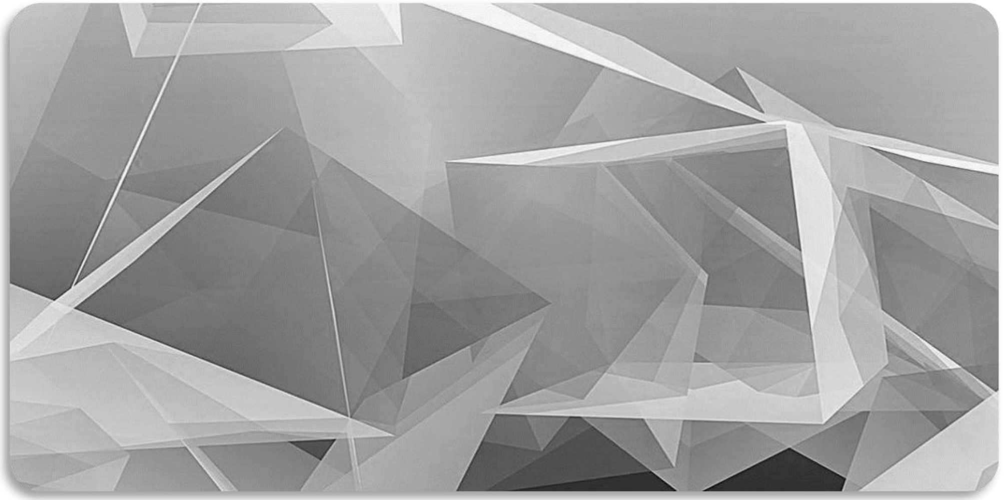
Its thermodynamic order is increasing because its microscopic particles are becoming more static

Its biological order is, however, declining, as it is dying

(Biological order requires movements of microscopic particles)



As per the third law of thermodynamics



The entropy of any system is ≥0

The entropy of a perfect crystal at absolute zero temperature =0

The microstate of a perfect crystal at absolute zero temperature =1

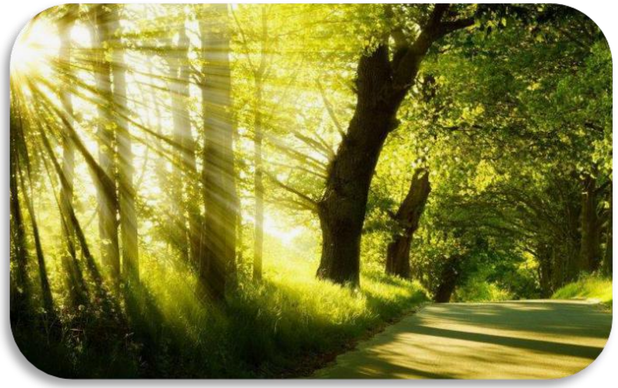
(all the microscopic particles in the crystal only have one fixed state)

A perfect crystal at absolute zero temperature has the highest order in thermodynamics

Thermodynamic order favors microscopic particles to be static

As per Clausius inequality, $dS \geq \delta Q/T$, absorbing heat of CBEs for organic synthesis means increase of entropy

H1-CBEs (e.g. CO_2, CH_4) → Absorb heat from warm environments → H2-CBEs (e.g. glucose) → Absorb heat from warm environments → H3-CBEs (e.g. proteins)



Boltzmann, a father of entropy, claimed that *Life relies on and struggles for entropy*

$S = K \times \ln\Omega$
(Boltzmann formula)

"**The general struggle for existence of animate beings is therefore** not a struggle for raw materials - these, for organisms, are air, water and soil, all abundantly available - nor for energy which exists in plenty in any body in the form of heat (albeit unfortunately not transformable), **but a struggle for entropy, which becomes available through the transition of energy from the hot Sun to the cold Earth.**

Boltzmann L. The second law of thermodynamics. In *Theoretical physics and philosophical problems* (pp. 13-32). Dordrecht, Netherlands: Springer, 1974.

This is because life relies on microscopic particles in moving states not in static states

Let's look how Wikipedia cited these sentences?

(https://en.wikipedia.org/wiki/Entropy_and_life)

“**The general struggle for existence of animate beings is therefore** not a struggle for raw materials - these, for organisms, are air, water and soil, all abundantly available - nor for energy which exists in plenty in any body in the form of heat (albeit unfortunately not transformable), but **a struggle for negative entropy, which becomes available through the transition of energy from the hot Sun to the cold Earth.**”

Why did Wikipedia intentionally add “negative” before “entropy” ?

Which is wrong on this topic, Wikipedia or Boltzmann?

“Negative entropy (negentropy)” promoted by Erwin Schrödinger *

- **Evolution leads to increase in biological order; this is likely contrary to the second law of thermodynamics which leads to increase in entropy (= decrease in thermodynamic order = increase in thermodynamic chaos) of isolated systems (Schrödinger's paradox)**
- **Many scientists and people assumed that an organism is a system with low entropy, and that an organism keeps low entropy through metabolism by absorbing low-entropy matter and discharging high-entropy matter, and thus the notion of “negative entropy (negentropy)” was established**
- **Negative entropy (negentropy) = Entropy of fed matter (low entropy) – Entropy of discharged matter (high entropy)**

*Schrödinger E. What is life – the physical aspect of the living cell. Cambridge University Press, 1944.

We believe negentropy is wrong in this field

The biological order in my body is established through long-term natural selection and is encoded by my genome, not due to a short-time metabolic effect of negentropy, and not due to the food I eat !

- Food provides only energy and materials for the tiger
- Food does not provide information or direction for the orderly movement of microscopic particles in the tiger
- Genomic sequences provide information or direction for the orderly movement of microscopic particles in the tiger

Negentropy is wrong to assume that all orders in the world are equal to thermodynamic order

- These systems have high entropy because they have many microscopic particles in rapid movement (namely that they have many microstates)
- The order of these systems is different from thermodynamic order where microscopic particles are in relatively static states

Biological order is different from thermodynamic order

When this seal is releasing heat and dying in the ice

Its entropy is declining

Its thermodynamic order is increasing

Its biological order is decreasing

When this frozen girl is reviving for absorbing heat

Her entropy is increasing

Her thermodynamic order is declining

Her biological order is increasing

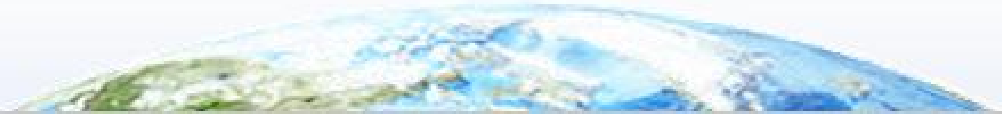
The high biological order in my body supports the high entropy of my body, or to say, supports relatively rapid movement of many microscopic particles in my body

This is similar to the fact that the traffic order supports relatively rapid running of cars in a metropolis

Short-time increase of entropy
Long-term accumulation of biological order

My entropy can be increased rapidly through absorbing heat from the sunlight

My biological order is accumulated slowly through long-term natural selection



Erwin Schrödinger likely knew that the notion “negative entropy” is wrong

- When Erwin Schrödinger proposed “negative entropy”, he met dramatic criticism from physicists
- He stated: if I had been catering for them alone, I should have let the discussion turn on free energy instead *

- He likely knew that “negative entropy” is wrong
- He was reluctant to abandon “negative entropy”
- We agree that free energy is superior to negative entropy for evolutionary issues, but the explanations based on free energy are much more complex than the CBET
- The notion negative entropy has been criticized for decades

*Schrödinger E. What is life – the physical aspect of the living cell. Cambridge University Press, 1944.

Another incorrect notion regarding entropy

- The wrong notion is that a pile of books placed **orderly** is claimed to have less entropy than the same pile of books placed **messily**
- In effect, the entropy of this pile of books changes little no matter whether they are arranged orderly or messily, since the books absorb little heat from the surroundings and release little heat to the surroundings through the arrangement

- The **macroscopic** chaos/order of the books we observe with eyes is different from the chaos/order of the books at the **microscopic** level which determines the entropy of the books
- A pile of books became messily, not because of **thermodynamics**, but because of **Newtonian mechanics** (e.g. thrown by hands)

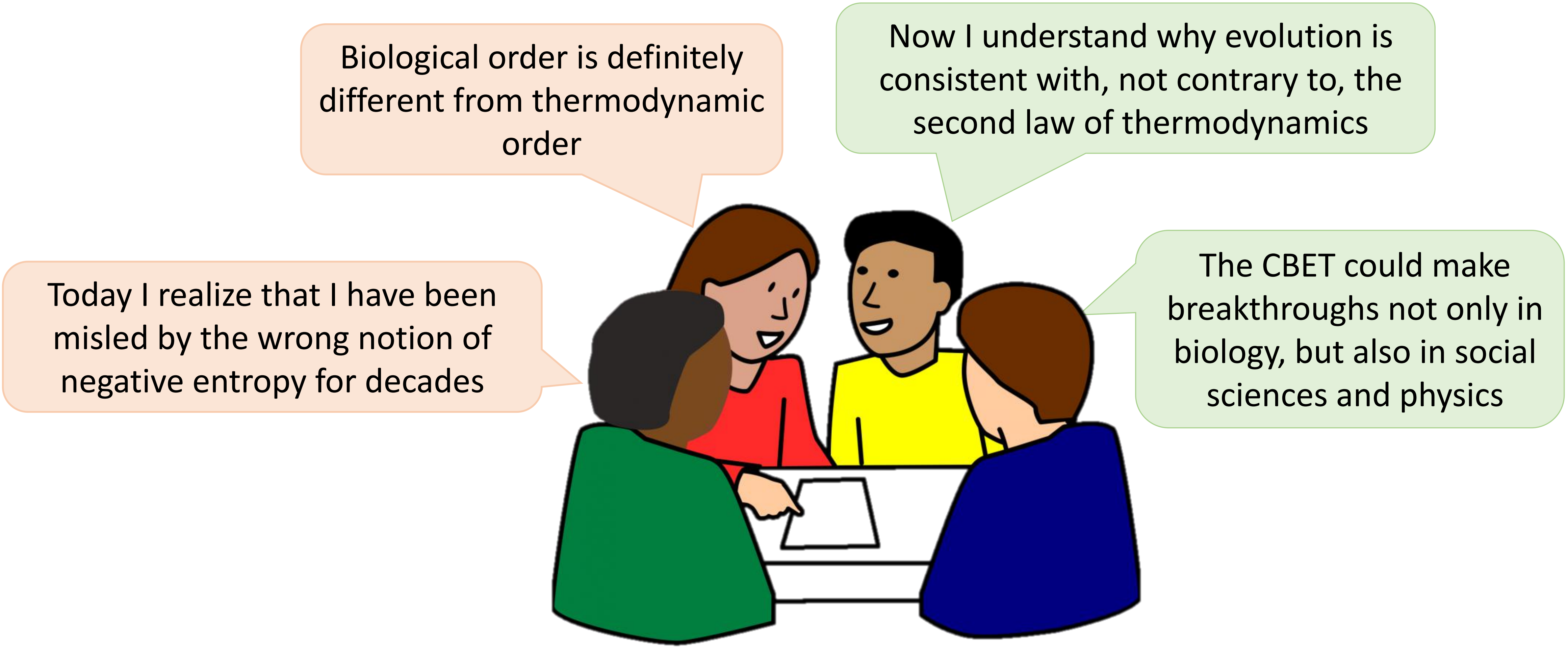
Information has also been linked elusively to entropy or negentropy

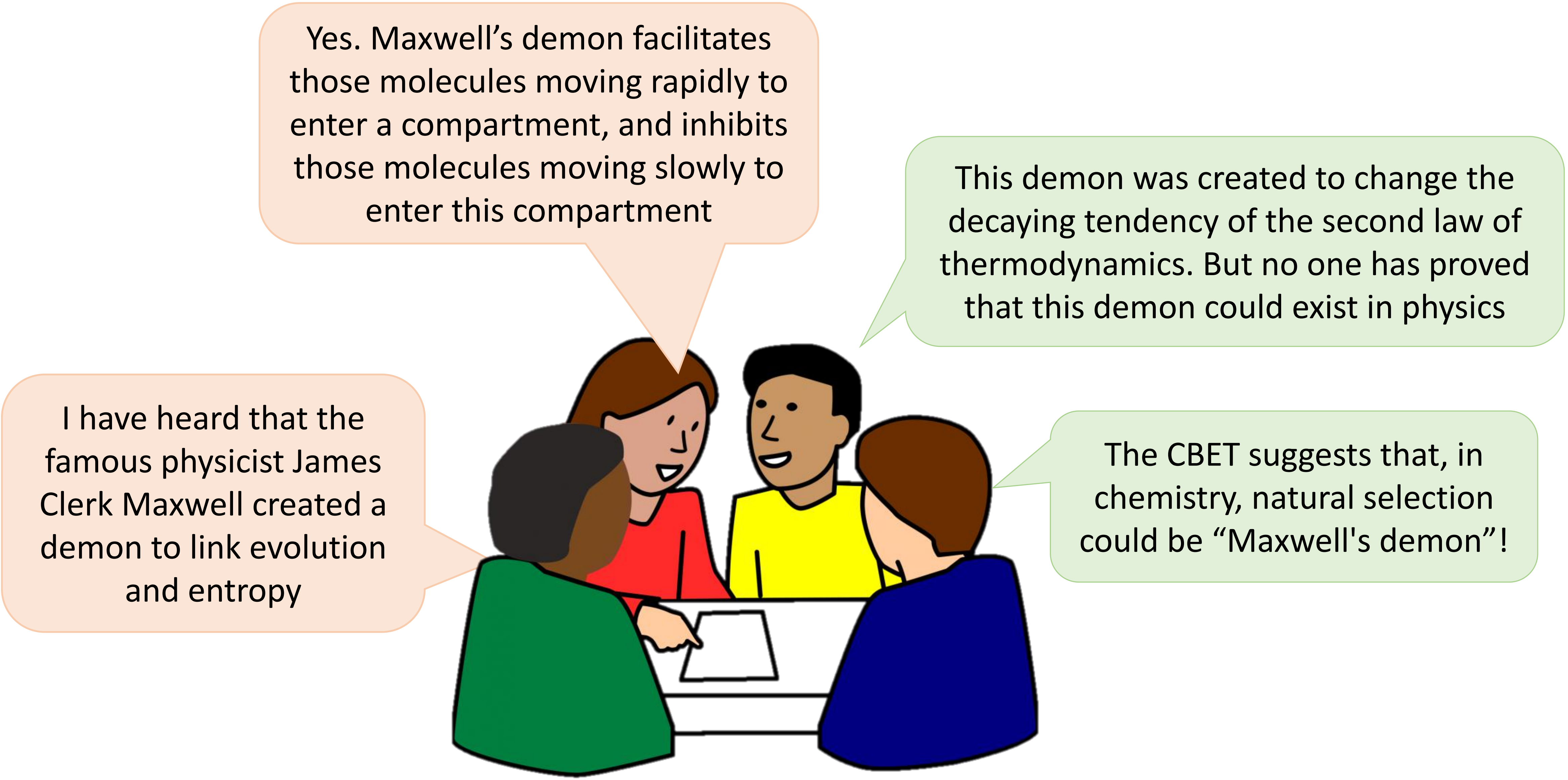
Entropy, not Negentropy

WOOLHOUSE[1] remarks that the work of Shannon and Brillouin showed the fundamental relationship between information defined as $I = -\Sigma P_i \log P_i$ (where $0 \leqslant P_i \leqslant 1$, $\Sigma P_i = 1$ and P_i is the relative probability of the ith symbol generated by a source), and entropy defined in statistical terms as $S = -k\Sigma P_i \log P_i$ (where $\Sigma P_i = 1$ and P_i is, in this case, the probability of an idealized physical system being in the state i of n possible equivalent states or complexions). It is the unwarranted extrapolation of this relationship to biological systems which, Woolhouse says, leads to erroneous conclusions. He points to the warning given by Brillouin himself, that the theory of information ignores the value or the meaning of the information which is quantified by the definition. Yet in spite of these warnings by Brillouin, the confusion is already present in his work even before its extension to biology.

Wilson JA. Entropy, not negentropy. Nature, 1968;219:535-536

- The link between information and entropy is controversial as exemplified by the left comments
- The information “I will go to Australia next month” has elusive influence on the information of the movement of microscopic particles in my body
- It hence **makes confusion** to discuss information without mention of the **hierarchy**
- The **microscopic** entropy, chaos, order, and information should not be extrapolated to the **macroscopic** world in a straightforward way

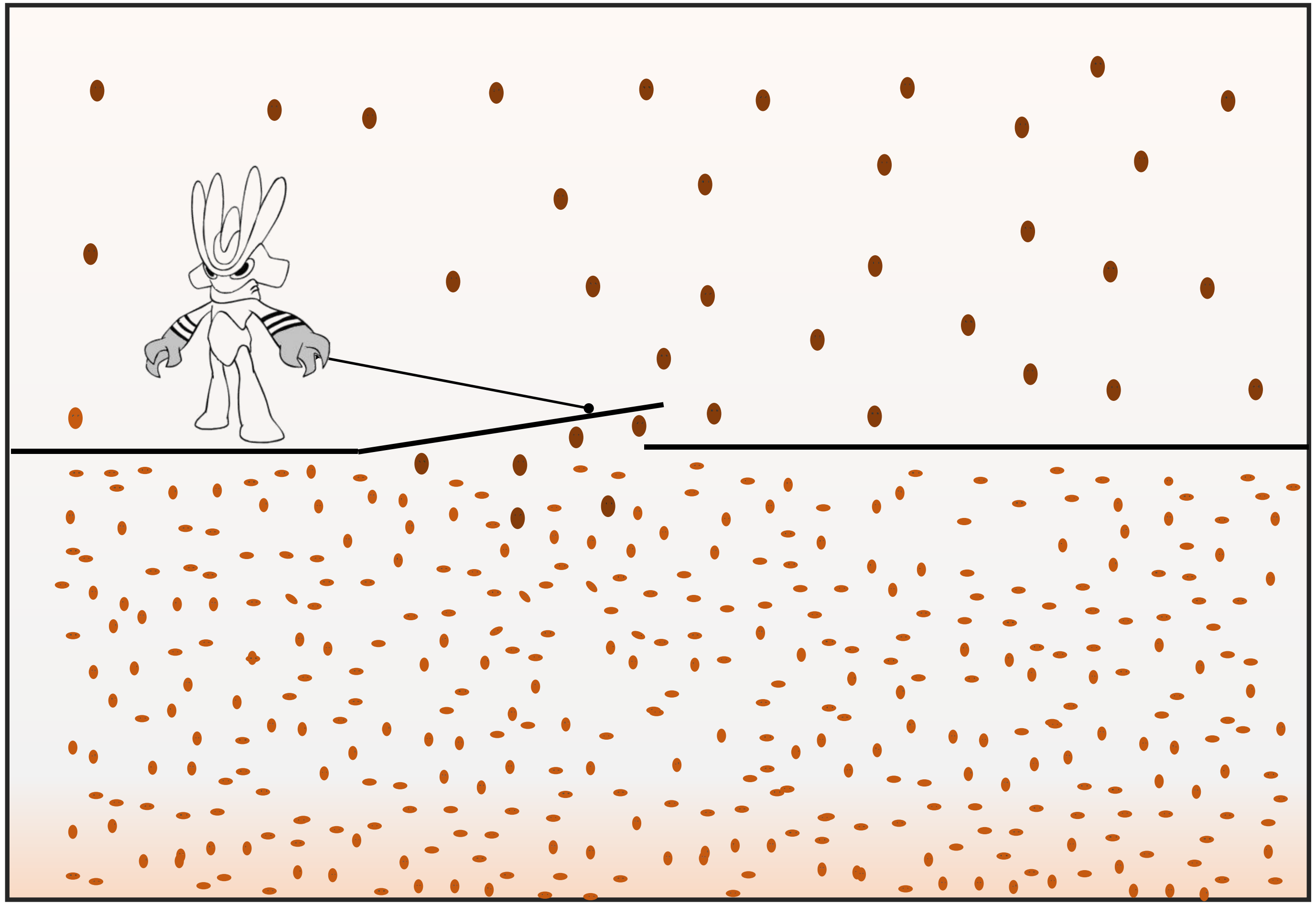

Biological order is definitely different from thermodynamic order
Now I understand why evolution is consistent with, not contrary to, the second law of thermodynamics
Today I realize that I have been misled by the wrong notion of negative entropy for decades
The CBET could make breakthroughs not only in biology, but also in social sciences and physics


I have heard that the famous physicist James Clerk Maxwell created a demon to link evolution and entropy
Yes. Maxwell’s demon facilitates those molecules moving rapidly to enter a compartment, and inhibits those molecules moving slowly to enter this compartment
This demon was created to change the decaying tendency of the second law of thermodynamics. But no one has proved that this demon could exist in physics
The CBET suggests that, in chemistry, natural selection could be “Maxwell's demon”!

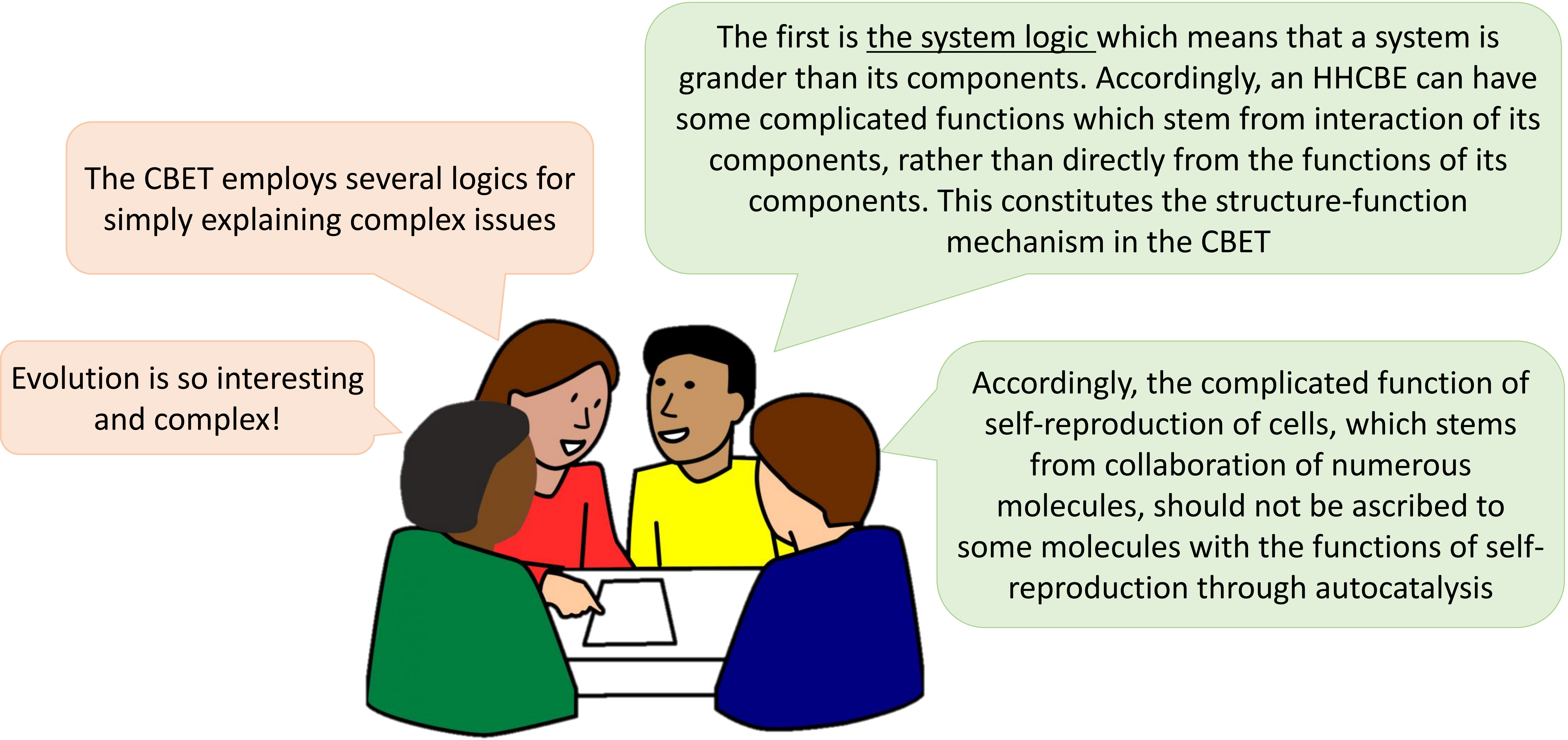
Natural selection is Maxwell's demon, which changes the second law of thermodynamics from a decaying force to a progressive force

Natural selection allows some HHCBEs to enter the upper compartment, namely that some HHCBEs can survive for some time, and so they can be accumulated and separate themselves from LHCBEs

Some LHCBEs chemically change to HHCBEs after absorbing heat as per thermodynamics and carbon chemical features



HHCBEs: higher-hierarchy carbon-based entities, e.g. proteins as compared with amino acids
LHCBEs: lower-hierarchy carbon-based entities, e.g. amino acids as compared with proteins


The first is the system logic which means that a system is grander than its components. Accordingly, an HHCBE can have some complicated functions which stem from interaction of its components, rather than directly from the functions of its components. This constitutes the structure-function mechanism in the CBET
The CBET employs several logics for simply explaining complex issues
Evolution is so interesting and complex!
Accordingly, the complicated function of self-reproduction of cells, which stems from collaboration of numerous molecules, should not be ascribed to some molecules with the functions of self-reproduction through autocatalysis

The second is <u>the perspective logic</u> which means different perspectives of the same thing can be expressed differently and can be explained with each other

Hence an organism can simultaneously have high order in biology and high chaos in thermodynamics

And accordingly, the function, fitness, collaboration, altruism, obeying rules, restriction of freedom regarding CBEs can describe the same or similar thing from different perspectives

This logic also suggests that a complex issue (e.g. evolution) is better to be explained through multidisciplinary integration in order to observe its panorama

1 History & background of the CBET

2 The primary driving force of evolution

3 The mechanisms of evolution

4 Reliability & significance of the CBET

5 Questions & answers

6 Generalization of the CBET

One sentence to summarize the CBET

Evolution is the increase in the amount, diversity, and fitness of higher-hierarchy carbon-based entities under natural selection and driven by the organic synthesis tendency on the Earth which stems from the thermodynamic features of the Earth

The concept of "carbon-based entities" is more comprehensive than "organisms" in previous mainstream evolutionary theories

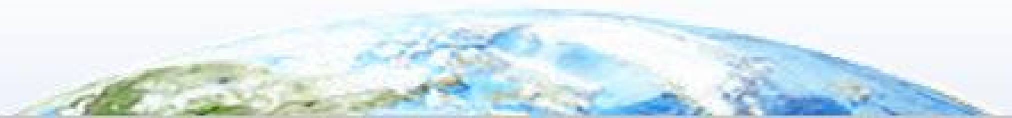
The above red words express some respects which have not been mentioned by previous mainstream evolutionary theories

One sentence to summarize the CBET

Evolution is the increase in the amount, diversity, and fitness of higher-hierarchy carbon-based entities under natural selection and driven by the organic synthesis tendency on the Earth which stems from the thermodynamic features of the Earth

"Natural selection" in the CBET is more scientific and comprehensive than "natural selection" in previous evolutionary theories, which leads to increase in the fitness of HHCBEs

The words "**driven by the organic synthesis tendency**" include the primary driving force of evolution, which leads to increase in hierarchy, diversity, and complicated functions of CBEs under natural selection



Achieved the five aims of the CBET? Need time to test…

- To be a more scientific and comprehensive evolutionary theory
- To better explain multiple evolutionary issues
- To reveal the evolutionary basis of multiple social notions
- To be the first bridge linking physics, biology, and social sciences
- To upgrade previous mainstream evolutionary theories

The CBET also refutes some incorrect views in thermodynamics (e.g. negative entropy) which has mislead many people for decades

Why these aims could be achieved?

Important factors for life origin and evolution	Employed by the CBET	Employed by previous theories
The simple expressions of laws of thermodynamics which are also directly applicable to evolution	Yes	Seldom if not no
The thermodynamic features of the Earth (temperate climate with much water)	Yes	Seldom if not no
The leading actor throughout life origin and evolution (namely CBEs)	Yes	Seldom if not no
The features and chemical reactions of CBEs related to evolution	Yes	Seldom
Logics for simply explaining complex issues	Yes	Seldom
Integration of geology, physics, chemistry, and biology using the above five factors	Yes	No

Thank you for your watching