GEOLOGIC TIME

TOPIC 1: RELATIVE DATING

TOPIC 2: ABSOLUTE DATING

TOPIC 3: EARLY EVOLUTION

TOPIC 1: RELATIVE DATING

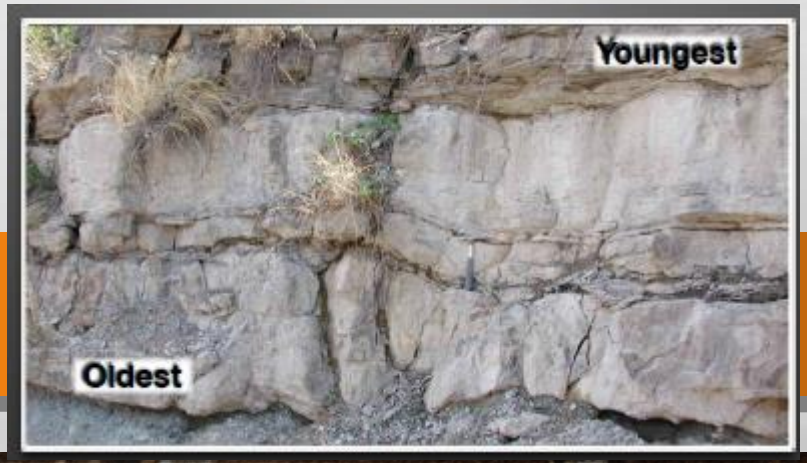
- ESSENTIAL QUESTION: HOW DO WE DETERMINE A ROCK'S AGE BY THE SURROUNDING ROCKS?

TOPIC 1: RELATIVE DATING

- UNIFORMITARIANISM: THE IDEA THAT THE SAME FORCES HAVE BEEN AND CONTINUE TO BE WORKING ON AND CHANGING EARTH
- "THE PRESENT IS THE KEY TO THE PAST"

TOPIC 1: RELATIVE DATING

- **RELATIVE DATING:** METHOD OF DETERMINING A ROCK'S OR EVENT'S AGE COMPARED TO OTHER ROCKS OR EVENTS
- **PRINCIPLE OF SUPERPOSITION:**
  - THE BASIS FOR RELATIVE DATING
  - STATES THAT THE BOTTOM ROCK LAYER IS OLDEST AND EACH LAYER ABOVE IT GETS PROGRESSIVELY YOUNGER



TOPIC 1: RELATIVE DATING

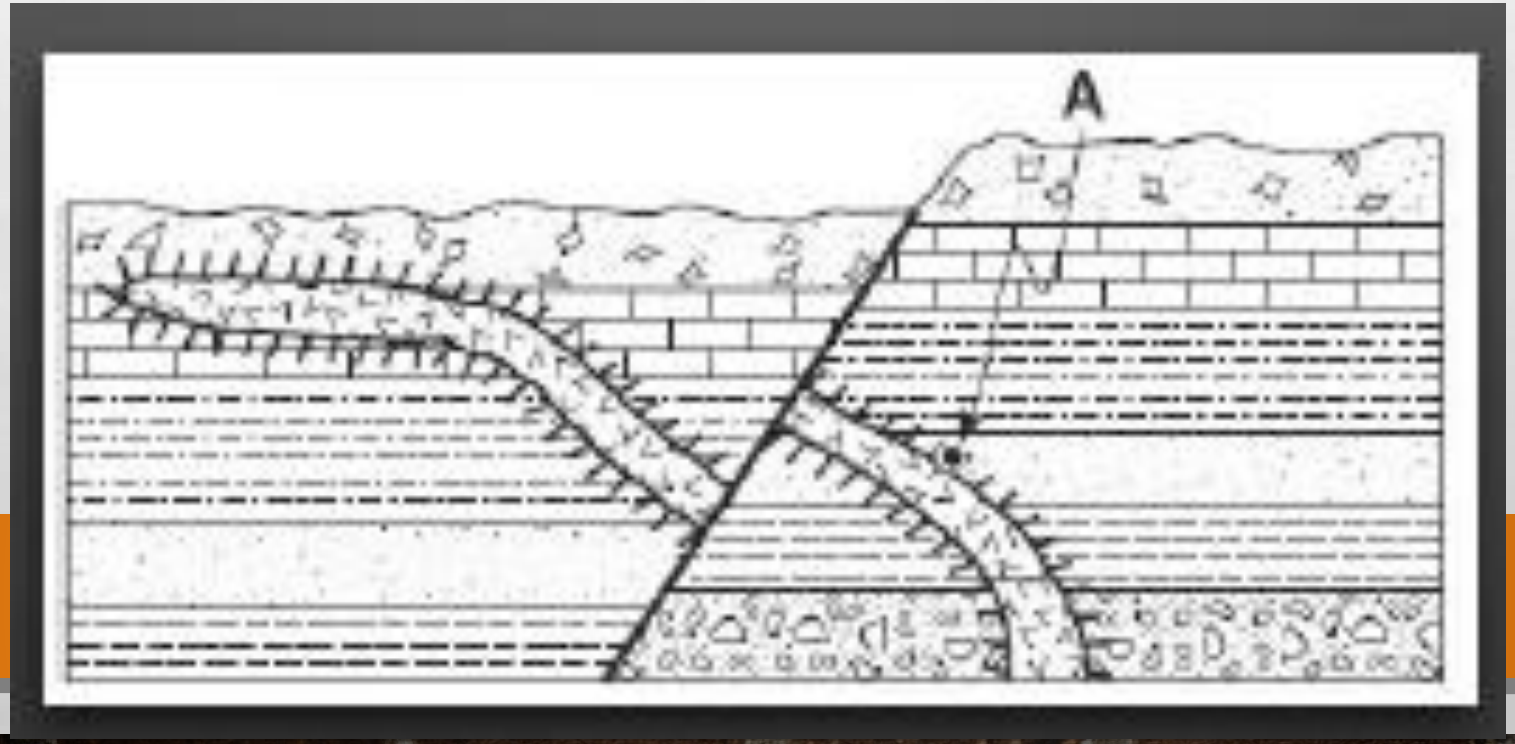
- **ORIGINAL HORIZONTALITY:**
  - **SEDIMENTARY AND IGNEOUS ROCKS ARE DEPOSITED IN HORIZONTAL, PARALLEL LAYERS TO EARTH'S SURFACE**

TOPIC 1: RELATIVE DATING

- BUT AS HAPPENS IN NATURE, THERE ARE EXCEPTIONS TO SUPERPOSITION/ORIGINAL HORIZONTALITY
- INTRUSIONS:
  - WHEN MOLTEN ROCK SQUEEZES INTO PRE-EXISTING ROCK LAYERS (MAGMA)
    - YOUNGER THAN THE ROCKS THEY CUT ACROSS

TOPIC 1: RELATIVE DATING

- **CONTACT METAMORPHISM: TEMPERATURE-INDUCED CHANGE OF PRE-EXISTING ROCKS ALONG AN INTRUSION**



TOPIC 1: RELATIVE DATING

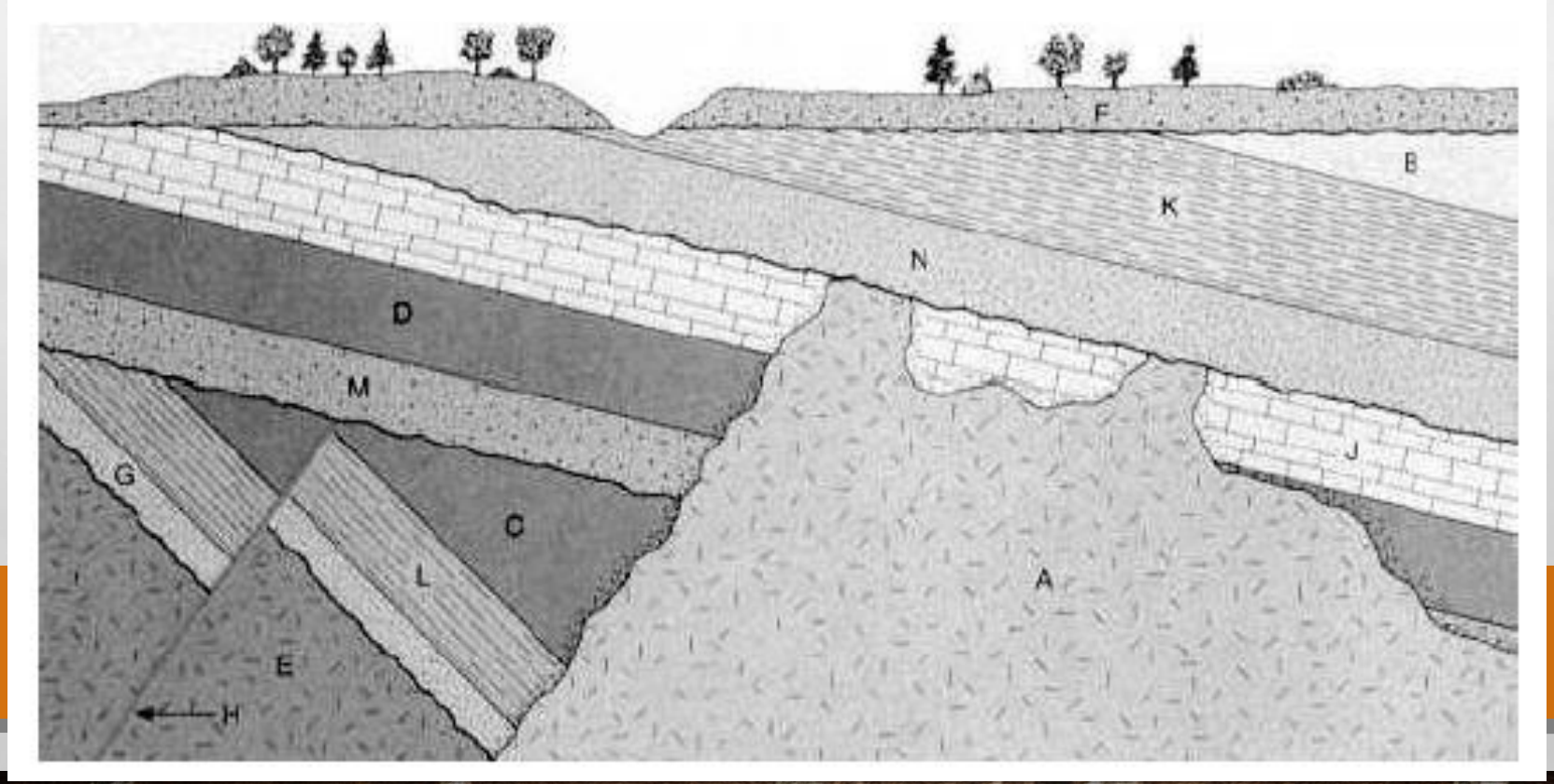
- BUT AS HAPPENS IN NATURE, THERE ARE EXCEPTIONS TO SUPERPOSITION/ORIGINAL HORIZONTALITY
- FAULTS:
  - CRACKS IN ROCKS WHERE MOVEMENT HAS HAPPENED
  - YOUNGER THAN THE ROCKS THEY CUT ACROSS

TOPIC 1: RELATIVE DATING

- BUT AS HAPPENS IN NATURE, THERE ARE EXCEPTIONS TO SUPERPOSITION/ORIGINAL HORIZONTALITY
  - FOLDS: WHEN PLATE TECTONICS CAUSES ROCK LAYERS TO BE PUSHED UP, THEN CAUSING PRE-EXISTING ROCK LAYERS TO OVERTURN

TOPIC 1: RELATIVE DATING

- USING THE DIAGRAM ON THE BOTTOM OF PG. 2 IN YOUR NOTES, WRITE THE ROCK LAYERS IN ORDER FROM OLDEST TO YOUNGEST



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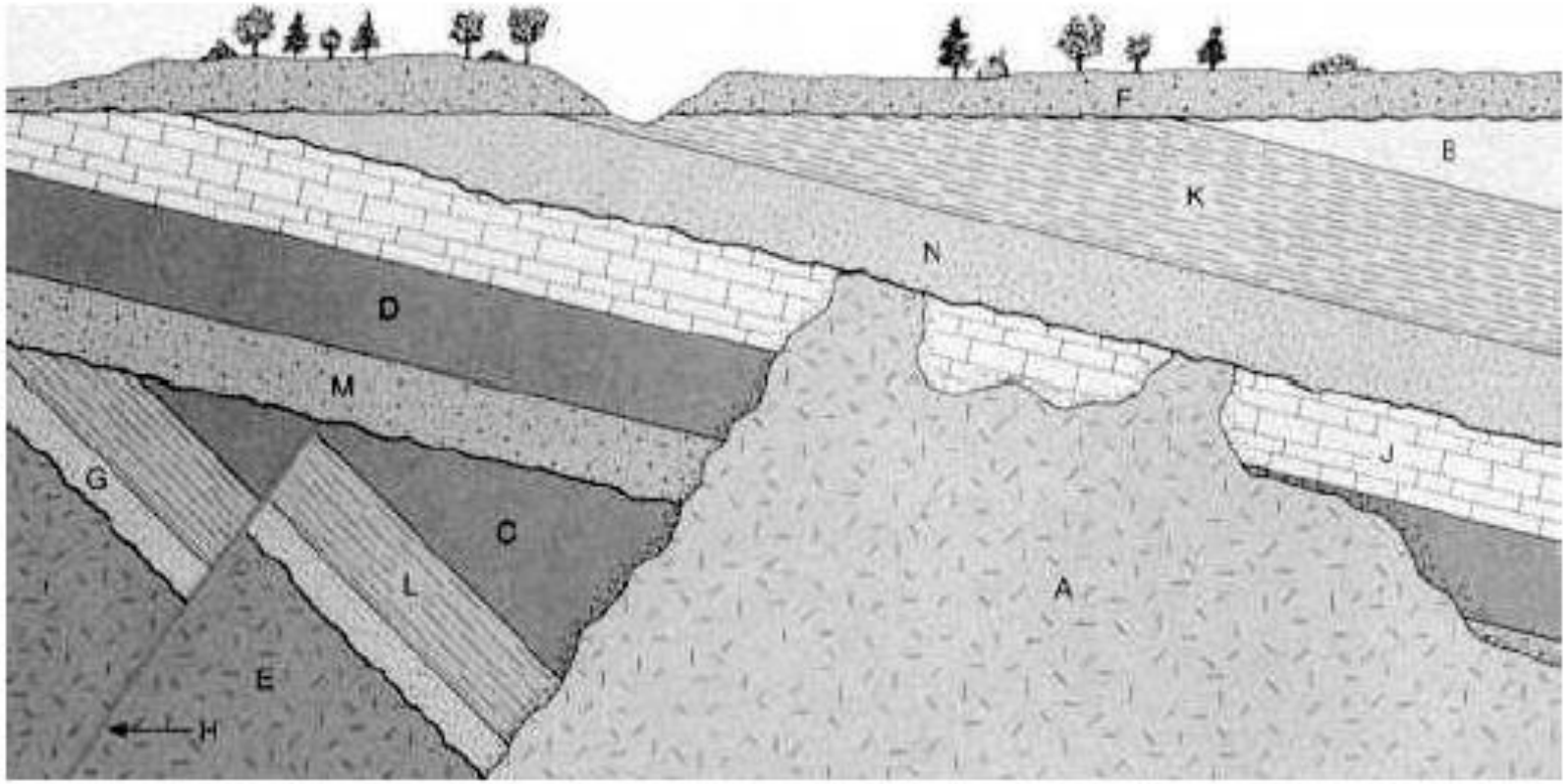


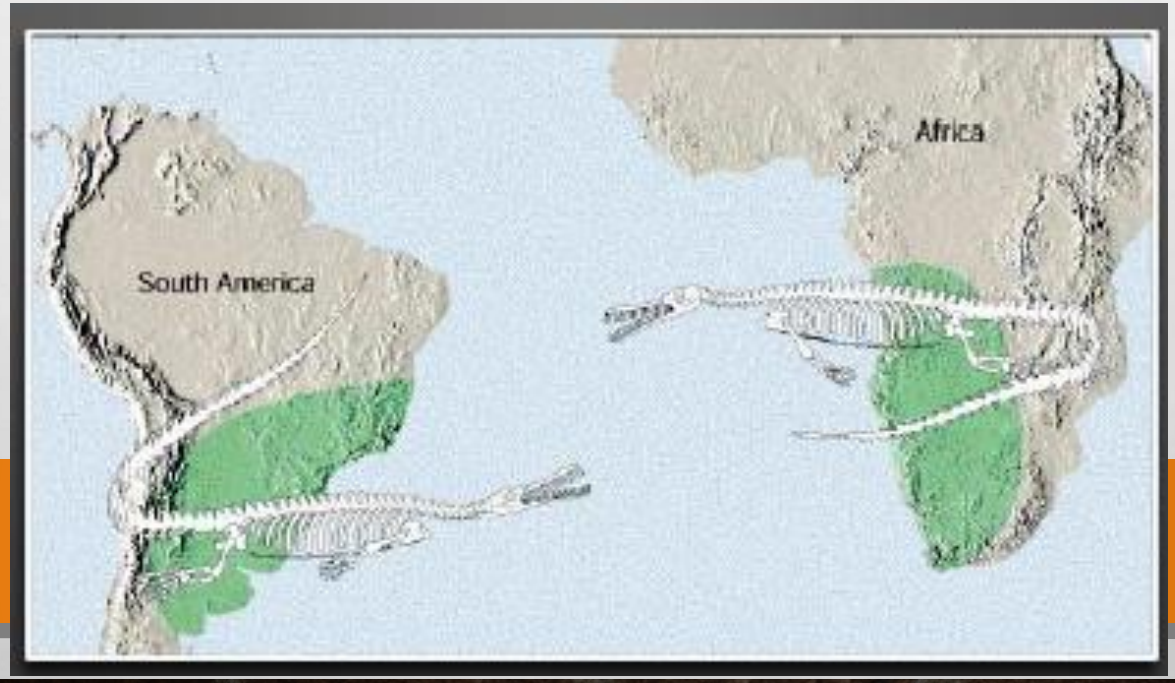
OLDEST

E
G
L
C
M
D
J
A
N
K
B
F

YOUNGEST

TOPIC 1: RELATIVE DATING

- **CORRELATION: THE PROCESS OF SHOWING THAT ROCKS OR GEOLOGIC EVENTS FROM DIFFERENT PLACES HAVE THE SAME OR SIMILAR AGES**
  - **THE MOST EFFECTIVE METHOD WHEN USING RELATIVE DATING**



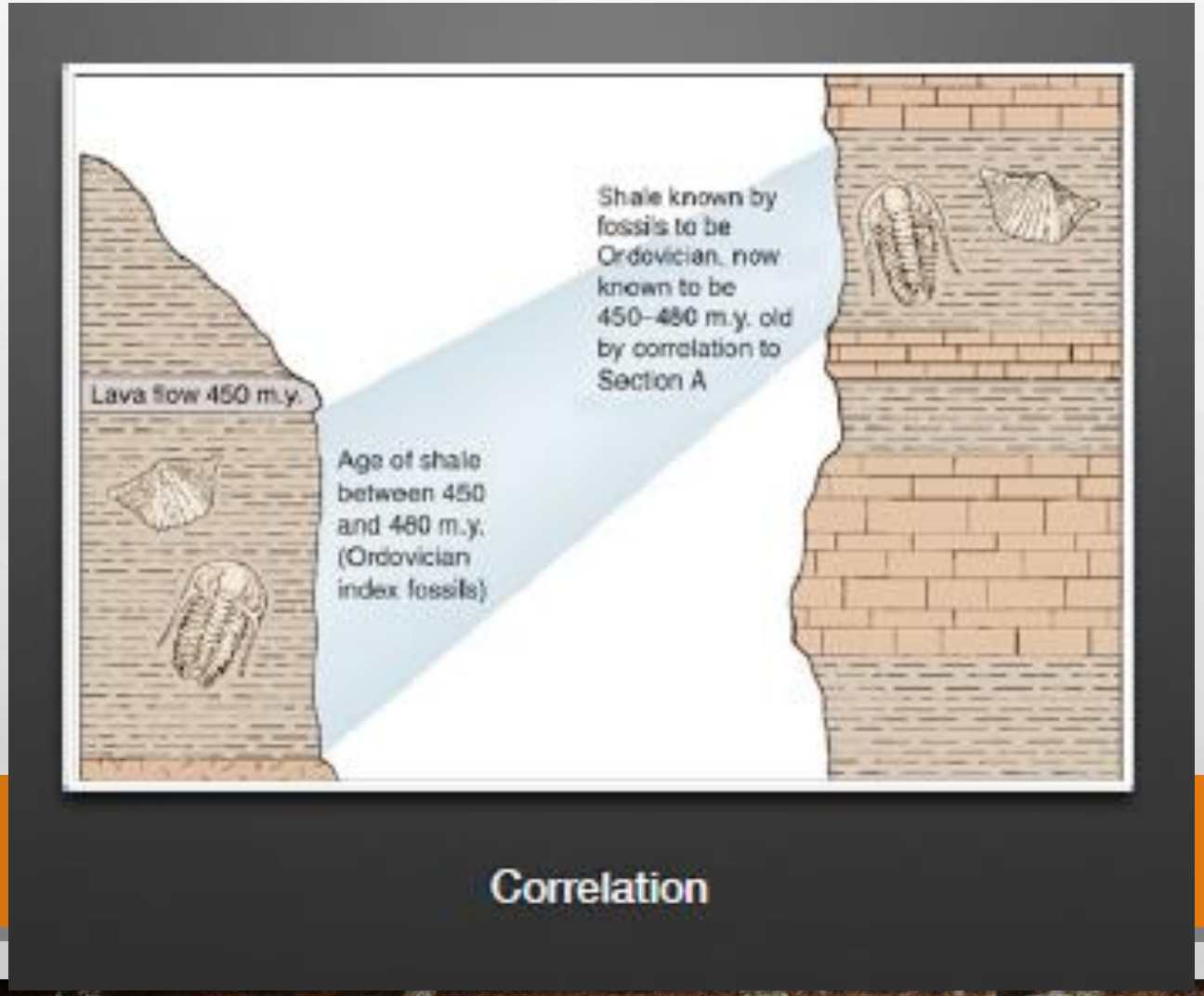
TOPIC 1: RELATIVE DATING

- WHAT TO LOOK FOR WHEN CORRELATING ROCKS:
  - SIMILARITIES IN ROCK TYPES
  - THE ORDER OF THE ROCKS (ROCK SEQUENCE)
  - MINERAL COMPOSITIONS
  - COLOR
  - FOSSILS

TOPIC 1: RELATIVE DATING

- FOSSILS: THE REMAINS OF ONCE-LIVING THINGS
  - EXAMPLES: BONES, SHELLS, FOOTPRINTS, & ORGANIC COMPOUNDS (DNA)
- INDEX FOSSIL: FOSSIL USED TO DEFINE AND IDENTIFY GEOLOGIC PERIODS
  - BEST METHOD FOR CORRELATING ROCKS
  - TO BE CONSIDERED A GOOD INDEX FOSSIL, IT NEEDS TO MEET 2 CRITERIA:
    - 1. LARGE HORIZONTAL DISTRIBUTION: ORGANISM EXISTED OVER A LARGE GEOGRAPHIC AREA
    - 2. SMALL VERTICAL DISTRIBUTION: ORGANISM EXISTED OVER A SHORT TIME

TOPIC 1: RELATIVE DATING



Correlation

TOPIC 1: RELATIVE DATING

- **GEOLOGIC TIME MARKERS: DEPOSITS SPREAD OVER LARGE AREAS THAT OCCURRED ON A SPECIFIC KNOWN DATE**
  - **EXAMPLES: VOLCANIC ASH DEPOSITS, METEORITE IMPACTS**

KT Asteroid - 65 mya
Meteorite Impact

Krakatau - 1883
Volcanic Ash Deposit

QUESTIONS?

TOPIC 2: ABSOLUTE DATING

- ESSENTIAL QUESTION: HOW DO WE USE RADIOACTIVE DECAY IN DATING THE ABSOLUTE AGE OF A ROCK, FOSSIL, OR EVENT?

TOPIC 2: ABSOLUTE DATING

- ABSOLUTE DATING: USING RADIOACTIVE DECAY TO DETERMINE THE EXACT AGE OF A ROCK, FOSSIL, OR GEOLOGIC EVENT
  - RADIOACTIVE DECAY: THE DISINTEGRATION OF AN UNSTABLE ELEMENT (ISOTOPE) OVER TIME
  - ISOTOPES: ELEMENTS THAT HAVE THE SAME ATOMIC NUMBER BUT DIFFERENT ATOMIC MASSES
    - EXAMPLE: STABLE CARBON HAS A MASS OF 12 UNITS (CARBON-12) WHILE ISOTOPIC CARBON HAS A MASS OF 14 UNITS (CARBON-14)

TOPIC 2: ABSOLUTE DATING

- **HALF-LIFE: THE TIME REQUIRED FOR HALF OF A RADIOACTIVE PRODUCT TO DECAY AND BECOME A STABLE PRODUCT**
  - **IN A GIVEN SAMPLE OF A RADIOACTIVE ISOTOPE, HALF OF THE ATOMS WILL DECAY TO A STABLE PRODUCT BUT THE REMAINING HALF IS STILL RADIOACTIVE**
  - **EACH ELEMENT HAS ITS OWN HALF-LIFE THAT RANGE FROM SECONDS TO BILLIONS OF YEARS**

RADIOACTIVE ISOTOPE	DISINTEGRATION	HALF-LIFE (years)
Carbon-14	$^{14}C \rightarrow {}^{14}N$	5.7×10^3
Potassium-40	$^{40}K \rightarrow {}^{40}Ar$, $^{40}K \rightarrow {}^{40}Ca$	1.3×10^9
Uranium-238	$^{238}U \rightarrow {}^{206}Pb$	4.5×10^9
Rubidium-87	$^{87}Rb \rightarrow {}^{87}Sr$	4.9×10^{10}

TOPIC 2: ABSOLUTE DATING

- THE HALF-LIFE OF AN ISOTOPE IS NOT EFFECTED BY ANY ENVIRONMENTAL FACTORS SUCH AS TEMPERATURE, PRESSURE, OR CHEMICAL REACTIONS
- FOR EXAMPLE:
  - URANIUM-238: ONE OF THE MOST IMPORTANT ISOTOPES WHEN DATING ROCKS OR EVENTS MILLIONS OF YEARS AGO
    - MASS: 238 UNITS
    - DECAY: URANIUM-238→ LEAD-206
    - HALF-LIFE: 4,500,000,000 YEARS

TOPIC 2: ABSOLUTE DATING

- **CARBON-14:** ONE OF THE MOST IMPORTANT ISOTOPES WHEN DATING ORGANIC (ONCE-LIVING) REMAINS WITHIN TENS OF THOUSANDS OF YEARS
  - **MASS:** 14 UNITS
  - **DECAY:** CARBON-14 → NITROGEN-14
  - **HALF-LIFE:** 5,700 YEARS

QUESTIONS?

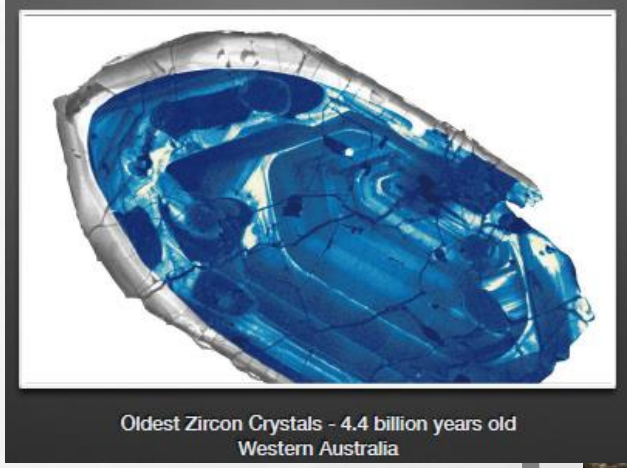
TOPIC 3: EARLY EVOLUTION

- ESSENTIAL QUESTION: HOW DID EVERYTHING EVOLVE ON EARTH?

TOPIC 3: EARLY EVOLUTION

- 4.6 BILLION YEARS AGO
  - RADIOACTIVE DECAY SHOWS THAT EARTH FORMED
  - DURING THE EARLY FORMATION, EARTH HEATED UP DUE TO THE RADIOACTIVE DECAY OF ISOTOPES WITHIN EARTH'S INTERIOR

TOPIC 3: EARLY EVOLUTION



Oldest Zircon Crystals - 4.4 billion years old
Western Australia

- 4.4 BILLION YEARS AGO
  - DURING EARTH'S EARLY MELTING, MATERIALS SEPARATED INTO ZONES ACCORDING TO THEIR DENSITIES
  - FE (IRON) AND NI (NICKEL) SETTLED INTO THE CORE
  - SILICATES (SIO2) FORMED THE EARLIEST CRUST
  - GASESOUS COMPOUNDS (N2, O2, H2) MADE UP THE ATMOSPHERE

TOPIC 3: EARLY EVOLUTION

- 4.2 BILLION YEARS AGO
  - SOLID CRUST FORMED AND PLATE TECTONICS STARTED
  - GASES TRAPPED INSIDE THE EARTH LEAKED OUT THROUGH OUTGASSING AND A COMPLETELY DIFFERENT SECOND ATMOSPHERE WAS CREATED

Oldest Rocks - 4.28 billion years old
Hudson Bay in Northern Quebec

TOPIC 3: EARLY EVOLUTION

- 3.9 BILLION YEARS AGO
  - AFTER THE CRUST HAD COOLED ENOUGH, WATER VAPOR IN THE ATMOSPHERE BEGAN TO PRECIPITATE AND FORM WATER ON EARTH

TOPIC 3: EARLY EVOLUTION

- 3.8 BILLION YEARS AGO
  - WEATHERING, EROSION, AND DEPOSITION BEGAN AND THE FIRST SEDIMENTARY ROCK WAS FORMED

TOPIC 3: EARLY EVOLUTION

- 3.5 BILLION YEARS AGO
  - LIFE FORMS THAT USED CO2 AND RELEASED OXYGEN (O2) BEGAN TO EVOLVE
  - THIS ALLOWED OXYGEN TO START BUILDING UP IN OUR ATMOSPHERE

TOPIC 3: EARLY EVOLUTION

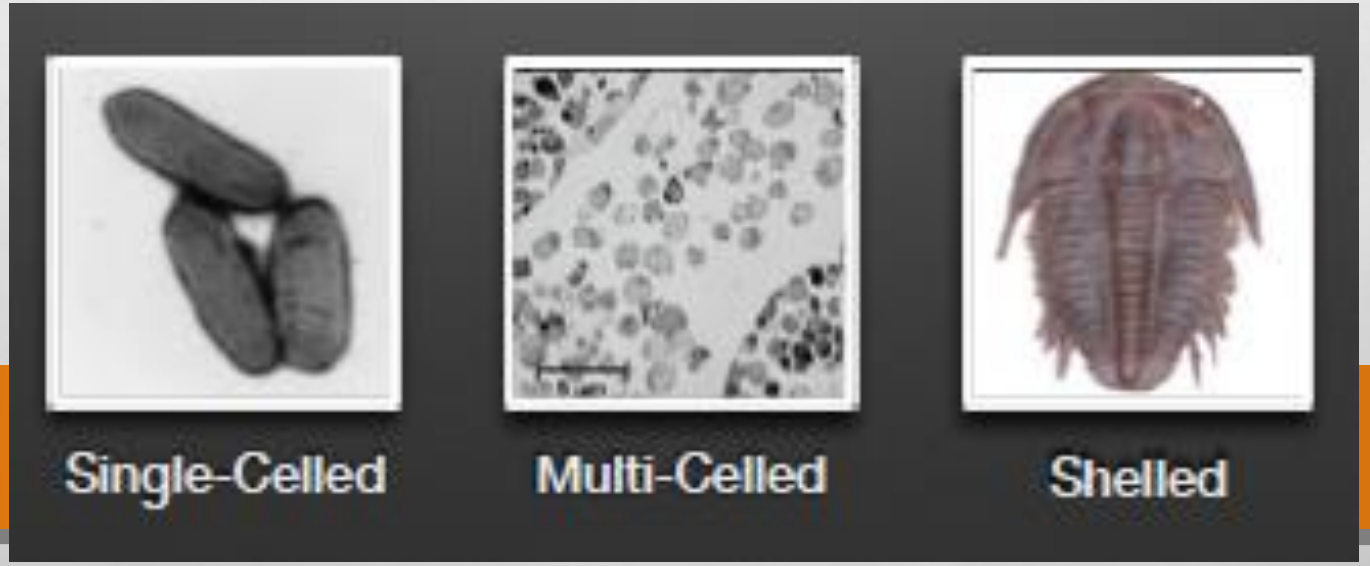
- 3.5-2.8 BILLION YEARS AGO
  - OXYGEN IN THE ATMOSPHERE REACTED WITH IRON IN THE SOIL TO CREATE **RUST**
  - EARTH'S SURFACE LOOKED LIKE THE SURFACE COLOR OF MARS

TOPIC 3: EARLY EVOLUTION

- 2.8 BILLION YEARS AGO
  - MOST OF THE IRON COMPOUNDS HAD REACTED WITH OXYGEN SO OXYGEN IN THE ATMOSPHERE CONTINUED TO INCREASE

TOPIC 3: EARLY EVOLUTION

- 2.8 – PRESENT BILLION YEARS AGO
  - LIFE SLOWLY EVOLVED FROM SINGLE-CELLED BACTERIA TO MULTICELLULAR TO HARD PARTS ON LIFE FORMS



TOPIC 3: EARLY EVOLUTION

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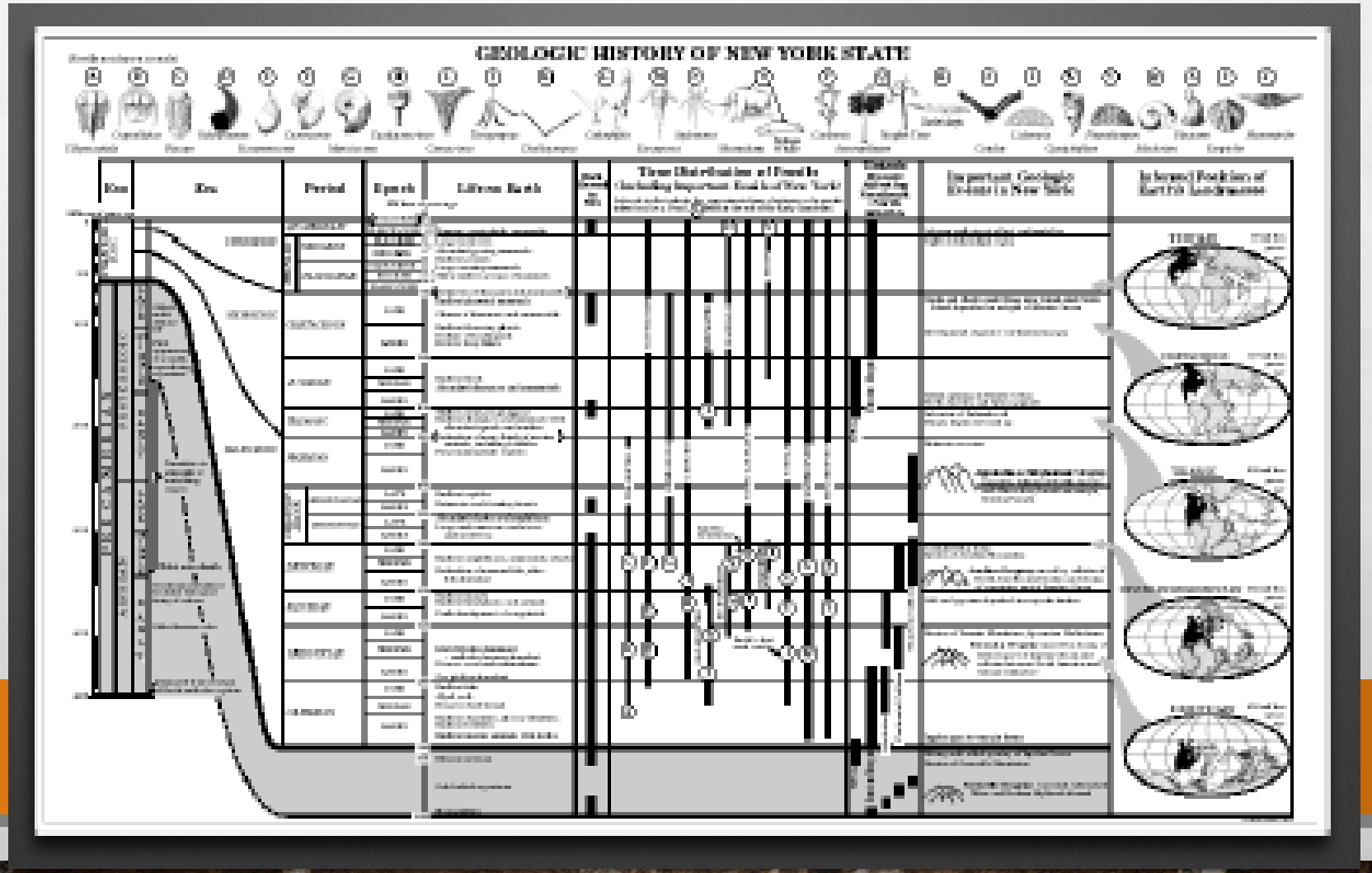

QUESTIONS?