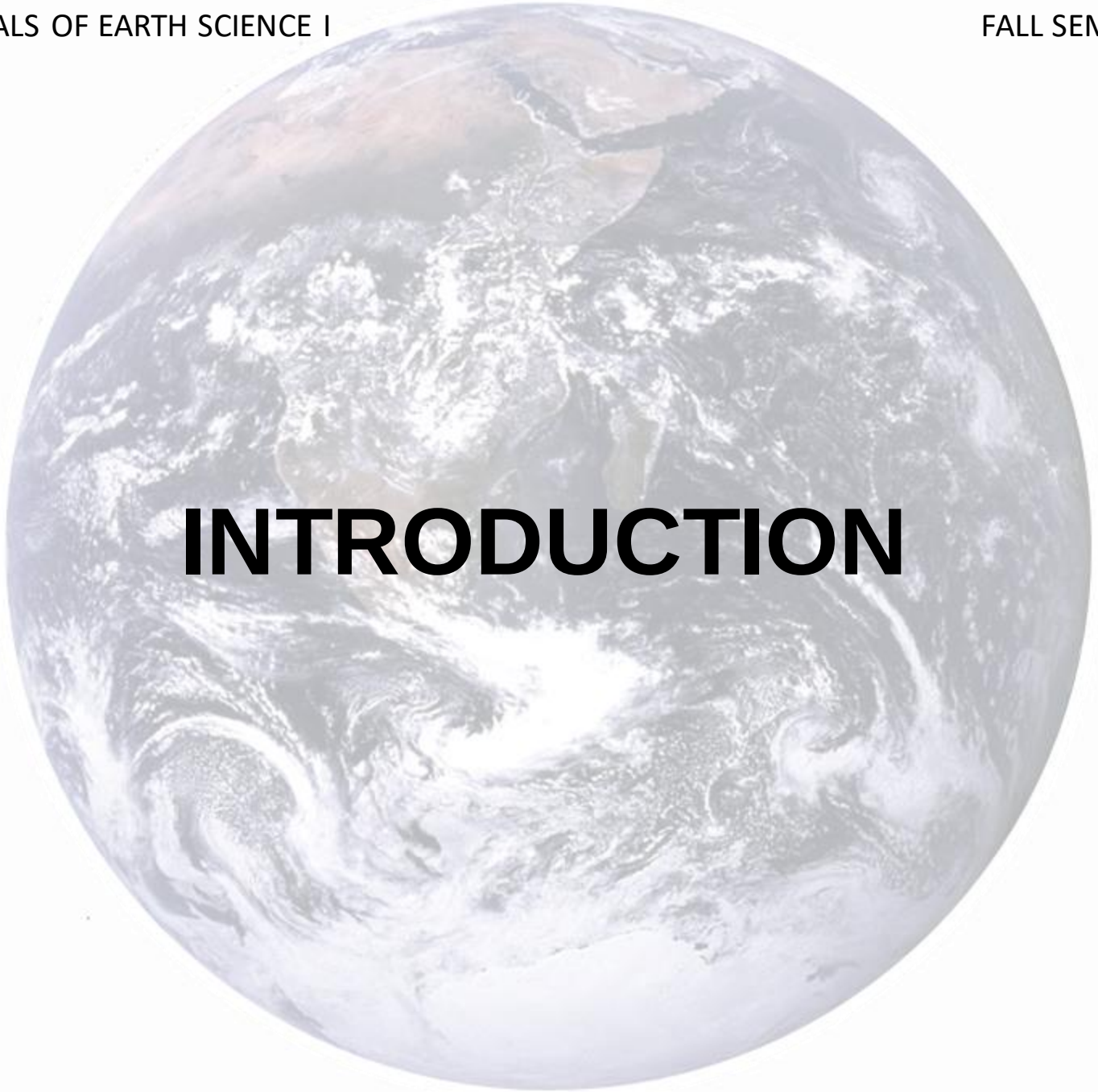
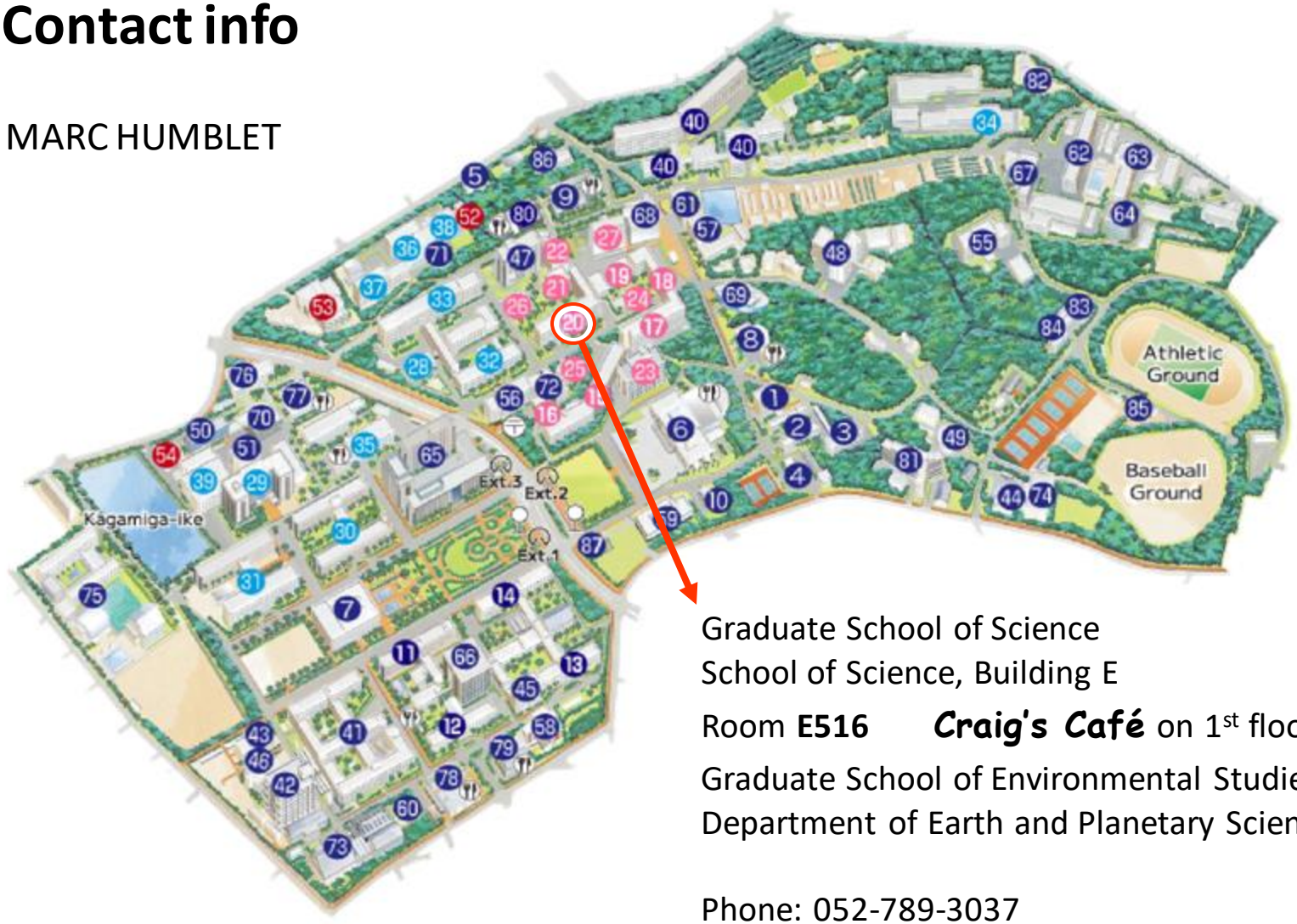


INTRODUCTION

- **Contact info**

MARC HUMBLET



Graduate School of Science
School of Science, Building E
Room **E516** ***Craig's Café*** on 1st floor
Graduate School of Environmental Studies
Department of Earth and Planetary Sciences

Phone: 052-789-3037
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http://www.nagoya-u.ac.jp/en/global-info/access-map/higashiyama/

Lecture 1	Introduction	**15/10**	(Chapter 1)
Lecture 2	The Solar System	**22/10**	Chapter 9
Lecture 3	Plate Tectonics	**29/10**	Chapter 2
Lecture 4	Minerals + Test 1 (lectures 1-3)	**5/11**	Chapter 3
Lecture 5	Rock I: Igneous Rocks	**12/11**	Chapter 4
Lecture 6	Rock II: Sedimentary Rocks	**19/11**	Chapter 5
Lecture 7	Lecture + Test 2 (lectures 4-6)	**3/12**	
Lecture 8	Rock III: Metamorphic Rocks	**10/12**	Chapter 6
Lecture 9	Lab session	**17/12**	
Lecture 10	The Age of Rocks	**TBD***	Chapter 8
Lecture 11	Paleogeography + Test 3 (lectures 8-10)	**26/12***	Chapter 10
Lecture 12	Origin and Evolution of Life I	**27/12***	Chapter 11
Lecture 13	Origin and Evolution of Life II	**8/1***	Chapter 11
Lecture 14	Lecture	**TBD***	
Lecture 15	Test 4 (lectures 3 + 11-14)	**14/1**	

* Make-up days

Lecture 1	Introduction	**15/10**
Lecture 2	The Solar System	**22/10**
Lecture 3	Plate Tectonics	**29/10**
Lecture 4	Lecture + Test 1 (lectures 1-3)	**5/11**
Lecture 5	Minerals + intro rocks	**12/11**
Lecture 6	Rock I: Igneous Rocks	**19/11**
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Lecture 14	Origin and Evolution of Life II	**TBD***
Lecture 15	Test 4 (lectures 3 + 11-14)	**14/1**

* Make-up days

- **Some more information**

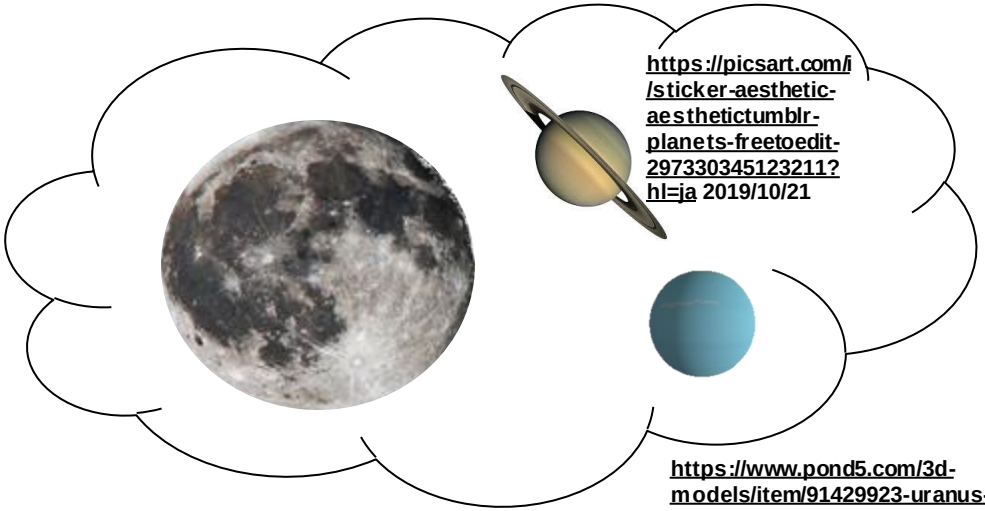
  - Test 1 (lectures 1-3)
  - Test 2 (lectures 4-6)
  - Test 3 (lectures 8-10)
  - Test 4 (lectures 3 + 11-14)

  - Tests: **25%** each (MCQ + short-answer Q)

SLIDES & **NOTES** AVAILABLE ONLINE FROM YOUR NUCT ACCOUNT

NO **ABSENT GRADE** AFTER **15th of November**.

Stargazing event (Fall or Spring semester)



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https://www.pond5.com/3d-models/item/91429923-uranus-planet 2019/10/21

©いらすとや

1 day field trip

Mizunami (Gifu Prefecture)

15-20 million years old fossils

Observation of outcrops
Fossil museum
Fossil hunting (depending on weather)

http://www.city.mizunami.lg.jp/docs/2014092922681/

✶ The scientific method

Finding things out about how nature works through observations and experiments

☺ Define a problem (questions)

☺ Collect data (through observations and experiments)

☺ Analyze data

☺ Formulate a **hypothesis** explaining the problem

☺ Confront hypothesis with new data, repeated testing

→ reject or keep with or without modifications

+ Scientific publication after **peer review**

- Set of hypotheses explaining some aspect of nature = **theory** (testable!)

  e.g. Darwin's theory of evolution by natural selection

- General principles about how the Universe works = **physical laws**

  e.g. Newton's law of gravity

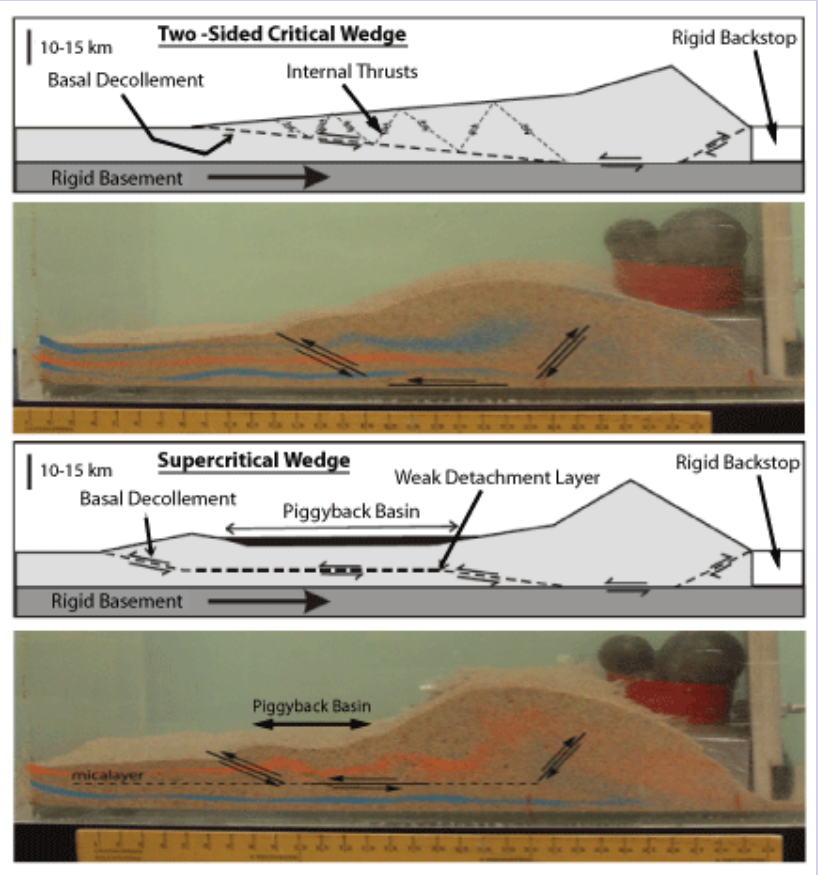
- Precise representation of how a natural system behaves based on many hypotheses and theories = **scientific model**

A model simulates and predicts the behavior of a natural system. A model can be for example a mechanical device (analogical modeling) or a computer simulation (numerical modeling).

Darwin's evolutionary tree of Life

Analogue modeling (geology)

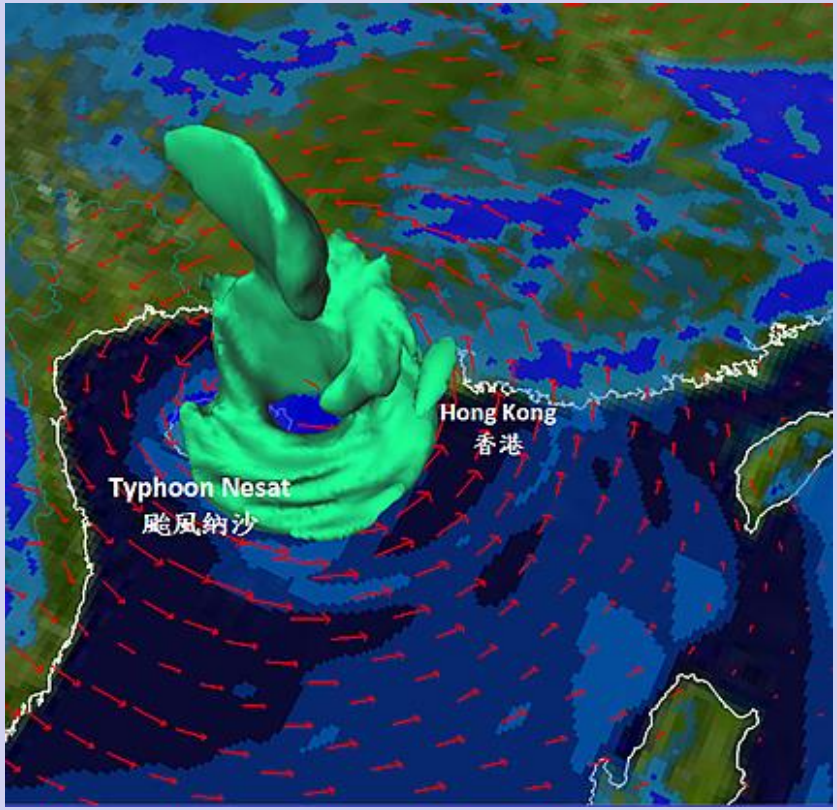
Example: fold and fault formation



Félice M.J. Naus-Thijssen (Uni. of Maine)

Numerical modeling
→ Computer models

Example: weather forecast



http://www.hko.gov.hk/aviat/amt_e/nwp_e.htm

✶ *Earth Science: a multidisciplinary field*

- **Geology**: study of the solid Earth (rocks) - history, composition, internal structure, and surface features

  Paleontology: study of past life based on fossils
  Geophysics: study of geological processes using tools and principles of physics
  Geochemistry: study of geological processes using tools and principles of chemistry

  Geologic record: information preserved in rocks formed at various times

  Data gathering: field observations, mapping, sampling, lab analysis (e.g. dating)

- **Other branches of Earth Science (or geoscience):**

  Oceanography: study of the oceans

  Meteorology: study of the atmosphere

  Geobiology: Study of the interactions between biosphere, lithosphere, hydrosphere and atmosphere (paleontology, micro-biology, sedimentology…)

- **Planetary science**: Study of planetary systems (planets, moons…)

  Ancient streambed gravels on Mars →

NASA

A classification of scientific disciplines

Historical	Partially historical	Non-historical
Paleontology Cosmology	Geology Evolutionary Biology	Physics Chemistry
Systematic observations used to construct and verify hypotheses about past events		Highly accurate theoretical predictions that can be verified in the lab

OBSERVATIONS → EXPERIMENTS

Data acquired by experiments or observations (empirical data) used to construct and verify/test hypotheses

Based on "Nonsense on stilt: How to tell science from bunk" by Massimo Pigliucci (2010)

A brief history of geology

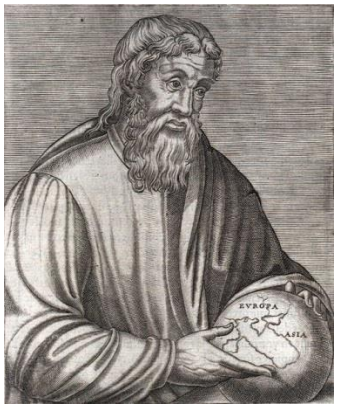
✶ Ancient Greek philosophers

Fossils of marine organisms (e.g. seashells) found well above sea level

Erastosthenes* (3rd century BC)

Hypothesis: sea level fall caused by the opening of the Strait of Gibraltar

* First person to calculate the circumference of the Earth



Strabo (ca. 63 BC – ca. AD 24)

Hypothesis: events like earthquakes, volcanic eruptions, landslides caused sea level variations


IRL
GBR
NLD
BEL
DEU
POL
BLR
KAZ
ATLANTIC
OCEAN
Celtic Sea
English Channel
LUX
CZE
UKR
RUS
SVK
AUT
MDA
Sea of Azov
FRA
CHE
HUN
Bay of Biscay
SVN
HRV
ROU
BIH
GEO
Black Sea
Ligurian Sea
SRB
Adriatic Sea
AND
ITA
BGR
PRT
ESP
MKD
Sea of Marmara
Balearic Sea
Tyrrhenian Sea
ALB
Thracian Sea
TUR
GRC
Aegean
Mediterranean
Strait of Gibraltar
Alboran Sea
Ionian Sea
Myrtoan Sea
Cilician Sea
SYR
CYP
Sea of Crete
LBN
IRQ
MLT
MAR
Libyan Sea
Sea
ISR
JOR
TUN
SAU
DZA
EGY
LBY
Red Sea
Tropic of Cancer
MRT
MLI
SDN
0°
10°E
20°E
30°E
40°E
30°N

✶ Ancient Greek philosophers

The peripatetics (Aristotle, 4th century BC)

The Earth is eternal. Processes of destruction are balanced by processes of regeneration so that a state of equilibrium is maintained.

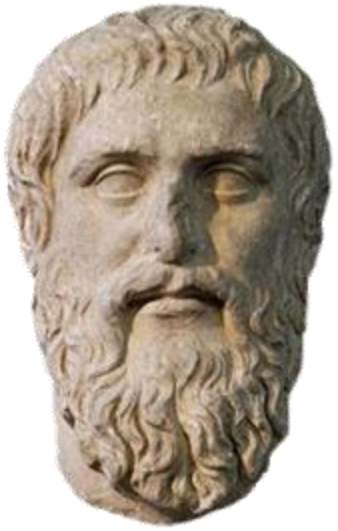
https://www.nationalgeographic.org/ 2019/10/21

The stoics (Zeno, 4th/3rd century BC)

The Earth is destroyed and periodically restored to its previous identical state with the same events happening again.

The epicureans (Epicurus, 4th/3rd century BC)

The Earth is destroyed and periodically restored but the same events do not necessarily happen again.



Plato (5th/4th century BC)

The Earth is not eternal because it has been created. The World itself is not destroyed periodically but all living creatures are by natural disasters of exceptional intensity. These destructions are divine acts carried out in order to purify the Earth.

✶ The World according to a 17th-century philosopher

René Descartes (1596-1650)

The Universe is filled with three types of particles. The stars are made of one type (matter of light). Terrestrial bodies are made of another. The sky is made of yet another type of matter.

Stars evolve into planets by formation of a solid crust around a central fire.

<u>Descartes' model of Earth formation</u>

REJECTED

...central fire; M = layer of the material of sunspots; B = atmosphere; C = ...r earth's crust (metallic); D = ocean; E = upper earth's crust (stony); ...subterraneous cavity

Figure 3.1. The Formation of the Earth (Modified after Descartes, Principles of Philosophy, 1644). The two diagrams (a and b) show the last two successive stages of the formation of the earth.

Gohau (1990)

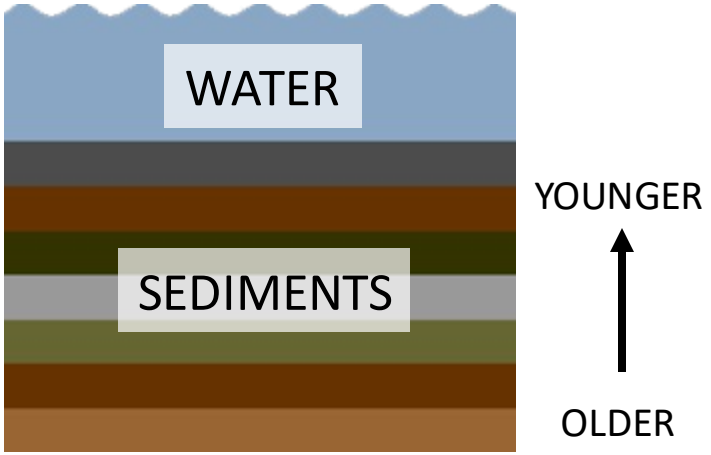
✶ The first geologists

Nicolas Steno (1638-1686)

First evidence of the organic origin of fossils based on the close resemblance between the fossil Glossopetrae and modern shark teeth.

Berkeley

First to realize the possibility to distinguish continental and marine sedimentary rocks based on their fossil contents: marine organisms vs. terrestrial plants.



First to formulate the principles of horizontality and superposition: sediments are originally deposited flat with older layers at the bottom and younger layers at the top.

✶ Two opposing theories of the 18-19th century

Neptunism

Benoît de Maillet (1656-1738)
Abraham Gottlob Werner (1749-1817)

Primitive Earth completely covered by ocean

Sea level has been dropping progressively

Rocks formed either by chemical precipitation of minerals or by deposition of sediments in the sea

Limited influence of Earth's internal heat on landscape

Modern landscape results from combined effects of erosion and deposition

REJECTED

http://monia2009.centerblog.net/voir-photo?u=http://monia2009.m.o.pic.centerblog.net/ahdbe5xj.jpg 2019/10/21

Plutonism

Lazzaro Moro (1687-1764)
James Hutton (1726-1797)

Major influence of Earth's internal heat on landscape (formation of mountains by uplift of the land)

Magmatic origin of magmatites

Role of heat and pressure in the process of sediment induration

CONFIRMED to some extent

https://shibamatax.exblog.jp/10755702/ 2019/10/21

✶ Contractionism: a popular theory of the 19th century

Léonce Élie de Beaumont (1798-1874)

Edward Suess (1831-1914)

Cooling of the Earth causes contraction of the globe and folding and collapse of the crust

https://www.mattid.no/nettbutikk/frukt-/-gront/frukt-/-baer/epler-gule-1kg 2019/10/21

https://www.dreamstime.com/stock-images-aging-skin-image17344544 2019/1021

✶ Uniformitarianism vs. catastrophism

Uniformitarianism

Charles Lyell (1797-1875)

Uniformitarianists held that "the present is the key to the past". They believed in the slow, gradual evolution of geological features and life, and emphasized the long duration of geological time.

CONFIRMED

But...

National Geographic

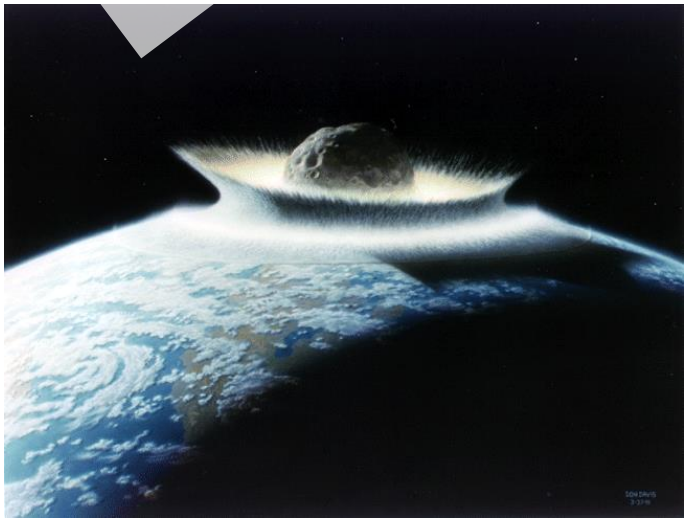
Catastrophism

Georges Cuvier (1769-1832)

Catastrophists held that catastrophes are the cause of many of the geological features we observe today and have caused multiple species extinctions. The intensity and/or nature of the former causes have no equivalent in present days.

REJECTED

But...



NASA (artist: Don Davis)

✶ Continental drift: a turning point in Earth science

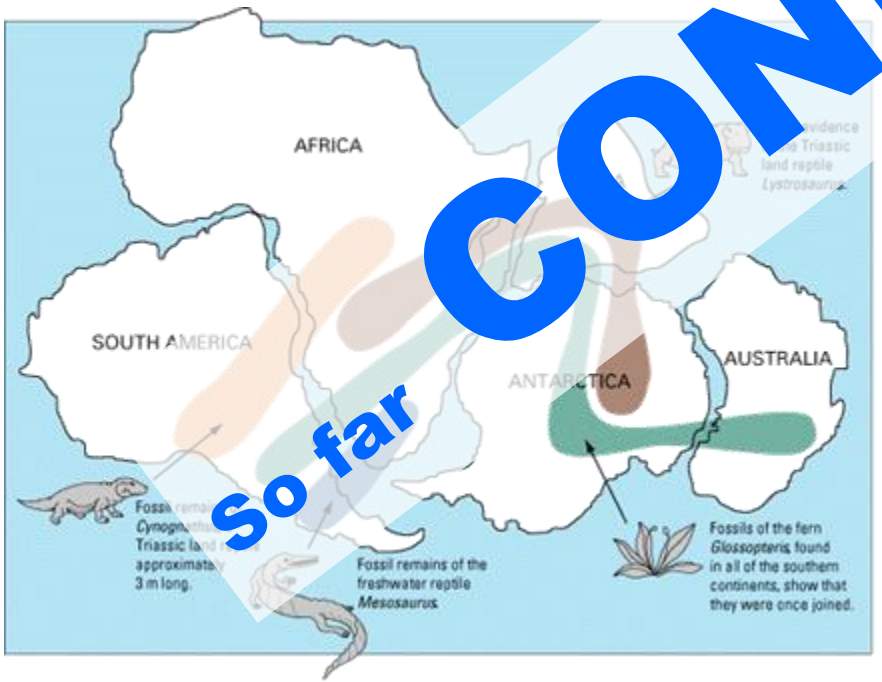
Alfred Wegener (1880-1930)

Wegener proposed that continents are slowly drifting based on strong scientific evidence

Congruence of coastline shape on both sides of the Atlantic

Similarities in geological features of mountain chains on both sides of the Atlantic (age, nature, and orientation of geological structures)

Antonio Snider-Pellegrini's map (1858)



USGS

Same fossils of plants and animals found in different continents at the end of the Paleozoic

Supporting evidence from paleoclimate data

Question: which mechanism lies behind continental drift?

CONFIRMED

So far

✶ The age of the Earth

Age based on religious believes

Archbishop James Ussher (1581-1656): **6000** yrs, based on a careful study of the Old Testament

Early scientific calculations

Comte de Buffon (1707-1788): **75,000** yrs, based on the time it takes for red-hot cannon balls to cool down extrapolated to an iron ball the size of the Earth

Jean Fourier (1768-1830): **100,000,000** yrs, based on a set of mathematical equations taking into account the insulating effect of the Earth's crust

Lord Kelvin (1824-1907): between **20,000,000** and **400,000,000** yrs, based on more advanced calculations in thermodynamics

John Joly (1857-1933): between **80,000,000** and **90,000,000** yrs for the oceans, based on their sodium content and assuming a constant supply rate by rivers

Radiometric dating and the correct age of the Earth

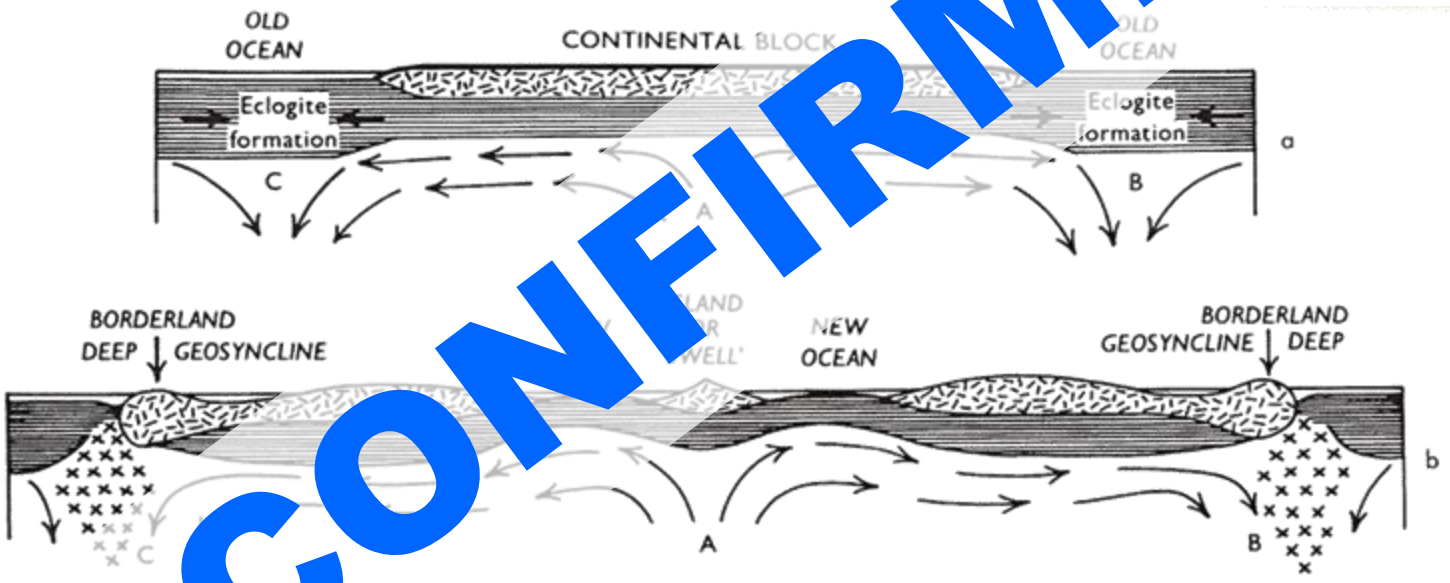
Henri Becquerel (1852-1908) discovers radioactivity in 1896.

Ernest Rutherford (1871-1937) came up with a technique to measure the age of rocks based on radioactive decay. He was the first to date a mineral and came up with an age of 500,000,000 years.

Clair C. Patterson (1922-1995): **4,550,000,000** yrs, currently accepted age of the Earth based on the age of meteorites

✶ Wegener's continental drift

Arthur Holmes (1890-1965) suggested that convection currents resulting from the heat generated by radioactivity could be the driving force of continent drift.



Gohau (1990)

CONFIRMED

So far

✶ Sea floor spreading: a mechanism explaining continental drift

Harry Hess (1906-1969) **and Robert Dietz** (1914-1995)

Discovery of the mid-Atlantic Ridge in 1872

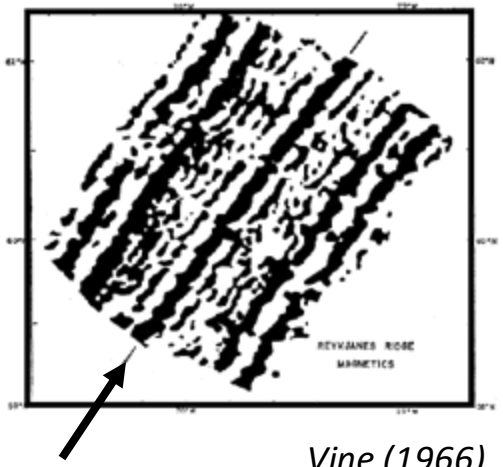
In the 1950s, other mid-oceanic ridges are discovered and associated with intense seismic activity

Disparities in the orientation of magnetic minerals in rocks of the same age on different continents support the theory of continental drift

Symmetry of patterns of magnetic reversals on both sides of mid-ocean ridges

CONFIRMED

So far



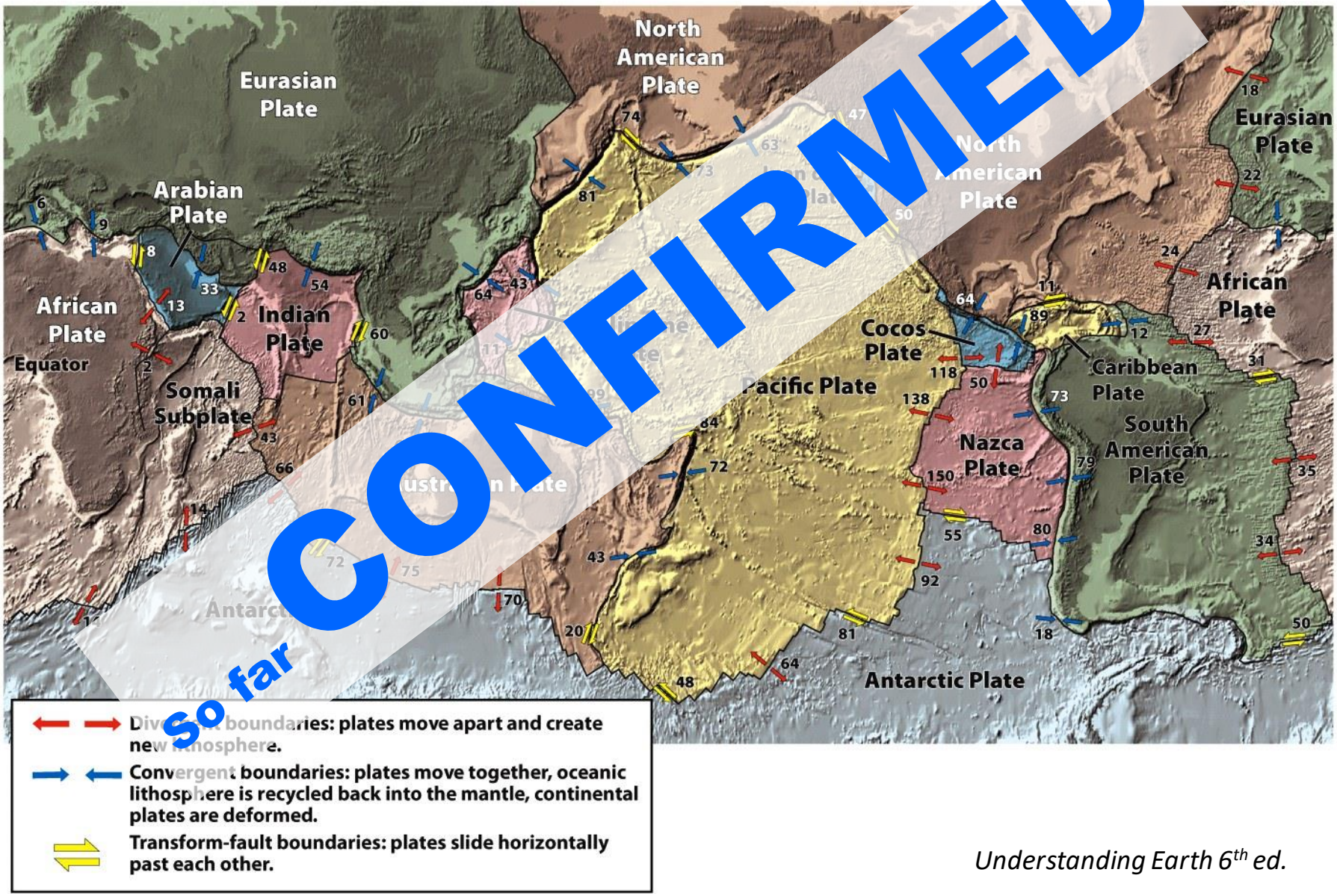
OCEAN RIDGE

Vine (1966)

New oceanic crust constantly produced by rising magma (linked to convection currents inside the Earth) at mid-ocean ridges whereas older oceanic crust is recycled at oceanic trenches where it plunges deep inside the Earth

✶ Plate tectonics: the unifying theory of Earth science

Sea floor spreading implies that the earth crust is divided into plates.



Understanding Earth 6th ed.