The Carbon-Based Evolutionary Theory (CBET)

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A new evolutionary theory deduced mathematically from entropy amplification

Jiming Chen

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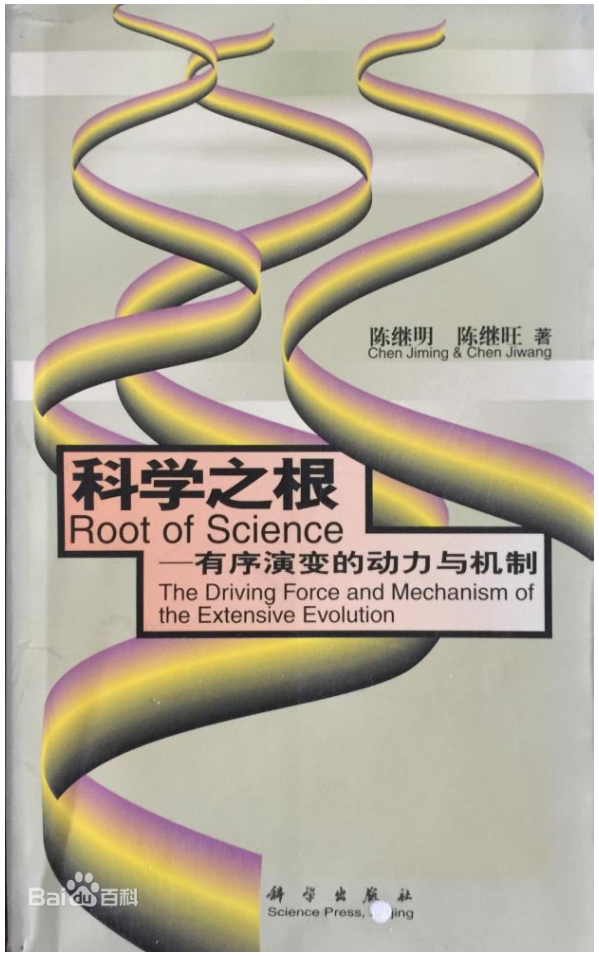
Abstract

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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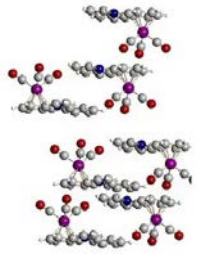
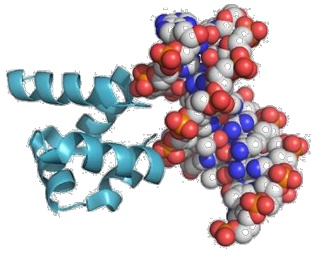
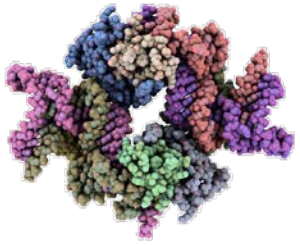
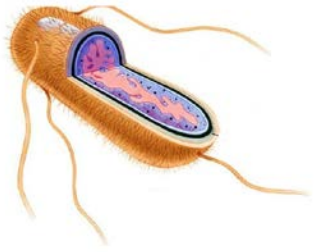
May, 2001

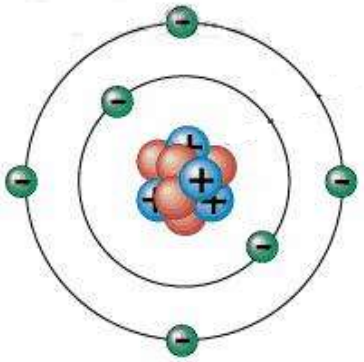
Afterward we spent around 20 years optimizing and simplifying it

CBEs are the leading actor in the CBET

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

Carbon atoms share electrons with various atoms and form many flexible CBEs



Carbon atom

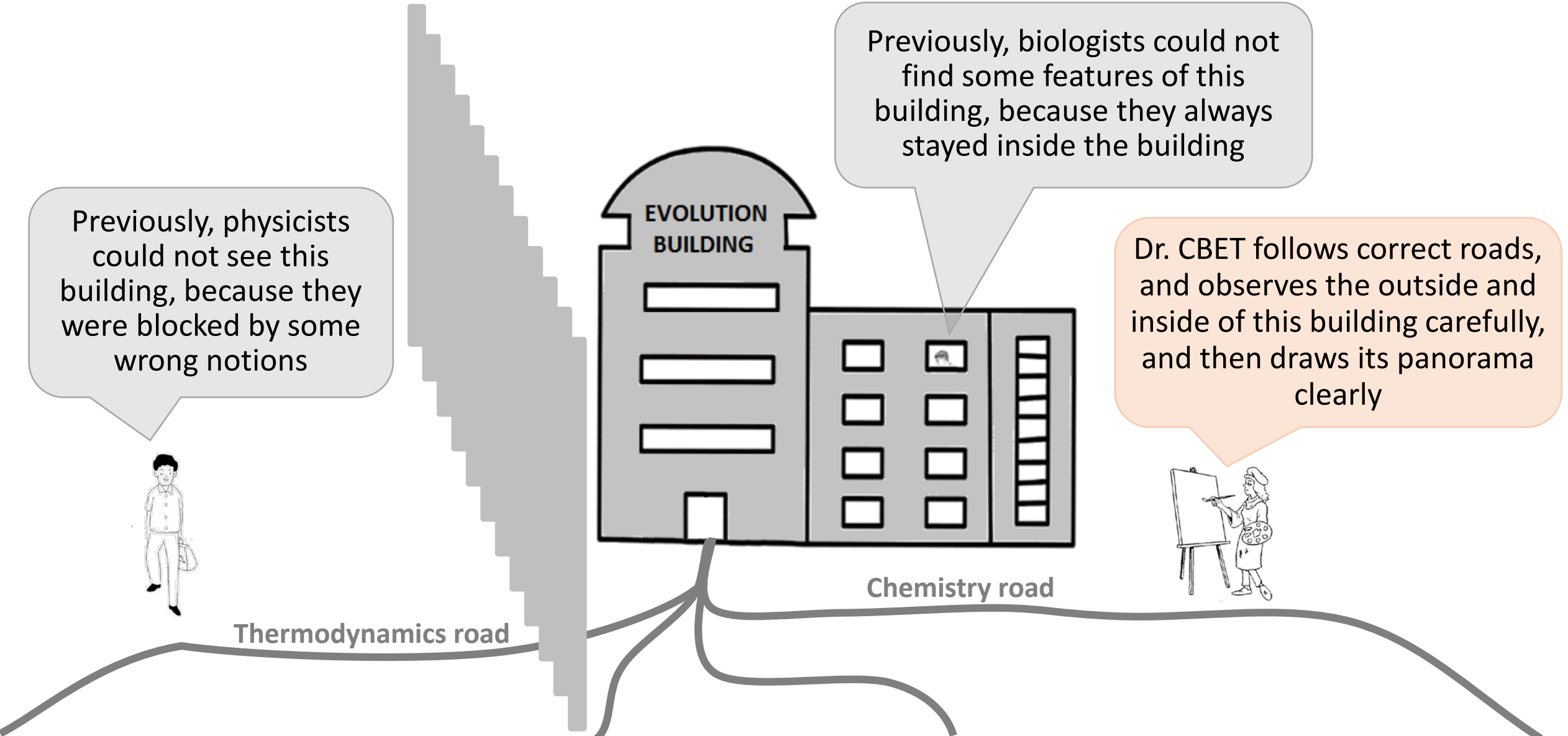
I am a CBE
I can change a lot
I can be very long
I can be very wonderful
Because I am good at sharing
Because I am flexible

CBEs can form higher-hierarchy CBEs (HHCBEs)
(e.g. amino acids can form proteins, and proteins can form cells with other organic molecules, and cells can form multicellular organisms)

Five aims of the CBET

- To be more scientific and comprehensive than previous evolutionary theories
- To provide better explanations for multiple evolutionary issues than previous evolutionary theories
- To refute some wrong notions in thermodynamics about evolution which have misled many people for decades
- To reveal the evolutionary basis of multiple important social notions
- To be a rare bridge via evolution linking physics, biology, and social sciences

How could achieve these ambitious aims?



How could achieve these ambitious aims?

Five factors crucial for evolution	Employed by the CBET	Employed by previous theories
The leading actor throughout life origin and evolution, CBEs	√	×
Chemical reactions of CBEs resulting in evolution	√	×
Temperate climate and much water on the Earth	√	×
Integration of biology, thermodynamics, and chemistry	√	×
Logics for complex issues including evolution	√	×

1 History & background of the theory

2 Deduction of the driving force of evolution

3 Deduction of major steps of evolution

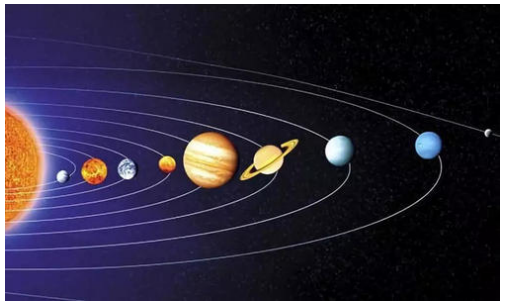
4 Deduction of the mechanisms of evolution

5 Reliability & significance of the CBET

6 Q&A with the focus on thermodynamics

7 Generalization of the CBET

Many temperate heat streams on the Earth



Due to the Sun

Due to geotherm

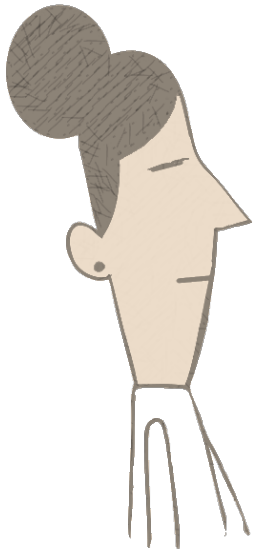
Due to biochemical energy

The Earth has much water and the atmosphere to make these heat streams more temperate, more widespread, last longer, through winds, rains, evaporation

Under sunshine and other temperate heat streams

- ✓ Stones spontaneously absorb heat as much as possible and increase their temperatures, as per physical reactions triggered by heat streams
- ✓ Some CBEs spontaneously absorb heat as much as possible and form higher-hierarchy CBEs (HHCBEs), as per chemical reactions triggered by heat streams, including synthesis of glucose, amino acids, and proteins

It is nice to use the simple example of stones to explain the thermodynamic process



Thank you. We also use examples to explain some complex logics in this article

When the environment becomes cold……

- ✓ Stones release heat and decrease their temperatures rapidly
- ✓ But some formed HHCBEs are relatively stable, and they are thus maintained and accumulated

- ✓ The accumulated HHCBEs can continue to absorb heat from temperate heat streams to form further higher-hierarchy CBEs, leading to hierarchy-wise evolution of CBEs
- ✓ Hierarchy-wise evolution of CBEs leads to life origin and life evolution

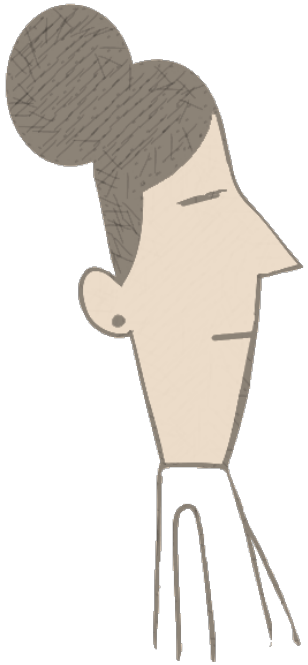
CBEs $\underset{\text{release heat}}{\overset{\text{absorb heat}}{\rightleftharpoons}}$ Higher-hierarchy CBEs $\underset{\text{release heat}}{\overset{\text{absorb heat}}{\rightleftharpoons}}$ Further higher-hierarchy CBEs

Under sunshine and other temperate heat streams

- ✓ Stones spontaneously absorb heat as much as possible and increase their temperatures, as per physical reactions triggered by heat streams
- ✓ Some CBEs spontaneously absorb heat as much as possible and form higher-hierarchy CBEs (HHCBEs), as per chemical reactions triggered by heat streams, including synthesis of glucose, amino acids, and proteins

These changes result from 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

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 applicable directly to evolution. The expression employed by the CBET is easily understandable and applicable directly to evolution

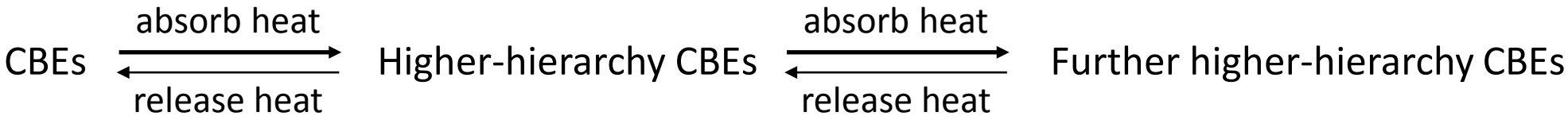
Yes. Many people have been misled by the wrong notion that biological order is equal to thermodynamic order, and they hence have this wrong assumption

Is this assumption wrong?

It is widely assumed that biological evolution is contrary to the second law of thermodynamics

We shall discuss this issue soon in this pPT

Under sunshine and other temperate heat streams

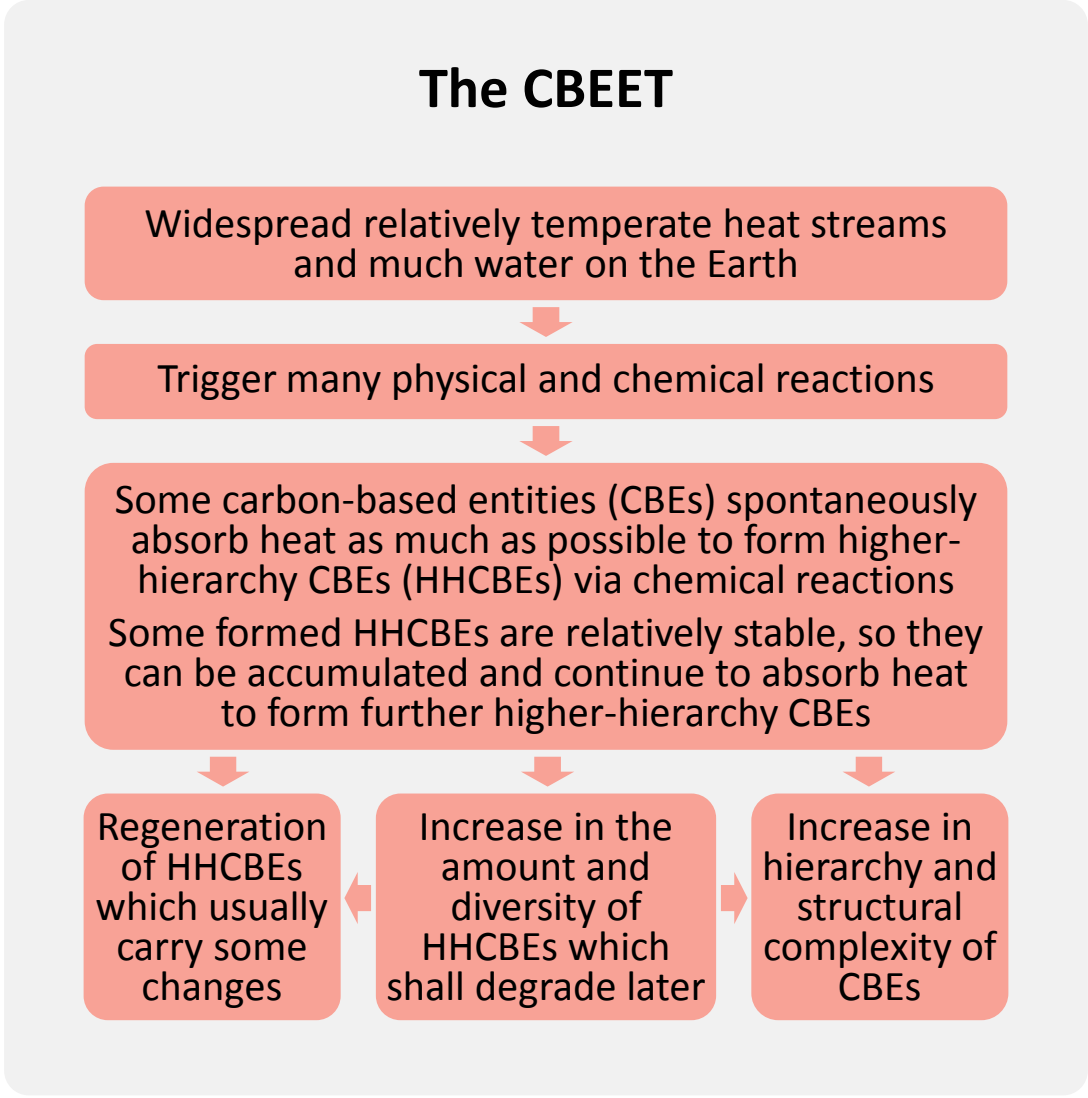


Increase of HHCBEs = Increase in hierarchy and structural complexity of CBEs

Increase of HHCBEs + Few mechanisms for making identical HHCBEs

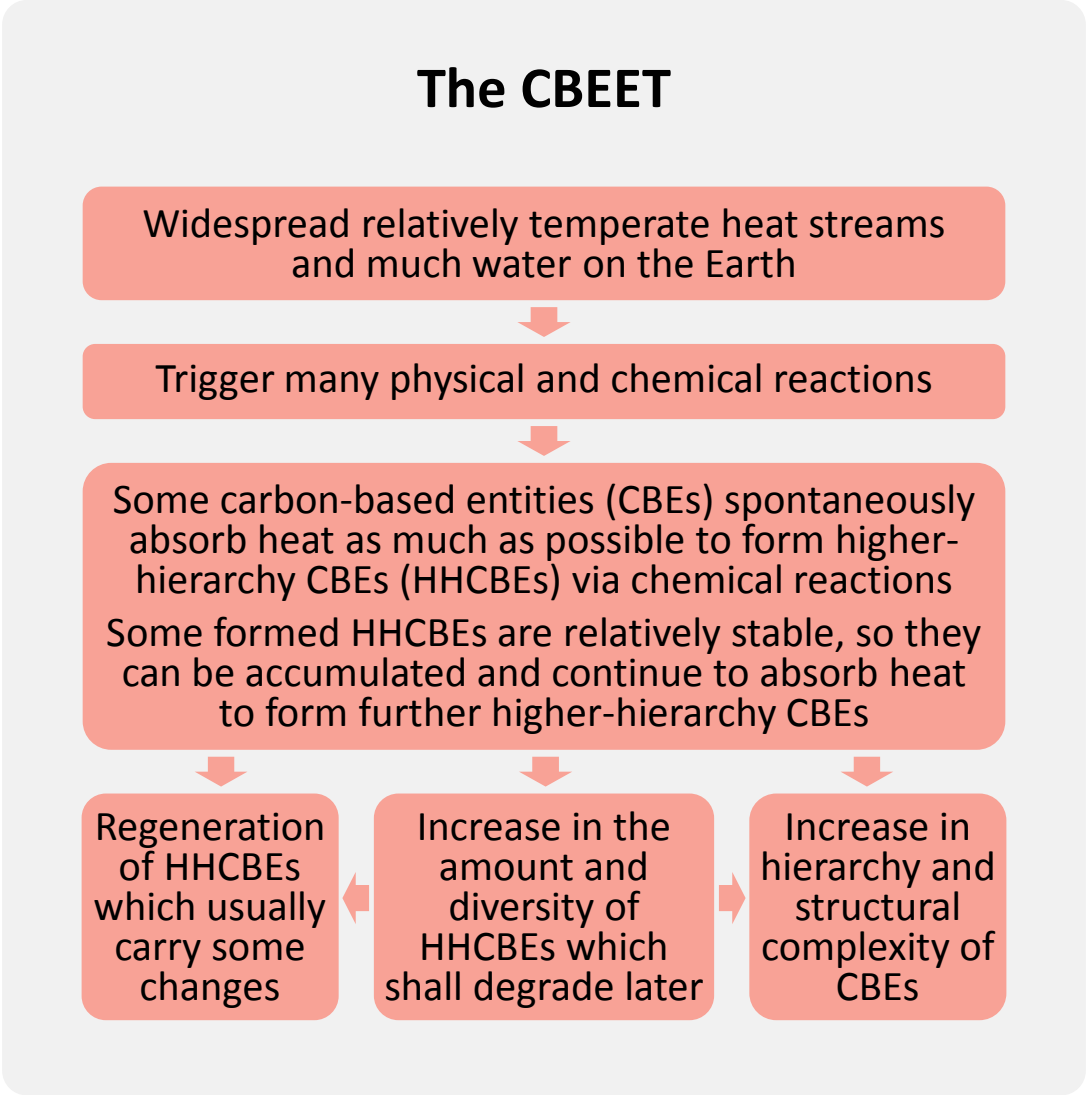
= Increase in diversity of HHCBEs and CBEs

So the driving force of evolution in the CBET stems from thermodynamics



Compared with previous theories

Previously, natural selection, mutation, genetic drift, or competition was claimed to be the driving force of evolution, but they are not directly related to energy



Previously, the role of energy in biological evolution was highlighted, but energy has not been linked to the driving force of evolution

Water and temperate heat streams are important for the hierarchy-wise evolution of CBEs

- Water makes many heat streams more temperate, last longer, and more widespread
- Water provides suitable environments for the formation of many HHCBEs
- Water flows facilitate many CBEs to meet each other to form CBEs
- Water participates in the formation of many HHCBEs as an important component
- Water maintains the normal structures and functions of many HHCBEs

- If heat streams were too cold, CBEs were difficult to absorb heat to form HHCBEs
- If heat streams were too hot, the formed HHCBEs could be destroyed rapidly

The CBET provides better explanations for macroevolution

	CBEs absorb heat as much as possible from temperate heat streams on the Earth to form HHCBEs	Due to advantageous or harmful mutations
Non-living materials evolved to lives	√	×
Unicellular organisms evolved to multicellular organisms	√	×
Ectotherm animals evolved to warm-blooded animals	√	×
Species explosion due to the environment is very suitable and far from saturation with certain HHCBEs	√	×
Mass extinction because temperate heat streams on the Earth are destroyed	√	×

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Increase in hierarchy of CBEs step by step

Amino acids, nucleotides and other middle organic molecules could not bypass the intermediate hierarchy of large organic molecules to form unicellular organisms

Large organic molecules could not bypass the intermediate hierarchy of unicellular hierarchy to form multicellular organisms

Therefore, backstepping from the current status of CBEs on the Earth, there should have occurred seven major steps of evolution on the Earth

Small inorganic and organic molecules (e.g. CO_2, CH_4, H_2O, NH_3)

↓

Middle organic molecules (e.g. amino acids, nucleotides)

↓

Large organic molecules (e.g. proteins, nucleic acids, lipids)

↓

Large organic molecule aggregates (e.g. lipid bilayer membrane)

↓

Complexes of large organic molecule aggregates (e.g. ribosomes)

↓

Unicellular organisms with self-replication & self-protection

↓

Multicellular organisms (e.g. fungi, plants, animals)

↓

Animal societies (e.g. ant societies, bee societies, human society)

The CBET highlights collaboration and altruism

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

Collaboration and altruism (a special collaboration supporting the production and functions of other entities) are important throughout evolution of CBEs

The CBET highlights obeying rules (restricting freedom)

- ✓ Atoms obey some rules and restrict their freedom in molecules
- ✓ Molecules obey some rules and restrict their freedom in cells
- ✓ Cells obey some rules and restrict their freedom in multicellular organisms
- ✓ Individuals obey some rules and restrict their freedom in animal societies
- ✓ Humans obey traffic rules and restrict their freedom in driving

Obeying rules (restricting freedom) constitute collaboration, altruism, fitness, and functions inside HHCBEs throughout evolution of CBEs

The CBET highlights proper increase in freedom

- ✓ Many atoms can move little in large molecules
- ✓ Many molecules can move around inside cells
- ✓ Many cells can move in multicellular organisms
- ✓ Many animal individuals can move in certain areas

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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 pages)

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, and proteins can form cobwebs which spontaneously catch insects, although no proteins can catch insects)

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

Some results of the structure-function mechanism

Sexual reproduction, non-random mutation, predation of animals, animal feelings, human accumulation of knowledge…

All these functions can be fulfilled through complicated structures, and they add fitness to the relevant HHCBEs

Non-random mutations

can be fulfilled through complicated structures of organisms, and they are useful to generate advantageous mutations and avoid disadvantageous mutations

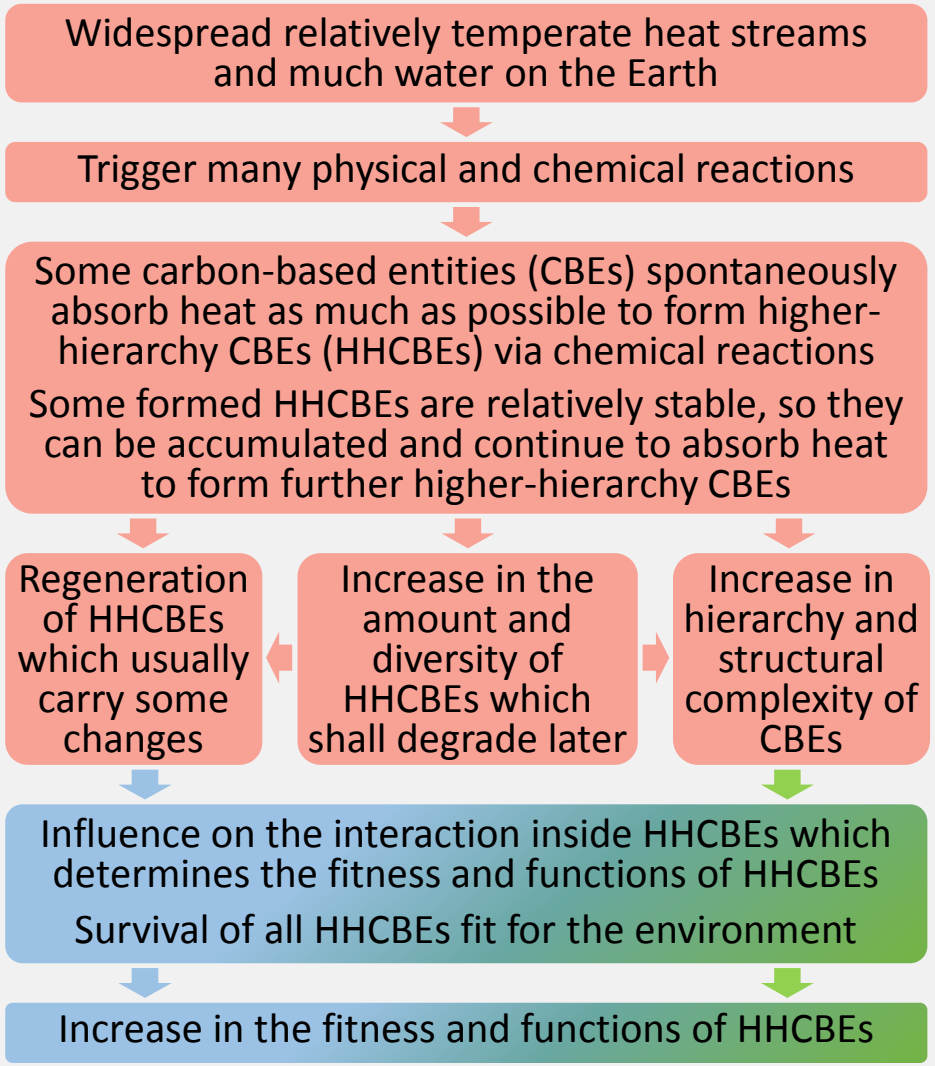
Sexual reproduction

generates 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

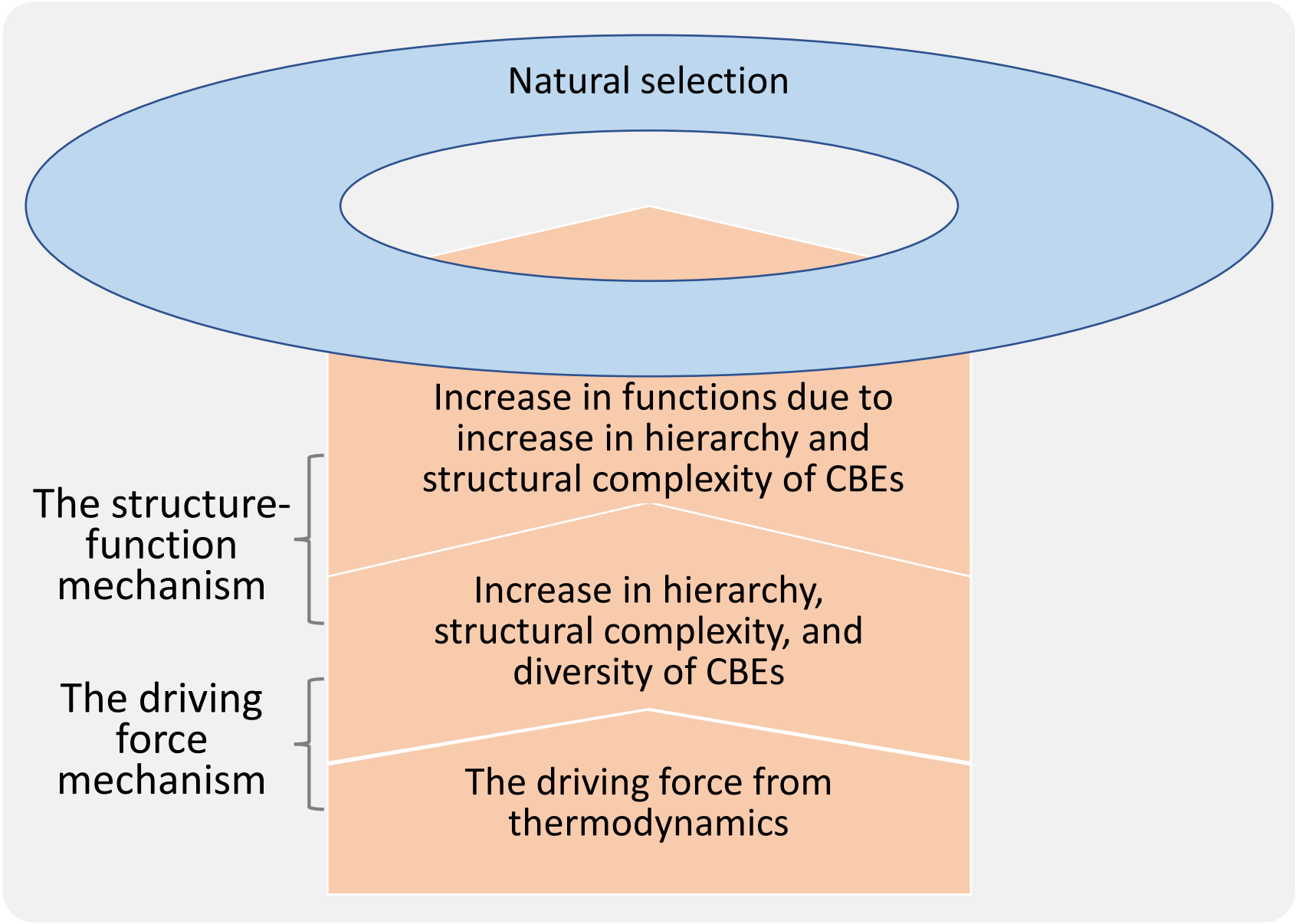
Red arrows :
The driving force mechanism

Blue arrows :
The natural selection mechanism

The CBET



Green arrows :
The structure-function mechanism


Natural selection
Increase in functions due to increase in hierarchy and structural complexity of CBEs
Increase in hierarchy, structural complexity, and diversity of CBEs
The driving force from thermodynamics
The structure-function mechanism
The driving force mechanism

The CBET reveals the prerequisite of natural selection for the first time

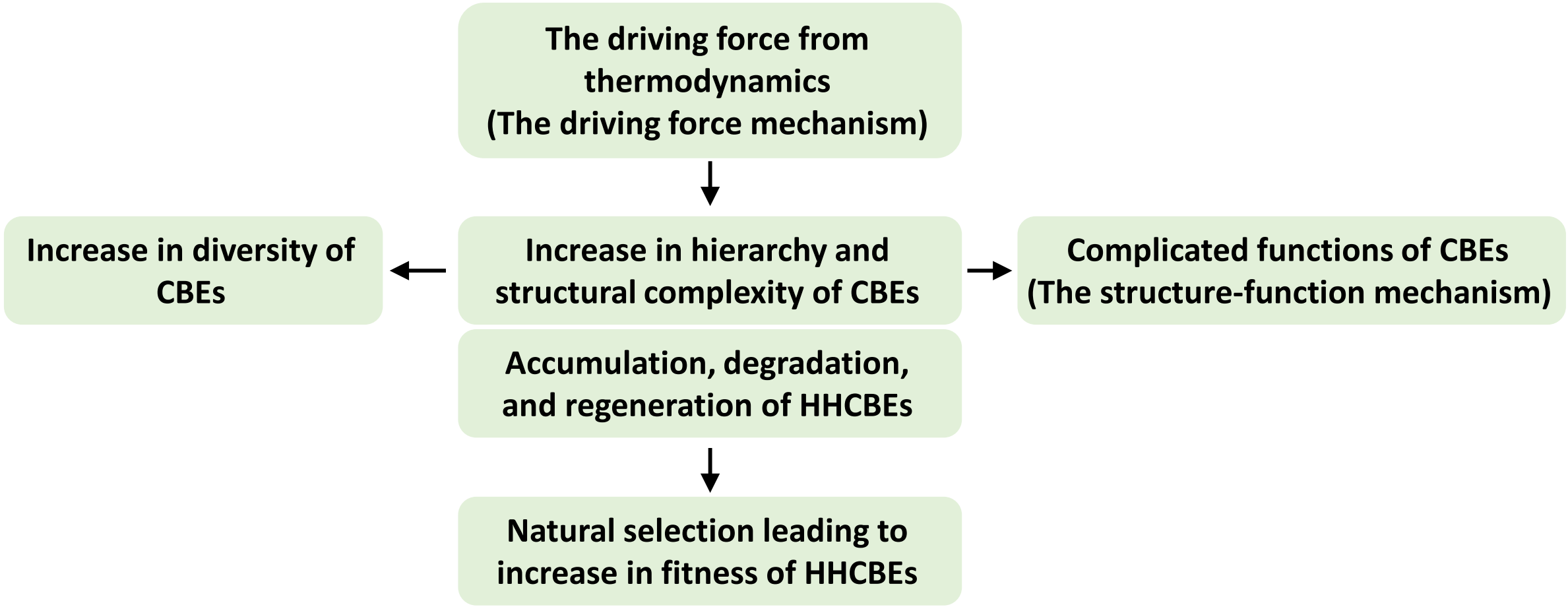
Natural selection is a tautology

Those fit survive, and those surviving are fit
Those having more individuals are the fitter, and the fitter have more individuals

The driving force of evolution provides the prerequisite for this tautology

Natural selection does not exist without regeneration of HHCBEs on the Earth
Natural selection must exist with regeneration of HHCBEs on the Earth
No mechanisms to make HHCBEs are regenerated and maintained at the same rates
↑
Regeneration of HHCBEs driven by the driving force from thermodynamics

The 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 supported by itself and hence rootless

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

In the CBET

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

Natural selection could be the second leading role in evolution

(The first role is the driving force deduced from thermodynamics)

The CBET provides better explanations for life origin

Previous theories have not revealed the driving force and mechanisms for life origin

Previous theories emphasize the special role of RNA and some organic molecules with the function of autocatalysis (e.g. the world of RNA hypothesis)

The CBET reveals the driving force and the progressive mechanisms for life origin from the thermodynamic features of the Earth (having many temperate heat streams and much water)

The CBET highlights collaborative interaction, i.e. collaboration, of many organic molecules and other CBEs, for life origin

Small inorganic and organic molecules (e.g. CO_2, CH_4, H_2O, NH_3)

Step 1

Middle organic molecules (e.g. amino acids, nucleotides)

Step 2

Large organic molecules (e.g. proteins, nucleic acids, lipids)

Step 3

Large organic molecule aggregates (e.g. lipid bilayer membrane)

Step 4

Complexes of large organic molecule aggregates (e.g. ribosomes)

Step 5

Unicellular organisms with self-replication & self-protection

Some bacteria created by humans supports the five steps given by the CBET for life origin through abiogenesis (https://doi.org/10.1126/science.aad6253)

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 sum of reproduction and existence, 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, e.g. Cambrian Explosion

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

Different from previous theories

Darwin's theory (Survival of the fittest)

Due to excessive reproduction and fierce competition

The Modern Synthesis (Survival of the fitter)

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

Positive selection: promoting accumulation of advantageous changes

Negative selection: inhibiting existence of disadvantageous changes

The CBET (Survival of the fit)

Those HHCBEs fitter in general are more relatively successful in the sum of reproduction and existence, 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, e.g. Cambrian Explosion

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

Competition

Mild competition

Fierce competition

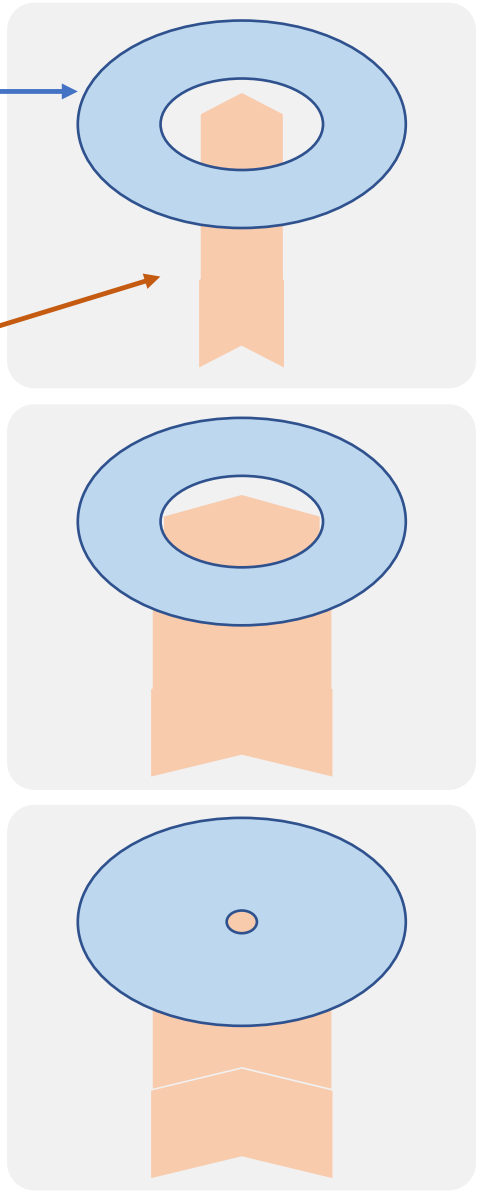
Competition

Mild competition

Fierce competition

Natural selection

Increase of HHCBEs driven by thermodynamics



The environment is far from saturated with certain HHCBEs
Natural selection restriction and competition are mild
Those HHCBEs with less fitness can survive and replicate

The environment is saturated with certain HHCBEs
Natural selection restriction and competition are fierce
This facilitates increase in fitness of the HHCBEs

The environment become very harsh
Natural selection restriction and competition are very fierce
This leads to mass elimination of the HHCBEs
including the fittest

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) 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 add fitness (e.g. long necks of giraffes are useful for finding predators, but add burdens to bones and hearts), so the trait may be under both positive selection and negative selection in various 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

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

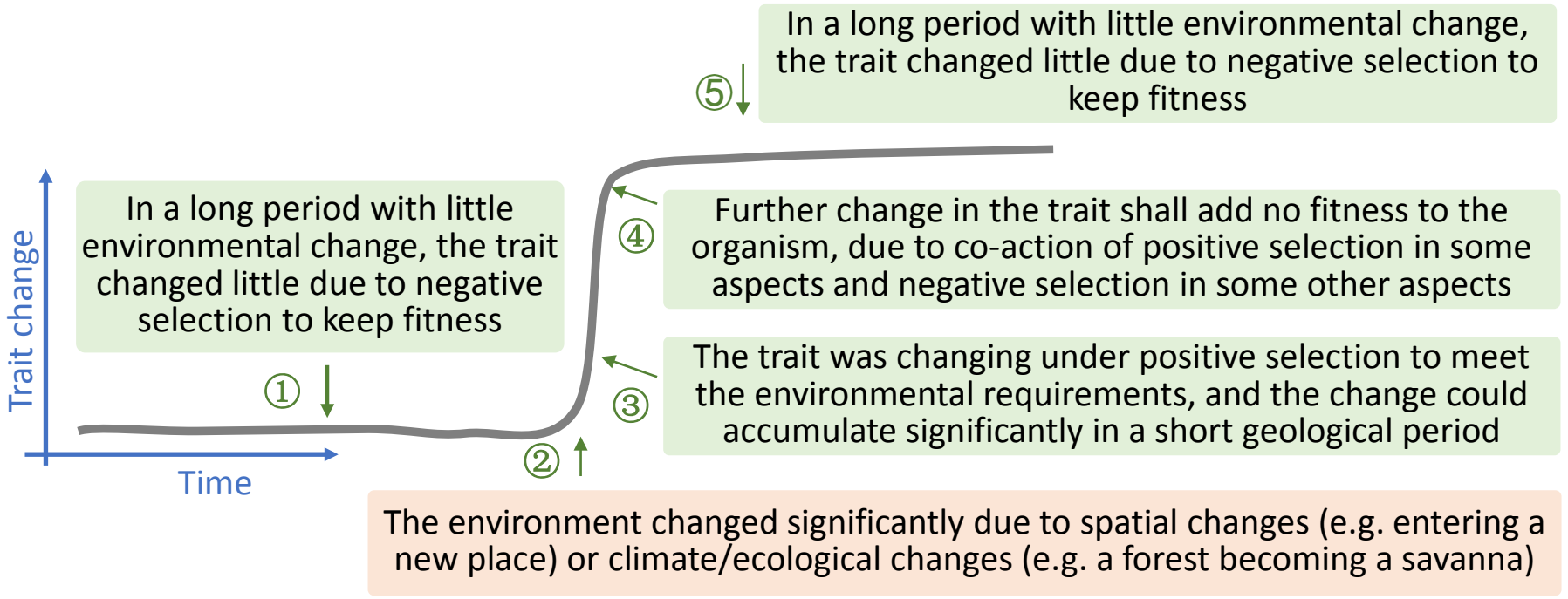
Punctuated equilibrium

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

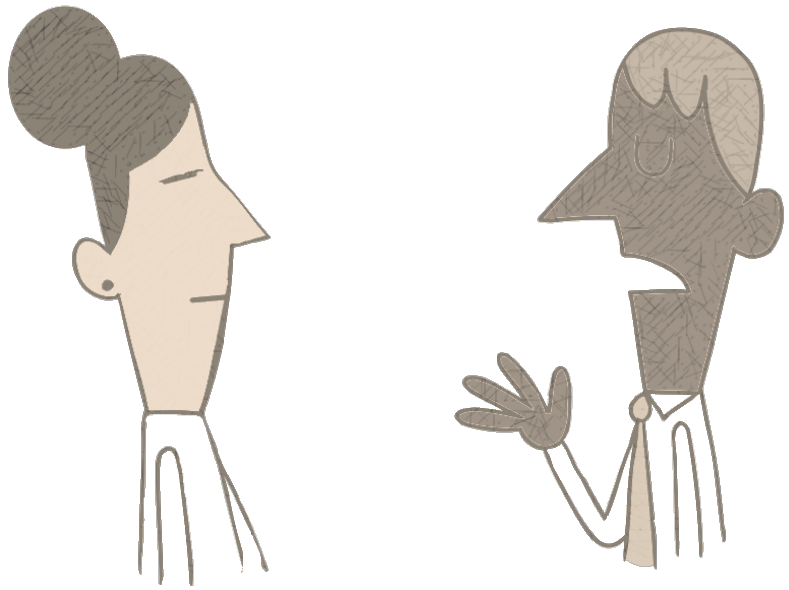
The CBET suggests a novel mechanism for punctuated equilibrium

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 rational explanations for the widespread neutral or harmful mutations, punctuated equilibrium, and non-random mutations



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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

The fact that CBEs absorb heat from temperate heat streams to form HHCBEs embodies in all known organisms and in many biomedical factories and laboratories

The CBET could be a rare bridge directly linking physics and biology and social sciences

Physics
Laws of thermodynamics

Biology
Origin and evolution of Life

Social sciences
Development of society

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

Highlights not only selfishness (e.g. self-reproduction and self-protection), fitness, and competition, but also diversity, collaboration, altruism, obeying rules, proper increase in restricted 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 from natural sciences

Significance of the CBET for biology

As compared with previous theories

The CBET provides the prerequisite or roots for natural selection

The CBET is more scientific because it provides better explanations for multiple evolutionary issues

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

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 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

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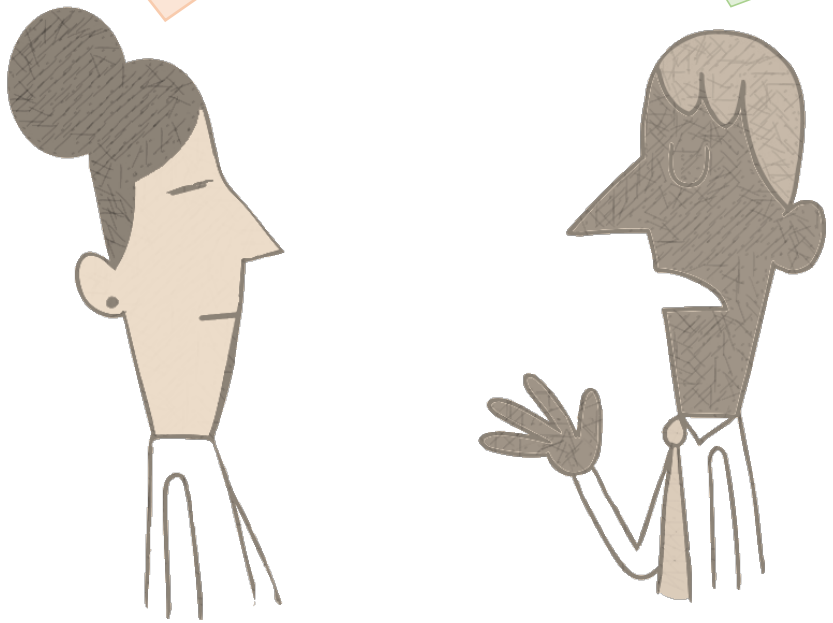
Questions & Answers

Why silicon-based entities (SBEs) could not evolve into lives on the Earth?

This is because SBEs are usually too hard to form multiple hierarchies



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

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 permanent, widespread, temperate heat streams and much water, providing a very rare and very big suitable thermodynamic environment for life origin

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

The CBET reveals the thermodynamic possibility (not certainty) regarding life origin on the Earth

- ✓ If a planet had permanent and widespread temperate heat streams and much water, life could (not must) have originated on the planet (e.g. Mars)
- ✓ This notion is widely accepted and supports the CBET

Questions & Answers

The CBET employs several logics for complex issues

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 result from interaction of its components, rather than directly from the functions of its components. This constitutes the structure-function mechanism in the CBET

Evolution is so complex!

Similarly, the complicated self-replication function of cells, which results from collaboration of numerous molecules, should not be ascribed to some molecules with the functions of self-replication through autocatalysis

Questions & Answers

The third is the perspective logic which means different perspectives of the same thing can be expressed differently and can be explained with each other

This leads to backstepping of the seven major steps of evolution

The second is the hierarchy logic covering hierarchy-wise increase of HHCBEs

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

The perspective logic leads to the fact that an organism can simultaneously have high order in biology and high chaos in thermodynamics, which will be discussed soon

Questions & Answers

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

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

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

Classical laws of thermodynamics

- **The first law of thermodynamics:** increase of 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… ystem 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…** constant value as its tempera… perfect 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

As per these two formulas

When the stone absorbs heat

1. Its temperature becomes higher
2. Its molecular movement becomes faster
3. The stone has less order at the microscopic level in thermodynamics
4. The stone 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 entropy is declining because its microstates are declining ($S = k \times Ln\Omega$)

Its thermodynamic order is increasing

because its microscopic particles are becoming more static

Its biological order is, however, declining

(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)

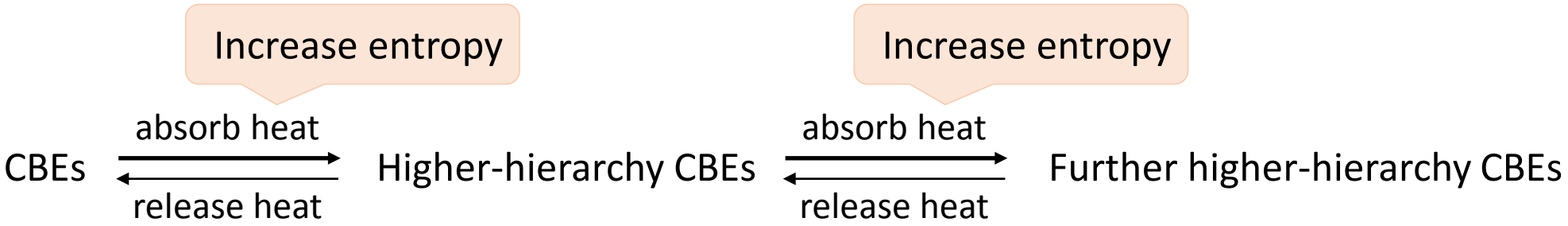
A perfect crystal at absolute zero temperature has the highest order in thermodynamics

Thermodynamic order favors microscopic particles to be static

Two ways to increase entropy or microstates

- ✓ Physical way: under heat streams, stones spontaneously absorb heat, which means that stones increase their entropies and microstates through physical reactions
- ✓ Chemical way: under heat streams, CBEs spontaneously absorb heat and form HHCBEs, which means that CBEs increase their entropies and microstates through chemical reactions

Formation of HHCBEs is increasing the entropy of CBEs



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

S = K×LnΩ
(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

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)” created 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 and 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 matters (low entropy) – Entropy of discharged matters (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 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 can be correct in other fields with a different definition

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

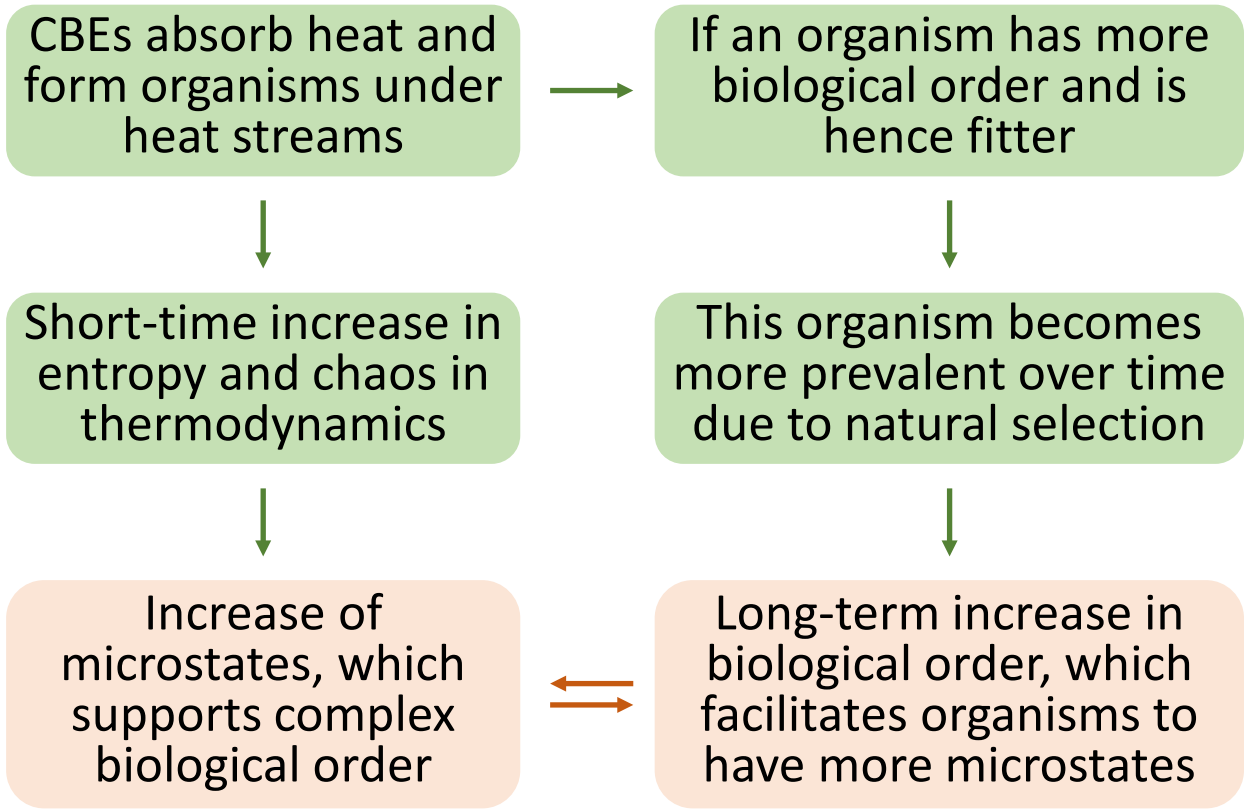
Her entropy is increasing

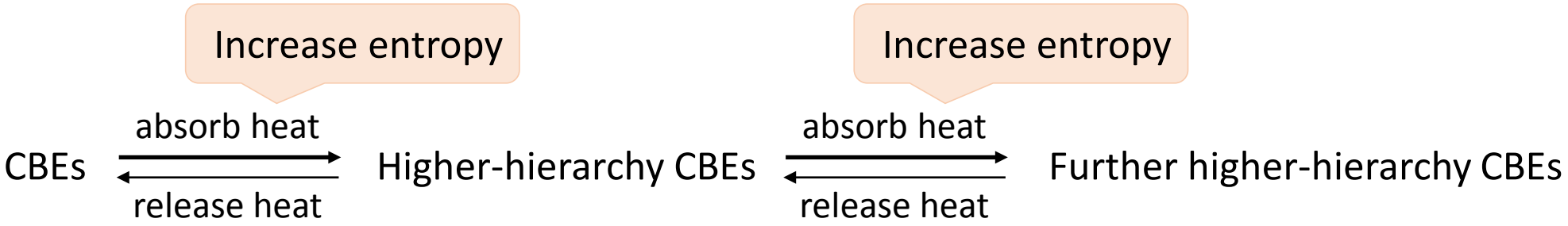
Her thermodynamic order is declining

Her biological order is increasing

The high biological order in my body is consistent with the high entropy of my body, because they both require relatively rapid movement of many microscopic particles in my body

Short-time increase of entropy and long-term accumulation of biological order support each other





Thermodynamics drives organisms to absorb heat, and hence organisms increase their entropy and chaos in thermodynamics

Natural selection increases biological order to make organisms absorb heat to increase entropy and chaos in thermodynamics in an efficient way

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 on this topic, but free energy is also elusive and nonessential for 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 dissipate 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 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

1 History & background of the theory

2 Deduction of the driving force of evolution

3 Deduction of major steps of evolution

4 Deduction of the mechanisms of evolution

5 Reliability & significance of the CBET

6 Q&A with the focus on thermodynamics

7 Generalization of the CBET

One sentence to summarize the CBET

Evolution is the increase in hierarchy, diversity, and fitness of carbon-based entities under natural selection and driven by thermodynamics

"Natural selection" in the CBET is similar to, but more scientific and comprehensive than "natural selection" in previous evolutionary theories

The words "driven by thermodynamics" include the driving force of evolution, the driving force mechanism, and the structure-function mechanism which directly results from the driving force mechanism

One sentence to summarize the CBET

Evolution is the increase in hierarchy, diversity, and fitness of carbon-based entities under natural selection and driven by thermodynamics

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

These five red words express some respects which have not been mentioned by previous mainstream evolutionary theories

The CBET versus previous mainstream theories

Major views of the CBET

Widespread relatively temperate heat streams and much water on the Earth

↓

Trigger many physical and chemical reactions

↓

Some carbon-based entities (CBEs) spontaneously absorb heat as much as possible to form higher-hierarchy CBEs (HHCBEs) via chemical reactions

Some formed HHCBEs are relatively stable, so they can be accumulated and continue to absorb heat to form further higher-hierarchy CBEs

↓

Regeneration of HHCBEs which usually carry some changes

Increase in the amount and diversity of HHCBEs which shall degrade later

Increase in hierarchy and structural complexity of CBEs

↓

Influence on the interaction inside HHCBEs which determines the fitness and functions of HHCBEs

Survival of all HHCBEs fit for the environment

↓

Increase in the fitness and functions of HHCBEs

Small inorganic and organic molecules (e.g. CO_2, CH_4, H_2O, NH_3)

↓

Middle organic molecules (e.g. amino acids, nucleotides)

↓

Large organic molecules (e.g. proteins, nucleic acids, lipids)

↓

Large organic molecule aggregates (e.g. lipid bilayer membrane)

↓

Complexes of large organic molecule aggregates (e.g. ribosomes)

↓

Unicellular organisms with self-replication & self-protection

↓

Multicellular organisms (e.g. fungi, plants, animals)

↓

Animal societies (e.g. ant societies, bee societies, human society)

Major views of previous mainstream theories

Reproduction of organisms with random genetic changes

↓

Survival of the fittest due to excessive reproduction and fierce competition (Darwin's theory)

Gradual changes in gene frequencies as the individuals carrying adaptive mutations are more reproductively successful (The Modern Synthesis)

↓

Speciation and increase in fitness of organisms

These theories cannot explain increase of these hierarchies

These theories have not integrated with multiple challenges

Achieve the five aims of the CBET

- To be more scientific and comprehensive than previous evolutionary theories
- To provide better explanations for multiple evolutionary issues than previous evolutionary theories
- To refute some wrong notions in thermodynamics about evolution which have misled many people for decades
- To reveal the evolutionary basis of multiple important social notions
- To be a rare bridge via evolution linking physics, biology, and social sciences

Thank you for your watching