Subdivisions of Time

- **Eon**
- **Era**
- **Period**
- **Epoch**
- **Stage**
- **Substage**

longer    shorter
### Modern Geologic Time Scale

<table>
<thead>
<tr>
<th>Periods</th>
<th>Eras</th>
<th>Epochs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phanerozoic</td>
<td>540 Ma</td>
<td>0 Ma</td>
</tr>
<tr>
<td>Proterozoic</td>
<td>2500 Ma</td>
<td>540 Ma</td>
</tr>
<tr>
<td>Archean</td>
<td>3800 Ma</td>
<td>540 Ma</td>
</tr>
<tr>
<td>Hadean</td>
<td>4600 Ma</td>
<td>540 Ma</td>
</tr>
</tbody>
</table>

**Epochs**
- Late Quaternary (0.01-0.018 Ma)
- Early Quaternary (0.018-0.02 Ma)
- Paleocene-Eocene Thermal Maximum (PETM; 53-51 Ma)
- Triassic-Jurassic Boundary (200-202 Ma)
- Permian-Triassic Boundary (252-251 Ma)
- Pennsylvanian-Carboniferous Boundary (323-324 Ma)
- Mississippian-Pennsylvanian Boundary (360-361 Ma)
- Devonian-Mississippian Boundary (380-381 Ma)
- Silurian-Devonian Boundary (408-409 Ma)
- Ordovician-Silurian Boundary (439-440 Ma)
- Cambrian-Ordovician Boundary (510-511 Ma)

**Eras**
- Holocene (0-0.01 Ma)
- Quaternary (0.01-2.6 Ma)
- Paleogene (65-26 Ma)
- Neogene (26-0 Ma)
- Cenozoic (65-0 Ma)
- Tertiary (65-25 Ma)
- Cretaceous (25-65 Ma)
- Jurassic (65-208 Ma)
- Triassic (208-251 Ma)
- Permian (251-323 Ma)
- Pennsylvanian (323-360 Ma)
- Mississippian (360-380 Ma)
- Devonian (380-408 Ma)
- Silurian (408-439 Ma)
- Ordovician (439-510 Ma)
- Cambrian (510-540 Ma)

**Phanerzoic**
- Cambrian
- Ordovician
- Silurian
- Devonian
- Mississippian
- Pennsylvanian
- Permian

**Mesozoic**
- Triassic
- Jurassic
- Cretaceous

**Paleozoic**
- Ordovician
- Silurian
- Devonian
- Mississippian
- Pennsylvanian
- Permian

**Hadean**

**Archean**

**Proterozoic**

**Periods**
- Hadean
- Archean
- Proterozoic
- Phanerozoic

**Quat.** = Quaternary
**Carb.** = Carboniferous

**Ma** = Million Years Before Present

540 Ma = 540 Million Years Ago

RIP = Record of Incarnation and Preservation
<table>
<thead>
<tr>
<th>Epoch</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>post-Diluvial</td>
<td>Flood Gravels</td>
</tr>
<tr>
<td>Diluvial</td>
<td>Layers composed of unconsolidated sediment</td>
</tr>
<tr>
<td>Tertiary</td>
<td></td>
</tr>
<tr>
<td>Secondary</td>
<td>Chalk down to the Coal Measures</td>
</tr>
<tr>
<td>Transitional</td>
<td>Hard rock layers with sparse fossils</td>
</tr>
<tr>
<td>Primary</td>
<td>Crystalline rock</td>
</tr>
</tbody>
</table>
Problem - how do you determine the order in which rock layers formed?

At a single place, layers can be ordered using Steno’s law of Superposition.

Within a local region, rock layers can be correlated on the basis of their lithology (physical characteristics) to define a geologic system.

How can we correlate widely separated rocks if the layers cannot be matched based on their physical features?
Correlation - the matching-up of rock layers between different places.

- Identify the same rock layer exposed in different places (tracing out a rock layer).
  - Lithostratigraphic correlation (local or regional)

- Identify rock layers in different regions that formed during the same interval of Earth History (matching up layers that formed at the same time).
  - Chronostratigraphic correlation (global)

- How can this be done??

### Geologic Systems

<table>
<thead>
<tr>
<th>Primary</th>
<th>Crystalline (metamorphic) strata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transitional</td>
<td>Old Red Sandstone</td>
</tr>
<tr>
<td></td>
<td>Devonshire strata</td>
</tr>
<tr>
<td></td>
<td>Welsh Greywackes</td>
</tr>
<tr>
<td></td>
<td>Mountain Limestone</td>
</tr>
<tr>
<td></td>
<td>Wenlock Limestone</td>
</tr>
<tr>
<td>Secondary</td>
<td>New Red Sandstone</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Tertiary</td>
<td>London clay</td>
</tr>
<tr>
<td></td>
<td>Parisian chalk</td>
</tr>
<tr>
<td>Diluvial</td>
<td>gravels</td>
</tr>
<tr>
<td>post-Diluvial</td>
<td>alluvium</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>British Isles</th>
<th>Continental Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parisian gypsum beds</td>
</tr>
<tr>
<td>Sicilian strata</td>
<td>Parisian chalk</td>
</tr>
<tr>
<td>Coal Measures</td>
<td>Muschelkalk - Trias</td>
</tr>
<tr>
<td>Lias</td>
<td>Perm strata</td>
</tr>
<tr>
<td>Oolites</td>
<td>Jura Mt. strata</td>
</tr>
<tr>
<td>Magnesian Limestone</td>
<td></td>
</tr>
</tbody>
</table>

Cretaceous System
D’Omalius d’Halloy, 1822
How can we correlate different systems if the layers cannot be correlated based on their physical features?

Great Britain

Continental Europe

William Smith (1769-1839)
surveyor, civil engineer
Geologic Systems and Geologic Time

• The Jurassic System was originally named for the rocks and fossils of the Jura Mountains between France and Switzerland.

• Now the Jurassic Period refers to the time interval during which the fossil species of the Jurassic System lived.

• Any rock layers with these fossils can be identified as Jurassic in age.
How do we assign sedimentary layers to their correct place in time?

- fossils
- each time interval in Earth history is defined by a unique set of species that existed at that time.
- Species evolve, live for a short time, and go extinct.
- The same species never evolves twice (extinction is forever).
- Evolution provides a “biological calendar” that geologists use to keep track of time.
- Fossils allow us to put the individual scenes from Earth history into the correct order to tell the full story.