Schedule of the lecture

1. Introduction (Kurokura) ---------- ----------4/18 (Fri.)
   History of the Earth and agriculture
2. Ground environment I (Okada---------- ----------4/25 (Fri.)
   Climate zone , Light environment, Atmosphere circulation, Soil
3. Growth of plants (Kobayashi)----------5/2 (Fri.)
   Growth of plant (1) Photosynthesis,
4. Ground Environment II (Mizoguchi)----------5/9(Fri)
   Soil formation, Water resource, Heat balance
5. Agricultural Organisms (Miyazawa)----------5/16(Fri.)
   Soil biodiversity and function
6. Cultivated crops I (Yamakawa)----------5/23 (Fri.)
   Breeding, Immunity, Resistance
7. Culutivated crops II (Yamakawa)
   Immunity and Resistance----------5/30(Fri)
8. Agricultural technology (Okada)----------6/6 (Fri.)
9. Agricultural production and Infrastructure (Mizoguchi) ------6/13 (Fri.)

9. Post harvest Technology (Araki) ---------- 6/20 (Fri.)
Preservation, Processing. Distribution, utilization ratio

10. Utilization of Plant material (Saitoh) ----------6/27 (Fri.)
Formation and function of cell wall, Processing, Biomass utilization

11. Farm management (Kiminami) - ----------7/4 (Fri.)
Farm economy, Cost and benefit, Analysis of Management

12. Agro-economy and trade (Takahashi) ----------7/11 (Fri.)
WTO, FTA, TPP

13. Agro-economy and policy (Takahashi)----------7/18 (Fri.)
Food safety, Quality certification

Student can obtain necessary information through internet.
Materials for lecture will be uploaded in HP by the day before the lecture, and student should print out the materials and take them to the lecture room. Student must make resume of the lecture and submit them by the day before the next lecture thorough e-mail (report@iai.ga.a.u-tokyo.ac.jp)

I. History of the Earth and Agriculture

Early history of the Earth

10^9 years ago

13.7 Birth of Space

8.3 Birth of the Galaxy

5.0 Birth of the Sun （Second generation Star)

4.6 Birth of the Earth （collision and incorporation of micro planets）

High temperature: Birth of primordial atmosphere

Cooling down by the decrease of collision,

Rain could be reach on the surface of the Earth.

The sea was produced with in thousand years.

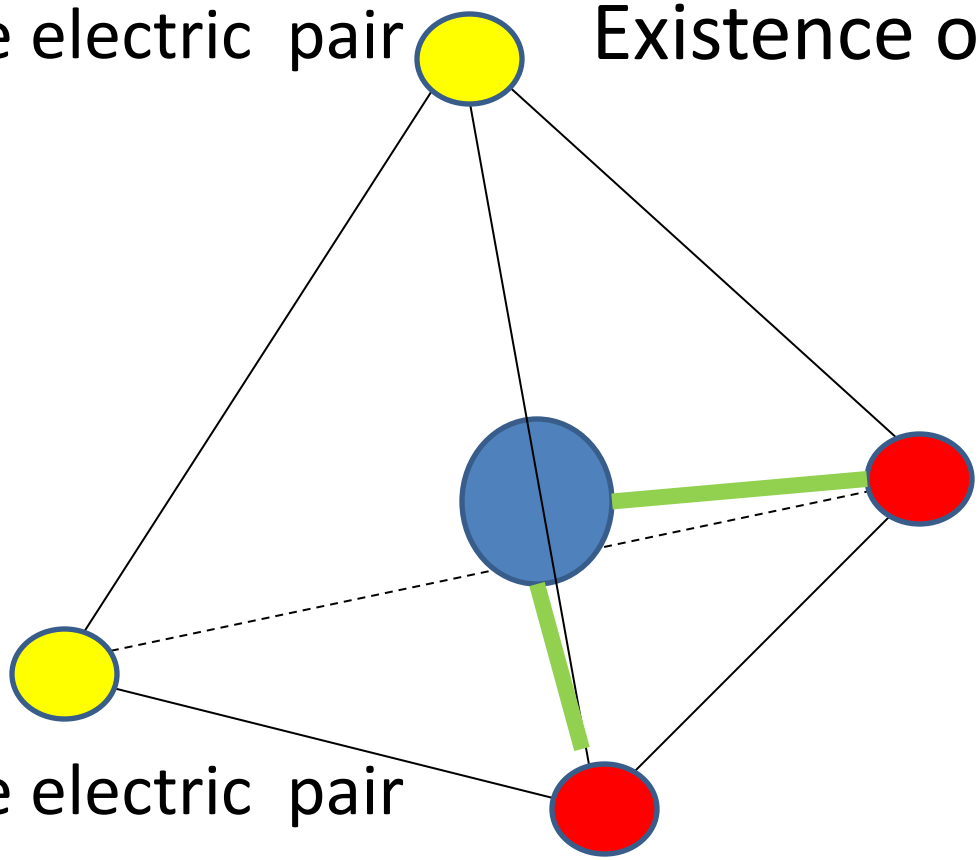
（Birth of the aquatic planet）

Why the Earth can be a aquatic planet

1. Characteristics of Water

Lone electric pair

Existence of 2 lone electron pairs



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Lone electric pair

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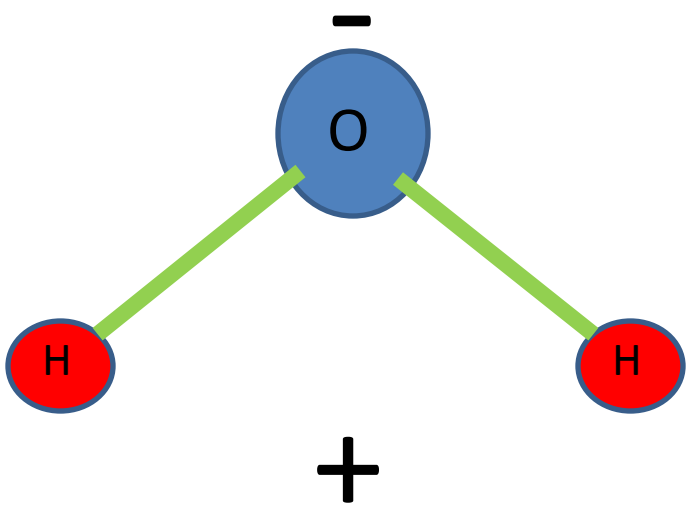
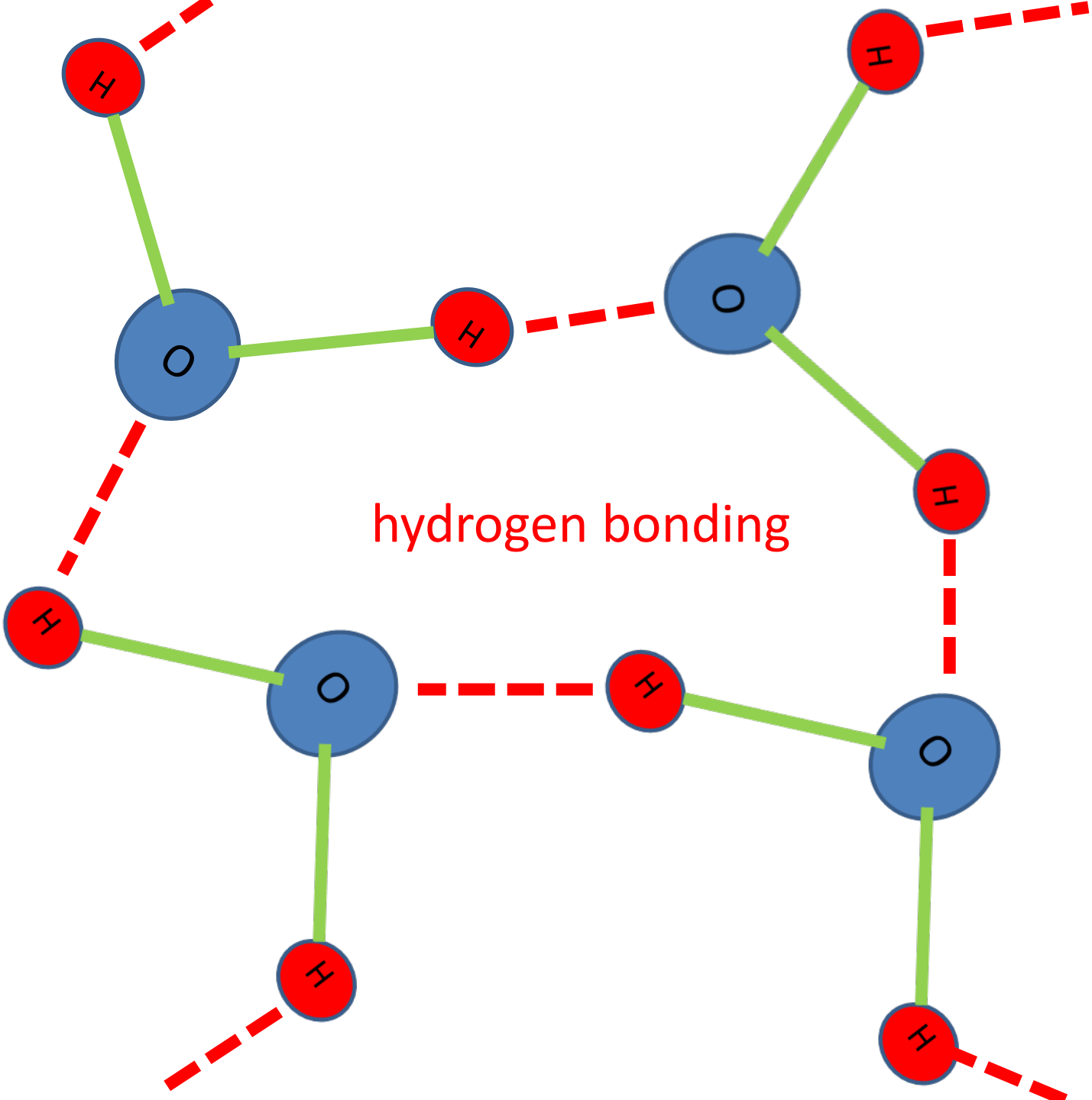


Water molecule has polar character


hydrogen bonding

Intermolecular force between water molecule is strong because of hydrogen bonding and polar character

	MW	BP	FP	Sublimation P.
Water (H_2O)	18	100°C	0°C	
Nitrogen (N_2)	28	-196°C		
Oxygen (O_2)	32	-183°C	-219°C	
Carbon dioxide (CO_2)	44			-79°C

Without hydrogen bonding force,

BP:-90°C FP: <-110°C

No liquid water could exist at normal temp.

(good solvent)

Water can contain various materials as dissolve substance

Ions : because of strong polar character

Sugars: because of hydrogen bonding

(solid water is lighter than liquid water)

Water reach the maximum density at 4^{o}C

Ice can float on the surface of water

(High specific heat) **stability of environment**

(High viscosity) easy to sustain the position

Comparison between air and water (20^{o}C)

	water	air	impact to aquatic organisms
Density	ca 1g/cm^3	1/800	easy to float
Specific heat (constant pressure)	4.18J/K/g	1/4	stability of water temperature
Viscosity	1.002X 10^{3}Pa s	2 order small	
Light absorption	large	small	vertical distribution of light
Oxygen	6-8 mg/l	1/5 of air	Oxygen deficiency happens
Acoustic velocity	1,500m/s	340m/s	
Phases	3	1	
	Vapor, Water, Ice		

Distribution of water and mean residence time

Place	volume(10^3km ^{3})	ratio (%)	MRT
Ocean	1,338,000	97	3,700 years
Permanent ice/ glacier	24,100	1.7	16,000 years
Ground water	23,400	1.7	300 years
Freshwater lake	91	0.007	10-100 years
Brackish lake	85	0.006	10-10,000 years
Soil moisture	16.5	0.001	280days
Atmosphere	12.9	0.001	9days
River	2.12	0.0002	12-20 days

Distance from the Sun and mass

Comparison among the planet

	Venus	Earth	Mars
Distance[1]	108,208,930,km	149,597,871km	227,936,640km
Irradiation[2]	2,660W/m^2	1,370W/m^2	590W/m^2
Albedo [3]	0.65	0.37	0.15
Surface temp.	400℃	15℃	-53℃
Mass	4.869X10^{24}kg	5.9736X10^{24}kg	0.64196X10^{24}kg
	Air	Air	Thin air

[1] Average radius of revolution orbit

[2] strength of irradiation of sunlight at revolution orbit

[3] reflection rate at the surface of planet

Early history of the Earth

10^9 years ago

13.7	Birth of Space
8.3	Birth of the Galaxy
5.0	Birth of the Sun
4.6	Birth of the Earth
3.8	Birth of Life

What was the materials of first living organisms

Materials of biological reaction

Proteins (Enzyme reaction, Motion)

The mechanism is still unclear

Discussions I know

* Amino acids can be produced by electric discharge in mixture gas of water vapor, Methane, Ammonia ad Hydrogen (Primordial atmosphere) in reduction condition (first amino acid was produced by chemical synthesis on the Earth

Counterargument

Primordial atmosphere was not include Methane and Ammonia .

Amino acid exist in space. D-amino acid is unstable in the space (amino acid came from the space)

Protein or DNA, or RNA

Proteins can not replicate themselves

DNA has no catalytic activity

RNA is unstable

Autotrophism or Heterotrophism

Chemical evolution theory : Heterotrophism

Surface metabolism theory: Autotrophism

formation of formic acid on the surface of pyrite

$FeS+H_2S+CO2 \rightarrow FeS_2+H_2O+HCOOH$ -11.7kj/mol (Exergonic reaction)

Was Hydrothermal deposit in sea the home of life ?

Geological timescale: Eon>Era> Period>Epoch

4 Eons

the Hadean（Birth of the Earth – 4x 10^9years ago)

Formation of crust and ocean, Chemical evolution

the Archean（4 x10^9 – 2.5 X 10^9 years ago)）

Birth of life

Procaryote

Archaebacteria, Eubacteria, Cyanobacteria

the Proterozoic (2.5 X10^9-542 x10^6 years ago)

Accumulation of oxygen in the atmosphere

Formation of ozonosphere, decrease of ultraviolet

Birth of eucaryote

Uptake of other procaryote

Multicellular organisms appeared in late Proterozoic eon

the Phanerozoic（ ^{9}-542 x10^6 years ago –today)

Large size multicellular organisms appeared

Precambrian age: the Hadean eon, the Archean eon, the Proterozoic

Precambrian age include many eras, periods, and epochs.
But, In do not know in detail

The Phanerozoic eon has 3 eras (Paleozoic, Mesozoic, Cenozoic)

The Paleozoic Era (542 x10^{6} -251 x10^{6} years ago)
From appearance of invertebrates to prosperity of dinosaur

The Mesozoic Era (251 x 10^{6} -65.5 x10^{6} years ago)
Prosperity of dinosaur and their Extinction
The Mesozoic Era consist of Triassic, Jurassic and Cretaceous period
Appearance of Magnoliophyta

The Cenozoic Era (from 65.5 x10^{6} years ago – today)
Prosperity of mammalia and Aves

The Cenozoic Era consists of Paleogen, Neogene and Quaternary periods

Human being appeared in the Quaternary period

The Quaternary period consists of Pleistocene and Holocene epoch

The Pleistocene epoch (2.588 x106-11,700 years ago)

Repeats of glacial ages

Holocene epoch(11,700 years ago –today)

From the end of last glacial age - today

History of living organisms

Birth of life （appearance of bacteria） 3.8 x10^9 yeas ago

Beginning of photosynthesis（appearance of cyanobacteria)

Increase of oxygen, formation of ozone layer 3.2 x 10^9

The earliest glacial age (presently known) 2.4～2,2 x 10^9

Huronian glaciation

Snow ball earth hypothesis

Appearance of eucaryote 2.1 x 10^9

Organisms which have nuclear separated by membrane, mitochondria, chroloplast centrosome

Monocellular: Protiocista

Appearance of green algae

Viridiplantae

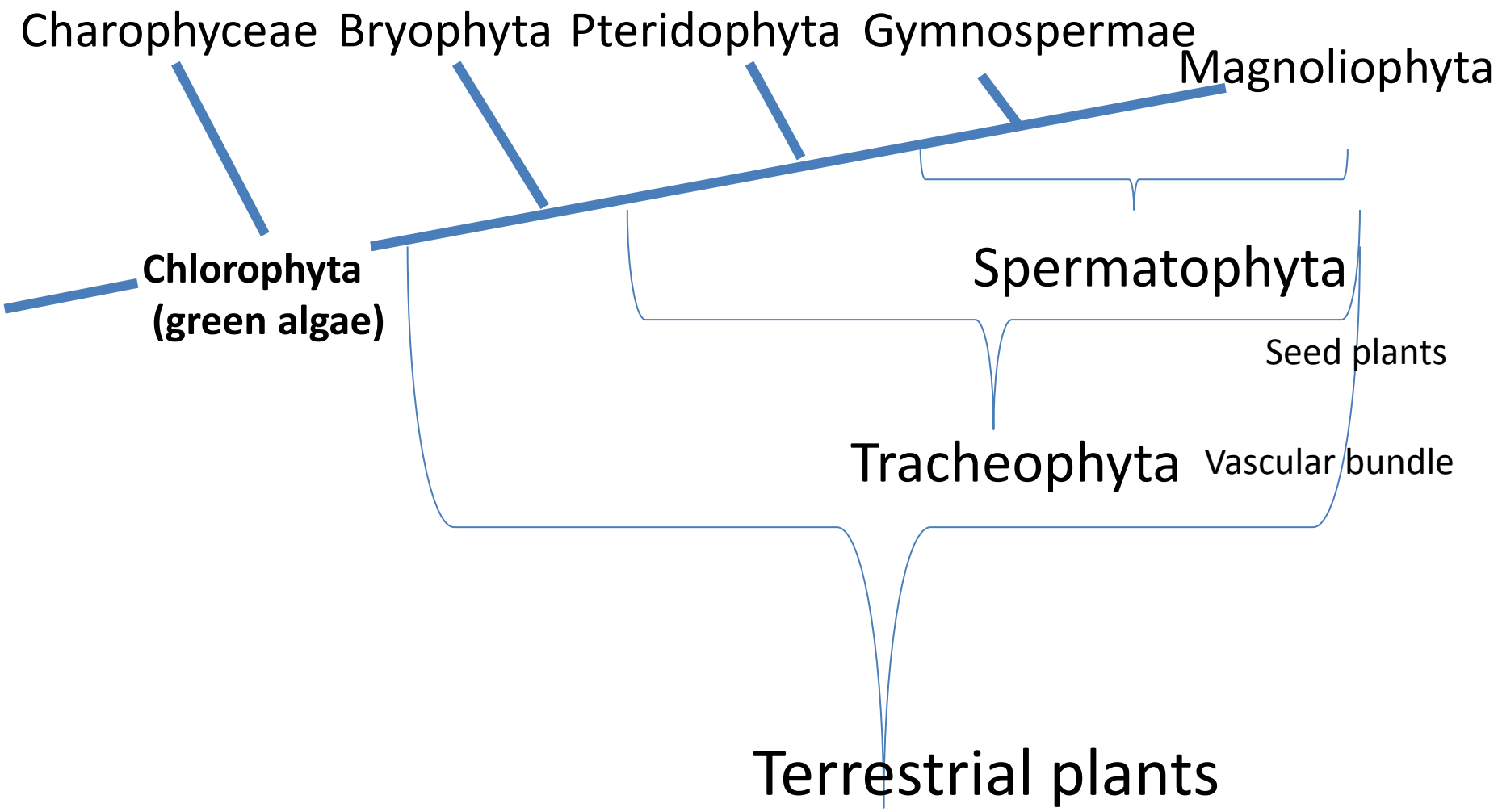
Chlorophyceae, Bryophyte (moss), Fern, Gymnospermae, Magnolyophyta

Photosynthetic pigment Chlorophyll a, b

Cell wall: Mainly cellulose

Storage energy: Starch

Viridiplantae



Photosynthesis

Light reaction: Reduction of water using light energy to make high energy molecule (NADPH, ATP)

Dark reaction: Synthesis of sugars from CO_2 using NADPH and ATP

Vascular bundle

Columnar structure in caulome (Stem)

Material transportation (sieve tube, vessel）

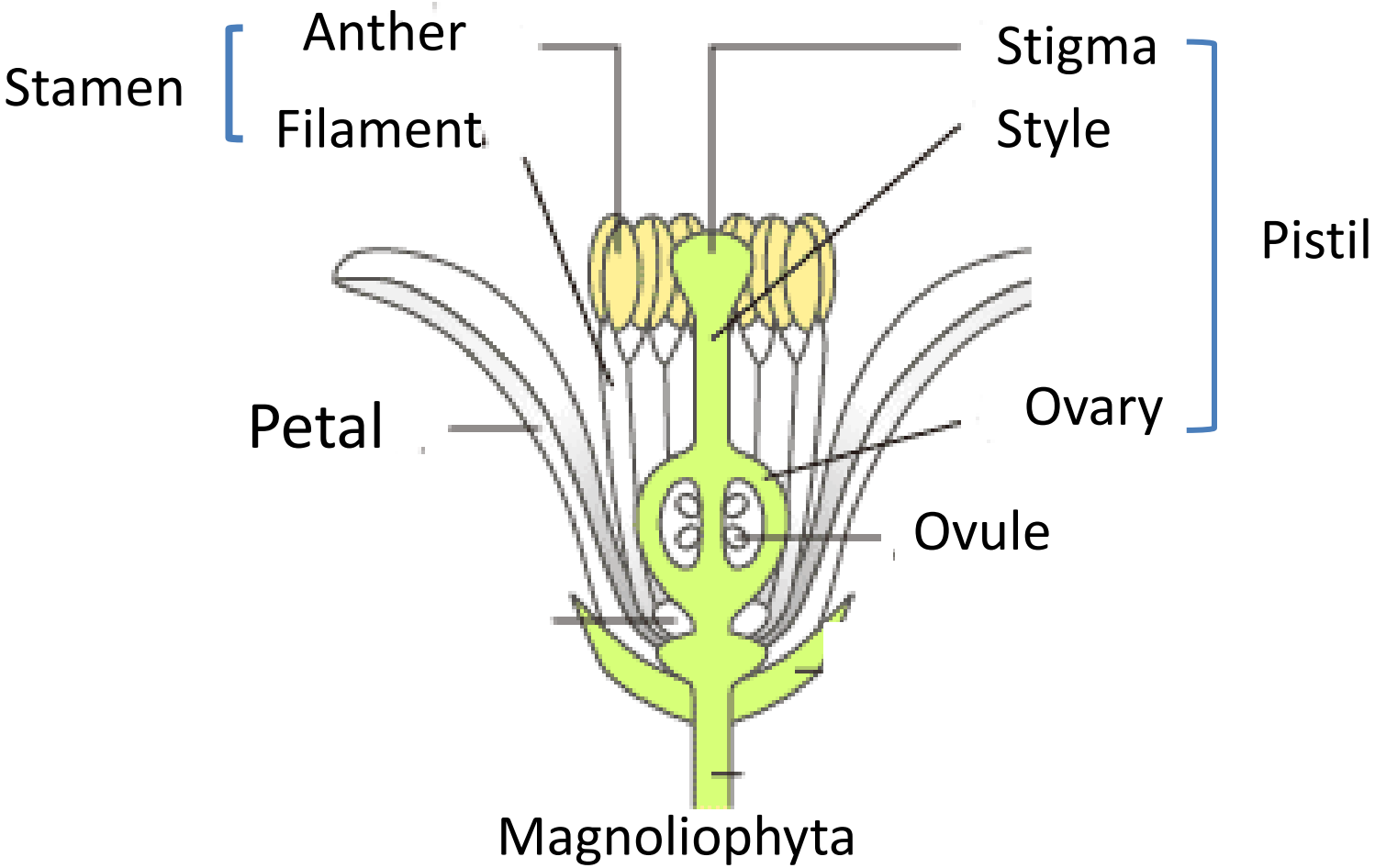
Mechanical support (string）

Cambium layer: between phloem and wood portion

Connecting absorption organ (root) and synthetic organ(leaf)

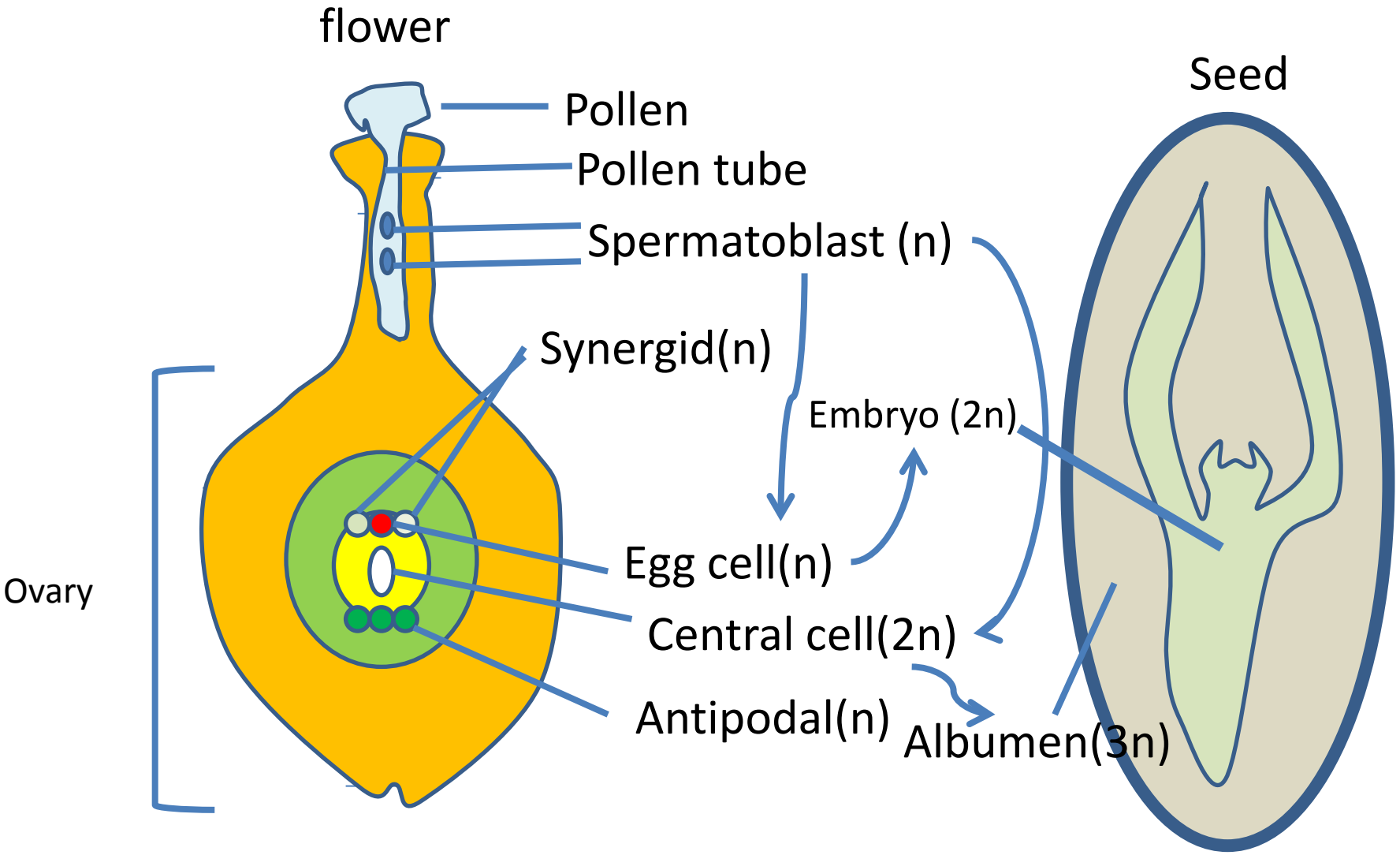
History of living organisms

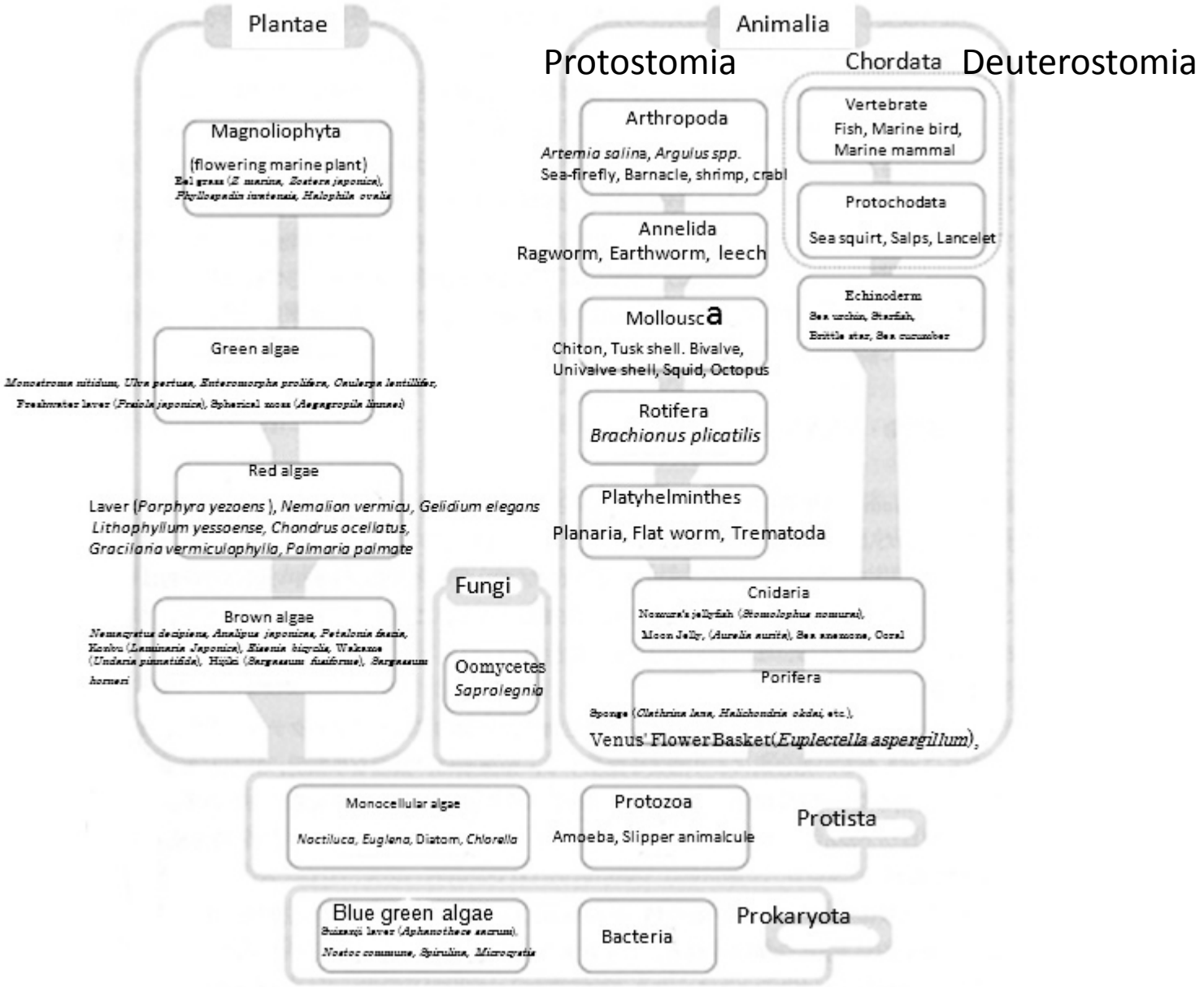
Birth of life （appearance of bacteria）	3.8 x10^9 yeas ago
Beginning of photosynthesis（appearance of cyanobacteria)	3.2 x 10^9
Appearance of Eucaryote	2.1 x 10^9
Appearance of green algae	
Appearance of multicellular organisms	1.0-0.6 X 10^9
Appearance of terrestrial plants	470 X 10^6
Appearance of Spermatophyta (seed plant)	Mid of Paleozoic Era 420-360 x10^6
Appearance of Magnoliophyta	Mesozoic Era Triassic or Jurassic period 251 x 10^3 -146 x10^3



Ovule is covered by carpel and exists in ovary.

Double fertilization





5 kingdoms system

x 10^9 y. ago

3.8	Birth of life
2.7	Beginning of Photosyhthesis (Cyanobacteria)
2.0	Appearance of Eucaryote (incorporation of procaryote)
1.0	Appearance of Multi-cellular organisms
0.47	Appearance of terrestrial plants (from green algae)
0.42	Appearance of Spermatophyta (seed plant)
0.25-0.15	Appearance of Magnoliophyta

Most agricultural crops (rice, wheat, bean, potato, mays, etc) and fruits (apple, orange, banana, strawberry, etc) are Magnoliophyta

Evolution of Animal

x 10^9 y. ago

3.8 Birth of life

2.7 Beginning of Photosyhthesis (Cyanobacteria)

2.0 Appearance of eucaryote (incorporation of procaryote)

1.0 Appearance of Multi-cellular organisms

0.6-0.5 Mass extinction of Protists（Snow ball earth hypothesis)

Appearance of **Ediacara fauna**

Extinction of **Ediacara fauna**

542 x10^6Beginning of Phanerozoic eon (Paleozoic era).

Cambrian period

Appearance of large multi-cellular animals (nearly all animal phyla)

Ordovician period (488-444 x 10^6) Appearance of fish

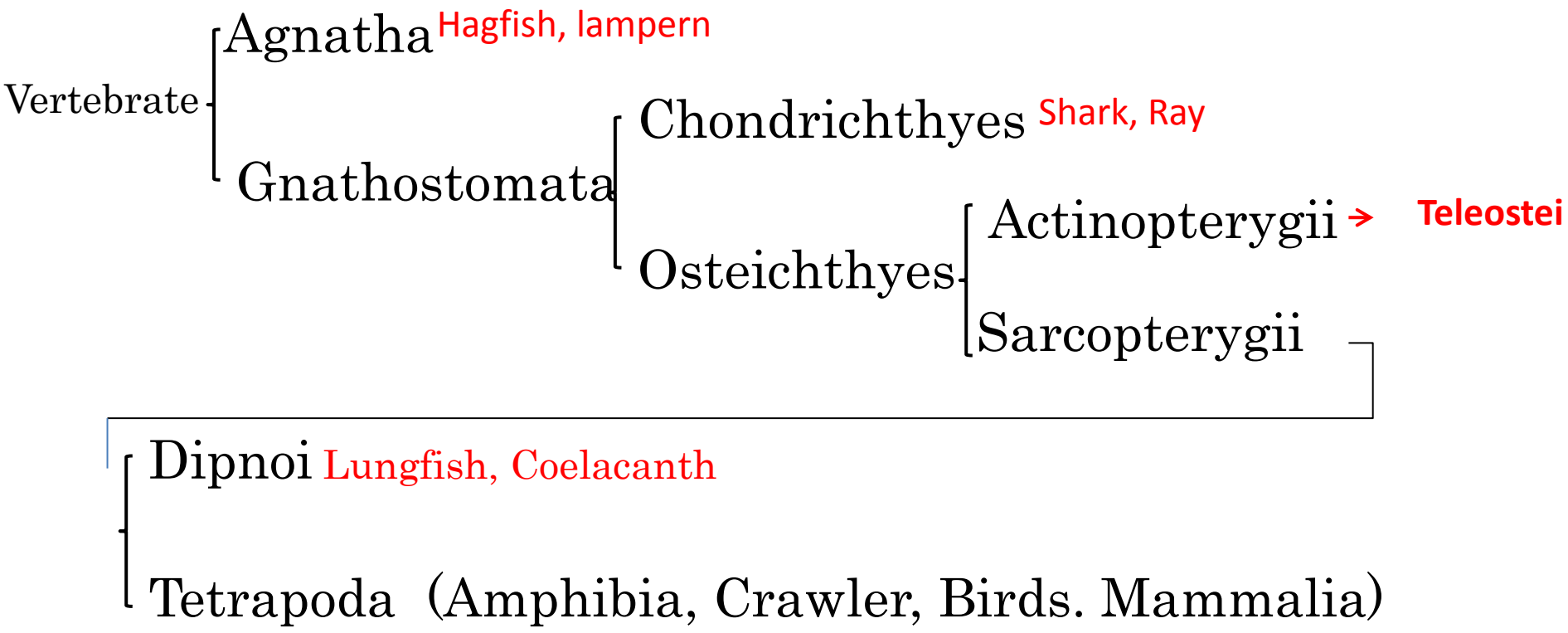
Devonian period (416-359 x10^6) Prosperity of fish

360 x 10^6 Appearance of Amphibia (Terrestrial animal)

300 x 10^6 Appearance of Reptillian (crawler)

225 x10^6 Appearance of Mammalia

Evolution of Vertebrate



Hugfish

lampern

Agnatha Hagfish, lampern

No jaw

Rudimentary inner skeleton (Cartilage, soft bone)

Undeveloped pair fin（Weak swimming capacity)

No air bladder (weak predation)

expand into freshwater environment to escape from nautilus

obtain osmotic control capacity

ChondrichthyesShark, Ray, elephant fish

Well developed chondral (soft bone) inner skeleton

Well developed rays

No air bladder

Actinopterygii (ossification progressed)

air bladder→lung

Actinopterygii： air bladder→floating, go back to ocean

Sarcopterygii: air bladder→lung

Dipnoi Lungfish, Coelacanth

Tetrapda → terrestrial animals

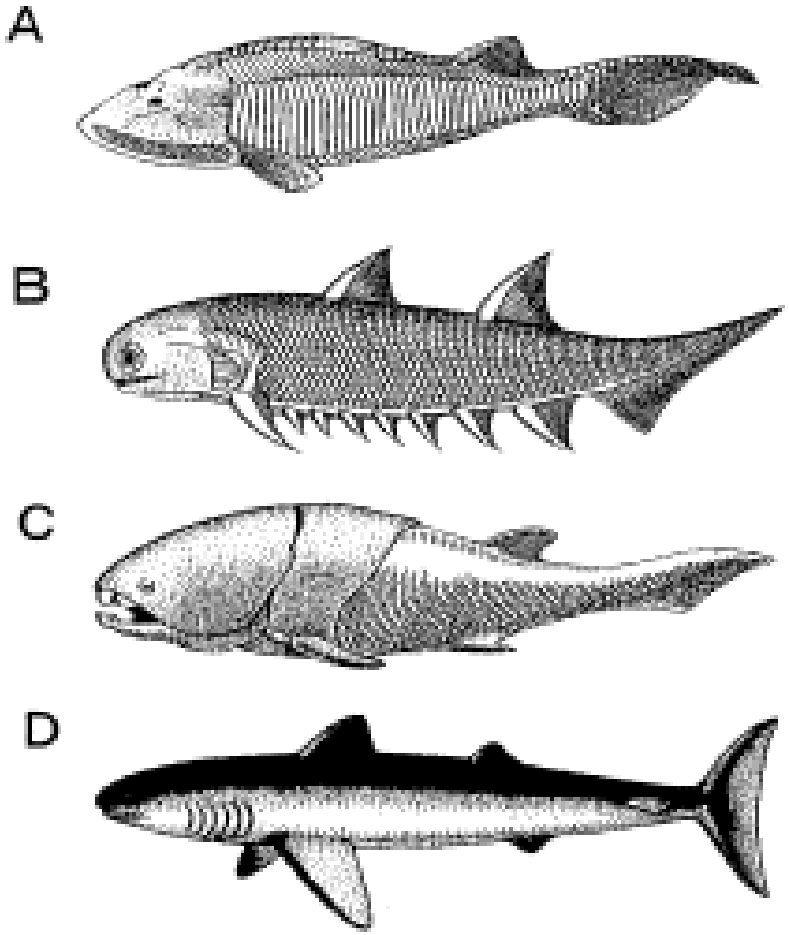
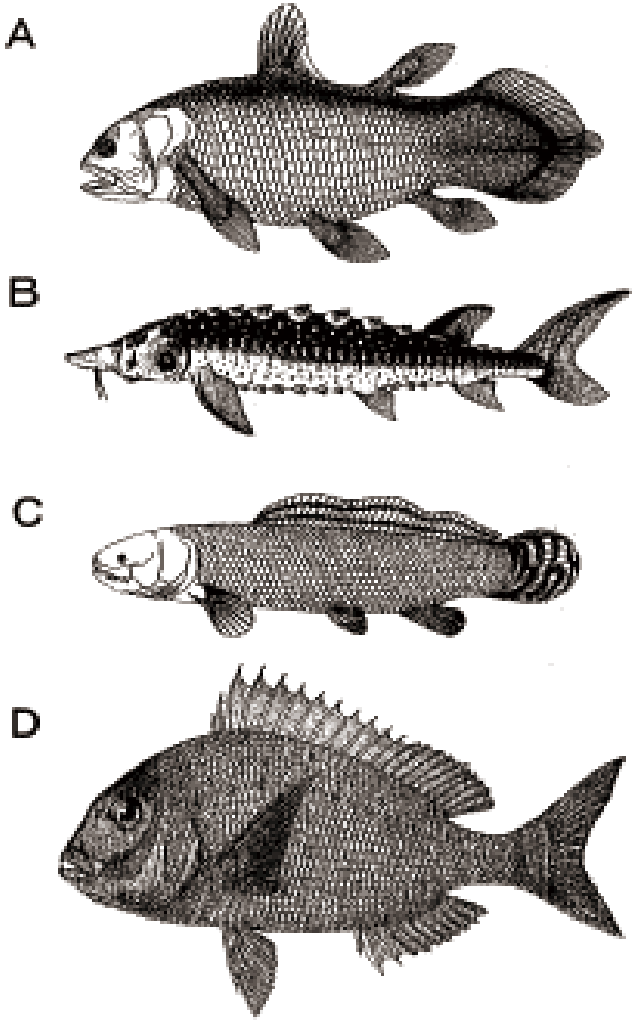


図 1　無顎類から軟骨魚類まで（奥野 1990 より）
A：ヘミキクラスピス（無顎類）
B：エウタカントゥス（棘魚類）
C：ココステウス（板皮類）
D：クラドセラケ（最古の軟骨魚類）



4　現生の硬骨魚類（A ～ C は奥野 1990、D は岡田 1969 より）
A：ラティメリア（肉鰭類）
B：チョウザメ（軟質類）
C：アミア（軟質類）
D：マダイ（真骨類）

Evolution（diversification of adaptation strategy and the Great Dying）

Snow ball earth hypothesis

The earth have been covered with ice to the vicinity of equator three times

In classic theory, snow ball earth was not probable.

When the surface of the earth were covered by ice, albedo of the earth would increase and the earth could not accept enough heat to recover.

The existence of the sea is the evidence

Recent theory for the mechanism to recover from snow ball earth

The sea is weak alkali and huge sink of CO_2 (green house gas)

CO_2 concentration increase by disappearance of sea.

Snow ball earth was contribute to the Great Dying (extinction)

The great dying (Extinction)

Huronian glaciation(2.45- 2.20 x 10^9 yeas ago)

Cyanobacteria consumed CO_2 I the air for phyto-synthesis.

(decrease of green house gas)

CO_2 level recovered by decomposition of dead organisms.

After that organisms that respire oxygen appeared.

Sturtian glaciation（730 x 10^6)and Marinoan glaciation(635x 10^6)

Land area increased, and alkali dissolved to sea.

Excessive CO_2 absorption capacity of sea

decrease green house gas effect

the Great dying of **Ediacara fauna**

↓

Cambrian Explosion

The Great dying after Paleozoic Era

The end of the Ordovician period（435 x 10^6 Y ago)

Explosion of supernova ?

８５% species became extinct. Trilobite decreased to half

Trigger of the Devonian period（prosperity of fish)

The end of the Devonian period (（360 x 10^6 Y ago)

Marine regression, aridification (dry up), Low oxygen

８２%, Armored fish (fish with hard outer skeleton) disappeared

The end of the Permian period（250 10^6 Y ago）

High temperature, low oxygen ?

９０～９５%

Extinction of Trilobite

Ancestor of dinosaur could survive (resistant to low oxygen)

After the Mesozoic era

The end of the Triassic（212 x 10^6 Y ago）

Volcanic action?

76% extinct

Large crawlers died off

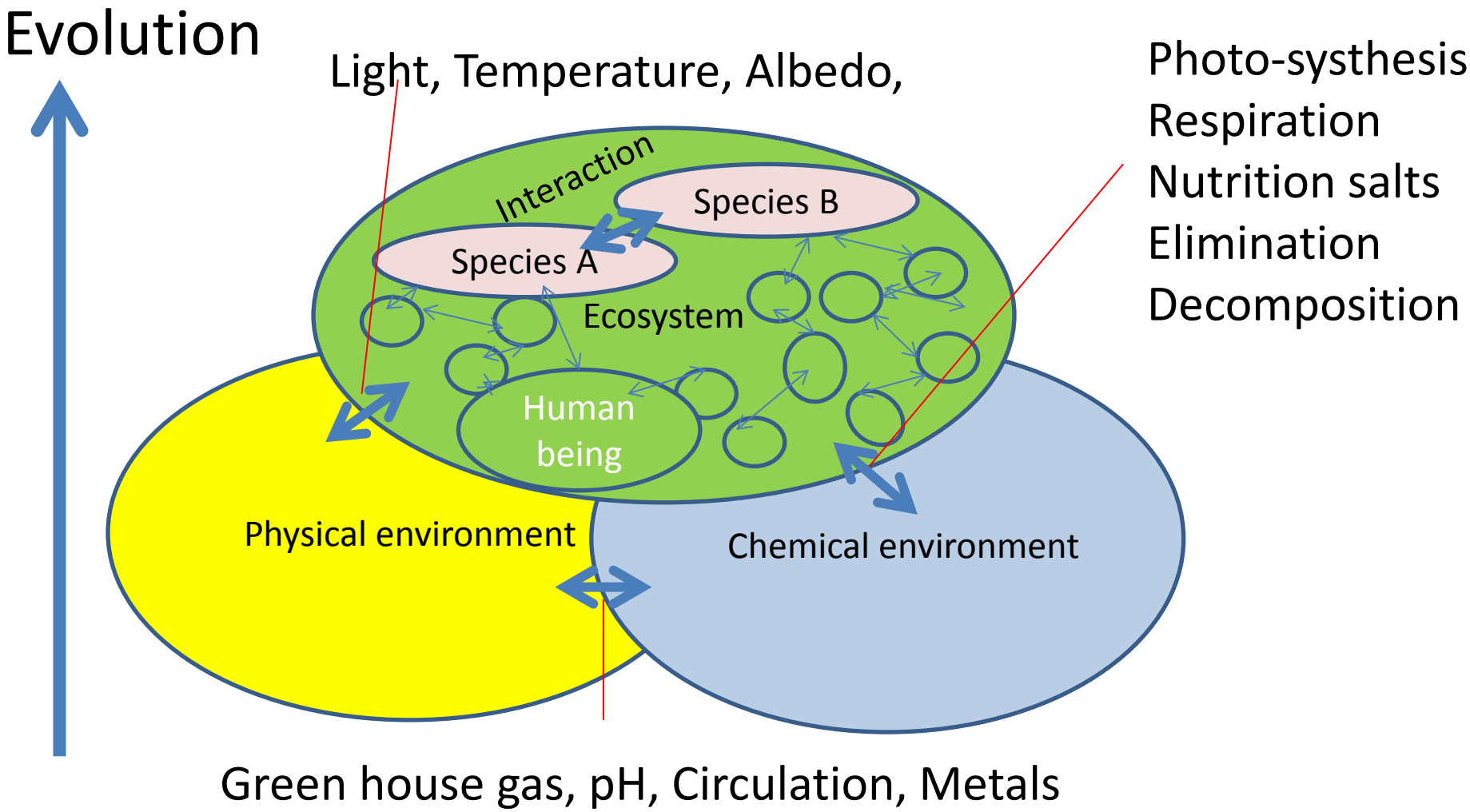
Ancestors of dinosaur were still small

Trigger of the Jurassic Period

The end of the Cretaceous period(65.5 10^6 Y ago）

Falling of huge meteor ?

Extinction of dinosaur


Evolution
Light, Temperature, Albedo,
Photo-systhesis
Respiration
Nutrition salts
Elimination
Decomposition
Interaction
Species B
Species A
Ecosystem
Human being
Physical environment
Chemical environment
Green house gas, pH, Circulation, Metals

Interaction of Species

heterotrophic nutrition: autotrophic nutrition

production of organic substances

predator: prey

Multi cellular organisms (function of mouth)

Competition

Size competition

Tracheophyta

competition of light

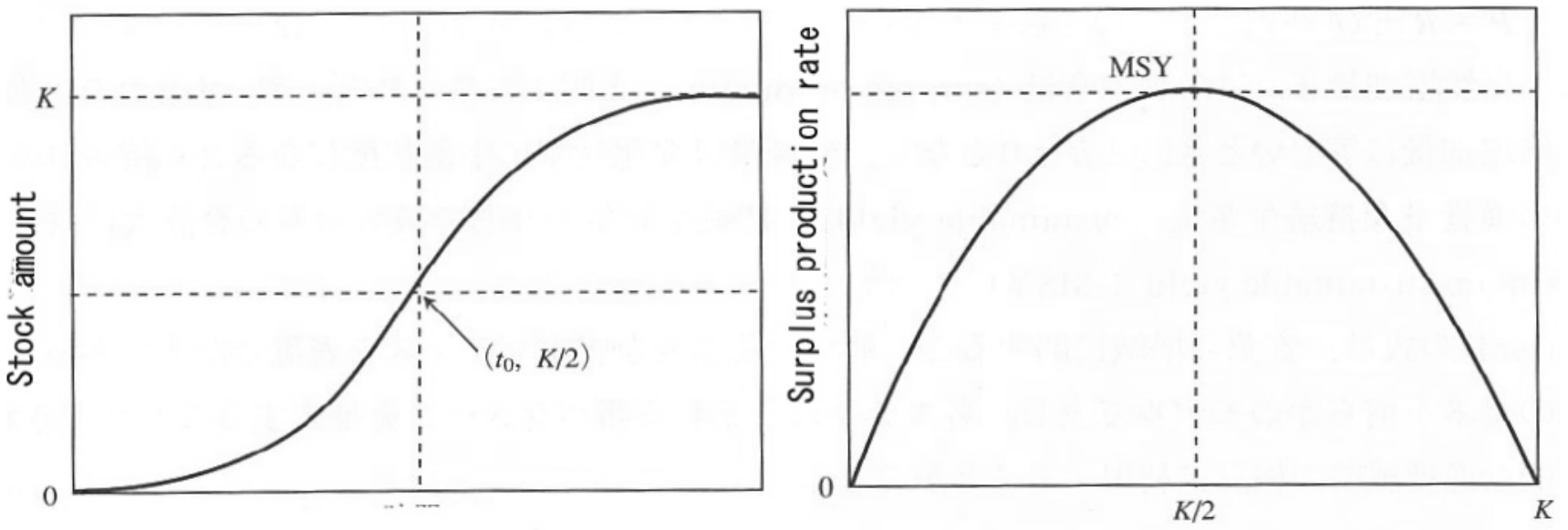
Trade off with absorption and transportation cost

Strategy

r-strategy: K strategy

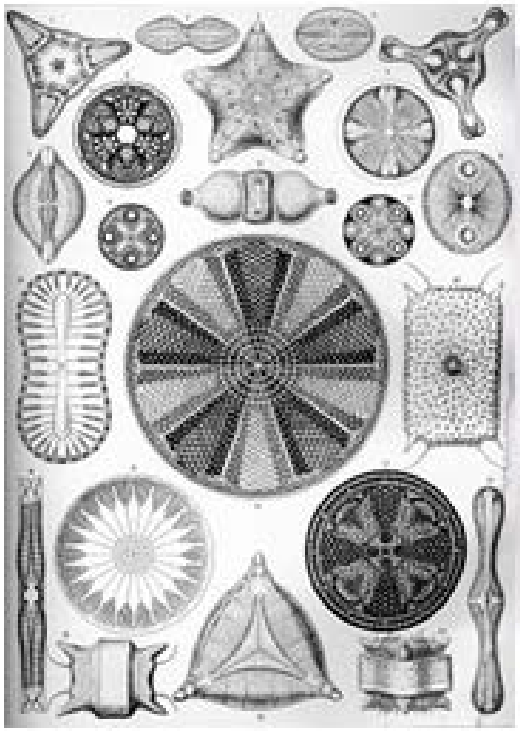
Adaptive strategy : r-K strategy theory

$$\frac{dN}{dt} = r(K - N)N$$



Population growth by logistic model (left) and relation between biomass and population growth rate in Scherfer's surplus production model (right).

Phytoplankton are r-strategy
Large trees are K-strategy



生物生産の特徴

r-strategy

smaller offspring size, larger number or offspring, Shorter life span

K-strategy

Lager offspring size. Smaller number of offspring, Longer life span

r-K strategies are in the relation of trade off.

When egg size increase, the number of egg decrease

In plants, r-selection and K selection exist

Competition for light, water, nutrition salts, etc

Cultivated crops have strategies convenient for human being

Periodical and stable harvest.

Trees are too long,

Phytoplankton are too short and unstable

Reclamation of forest makes place to obtain enough light for cultivated crops.

History of human being

$x10^6$ years ago

65 Appearance of **Primates**

63 Appearance of **Haplorhini (**lacks vitamin C synthesis capacity)

25 Appearance of **Ape**

6-5 Differentiation of human being

Australopithecine

2.5-1.8 Use of stone tools

Oldowan stone affairs (Olduvai valley:Tanzania)

0.5 Appearance of *Homo erectus pekinensis*

0.23 Appearance of *Homo neanderthalensis*

0.2 Appearance of *Homo sapiens*

0.1 *Homo sapiens* departed Africa

0.075 Toba event (gigantic explosion of Toba volcano)

Human population decreased to less than 10 thousands

0.03-0.02 Mongoloids got across to the New World

0.01 The end of last glacial age

Dogs had been domesticated by the end of last glacial age

Mongoloids reached the southern edge of the New World

12,000 BC Cultivation of upland rice in Hoxi and Hunan province in China

11,500 Construction of ruins of Göbekli Tepe (Southeast Turk)

Shrine of hunting people

Village formation ⇆ development of agriculture

9,000年前 Ruins of Jericho

Evidence of keeping animal and agriculture

Barley, Wheat, Pea, Beet

Goat, Sheep, Pig

Evidence of man made channel (Papua New Guinea)

Sugarcane, Yam, Taro, Banana

Dog, Pig, Chicken

Stone axe, Stick (no spade)

7,000-6,500 Large scale paddy rice cultivation (Zhejiang province)

5,000 Evidence of agriculture in the New World

Potato, Tomato, Corn, Pumpkin

Lama, No iron culture

? Savanna agriculture in West Africa

Black eyed pea, gourd, Sesami

Plural origins of agriculture

4500～4000 BC　Construction of shrine in Mesopotamia
Formation of agricultural community (Neolithic age)
3,500 BC　Sumerian moved too south Mesopotamia
3,150 BC　Integration of upper and lower Egypt dynasty
1,800 BC　Oldest iron tool (Kaman Kalehoyuk ruins, Turk)
1,700 BC　Yin dynasty (China)
1,680 BC　Hittite Kingdom was established
(iron culture)
1,190 BC　Downfall of　Hittite Kingdom
expansion of iron culture to Egypt and Mesopotamia

Late　Spring and Autumn period (770年～221 BC）
Popularization of iron too in China

Iron tools and development of agriculture

Iron spade, Iron fork

Working cattle

Large scale irrigation

Domestication of animals

Dog	12,000 BC	North Africa, China, Southwest Asia
Goat	10,000 BC	Southwest Asia
Sheep	10,000 BC	Southwest Asia
Pig	8,000 BC	China, Southwest Asia
Cattle	8,000 BC	West Asia
House	5,000 BC	South Russia
Chicken	4,000 BC	Southeast Asia

Dairy husbandry 5,000 BC Mesopotamia

History of Agriculture

6000 BC Construction of irrigation facilities

Mesopotamia, Egypt, Iran

600 BC Wood harrow

8-9 century Feudal system was established in Europe

Agricultural community popularized in west Europe

Against entrance of different ethnic groups

10-11 C Beginning of three field system in Europe

1492 Columbus discovered the New World

18 C Agricultural revolution

Norfolk farming method

Barley→Clover→Wheat→Turnip

Enclosure → Rich land owner

Industrial revolution

Colony: Supplier of raw materials, consuming region

1798 "Theory of population"(Malthus)

1817 "Principles of political economy and taxatation"(Ricardo)

Gain from trade, Comparative advantage

1859 “On the origin of species” (Darwin)
Sale of steam tractor
1865 Discovery of Mendel’s Law
1892 Sale of internal combustion tractor
1900 Rediscovery of Mendel’s Law
1908 Invention of Haber-Bosh process
Cheap fertilizer
1917 Sale of Fordson Tractor model F
1940-1960 Green revolution
1945 Institution of FAO
1953 Propose of Double helix structure of DNA
(Watson and Crick)
1958 Keeling start the measurement of CO2 in atmosphere
in Hawaii

1960 Founding of IRRI (International Rice Research Institute)
1962 Rachel Carson published “Silent Spring”
1966 IR-8 was made
1979 Completion of Aswan High Dam
1971 Institution of CGIAR
Consultation Group for International Agricultural Research
1972 Club of Rome published “The limit to growth”
1986 Start of GATT “Uruguay Round”
1995 Founding of WTO (World Trade Organization)
2008 Escalation of oil and crop prices
2011 Accident in Fukushima Atomic Power Plant

Home work

Make resume of this lecture within 200word in English and 300 characters in Japanese.

Submit the resume through e-mail (report@iai.ga.a.u-tokyo.ac.jp) as attachment file of word