The textbooks for Ge 11b and Ge 104 are C. Emiliani (1995), *Planet Earth*, and A. H. Knoll (2003), *Life on a Young Planet*. Additional readings are included in this sourcebook (PDFs are available at http://www.gps.caltech.edu/CITonly/classes/ge11b/). Many of the pre-1970 readings are from or selected on the basis of inclusion in P. Cloud, ed. (1970), *Adventures in Earth History*, which, though out of print, is highly recommended and readily available for purchase online.

I. Ordering Principles in Earth History

1. P. Cloud, (1970), Intro to Ordering Principles in Earth History (in Cloud, 3-8; 6 pp.)
2. N. Steno (1669), An Early Statement of Ordering Principles in Earth History (in Cloud, 21; 1 p.)
3. J. Playfair (1822), James Hutton Observes the Great Unconformity at Siccar Point (in Cloud, 22-23; 2 pp.)
4. A. H. Knoll et al. (2004), A new period for the geologic time scale (Science 305, 621-622: 2 pp.)
5. National Academies Space Studies Board, Assessment of Mars Science and Mission Priorities (2003). Ch. 4: Stratigraphy and Chronology (pp. 26-33; 8 pp.)
6. C. Patterson (1956), Age of Meteorites and the Earth (GCA 10, 230-237; in Cloud, 172-177; 8 pp.)

Also read: Emiliani, ch. 18

PART ONE: PRECAMBRIAN EARTH

II. Early Earth

1. E.G. Nisbett & N. H. Sleep (2001), The Habitat and Nature of Early Life (Nature 409, 1083-1091; 9 pp.)
2. J. L. Kirschvink & B. P. Weiss (2001), Mars, Panspermia, and the Origin of Life (Paleolontogia Electronica 4, 8-15; 8 pp.)
3. S. Simpson (2003), Questioning the Oldest Signs of Life (Scientific American, April 2003; 8 pp.)

Also read: Knoll, ch. 1-5 and 13
Emiliani, ch. 19

III. Glaciations, Snowball Earths, and the Rise of Oxygen

1. P. F. Hoffman & D. P. Schrag (2000), Snowball Earth (Scientific American, Jan. 2000; 8 pp.)
2. R. E. Kopp, J. L. Kirschvink, I. A. Hilburn, and C. Z. Nash. (2005), The Paleoproterozoic snowball Earth: A climate disaster triggered by the evolution of oxygenic photosynthesis (PNAS 102, 11131-11136; 6 pp.)

Also read: Knoll, ch. 6-7 and 12
Emiliani, ch. 20

PART TWO: PHANEROZOIC EARTH

IV. The rise of animals and the start of the Phanerozoic

1. J. L. Kirschvink & T. D. Raub (2003), A methane fuse for the Cambrian explosion (C.R. Geoscience 335, 65-78; 14 pp.)

Also read: Knoll, ch. 8-11
Over units IV-V, also read: Emiliani, ch. 21-22

V. Population genetics and the fossil record

1. S. J. Gould & N. Eldridge (1993), Punctuated Equilibrium Comes of Age (Nature 366: 223-227; 5 pp.)
2. R. Dawkins (2004), The Host's Return (in *The Ancestor's Tale*, 582-614: 33 pp.)

VI. Extinctions

1. D. M. Raup and J. J. Sepkoski (1982), Mass extinctions in the marine fossil record (Science 215: 1501-1503; 3 pp.)
2. L. W. Alvarez et al. (1980), Extraterrestrial Cause for the Cretaceous-Tertiary Extinction (Science 208: 1095-1108; 14 pp.)
3. M. J. Benton and R. J. Twitchett (2003), How to kill (almost) all life: the end-Permian extinction event (Trends in Ecology and Evolution 18: 358-365; 8 pp.)

Also read: Emiliani, ch. 23

VII. Plate Tectonics

1. J. T. Wilson (1966), Did the Atlantic close and then re-open? (Nature 211: 676-681; 6 pp.)
2. A. Cox et al. (1967), Reversals of the Earth's Magnetic Field (Scientific American 216, 44-54; in Cloud, 323-334; 11 pp.)
3. P. M. Hurley (1968), The Confirmation of Continental Drift (Scientific American 218, 52-64; in Cloud, 335-350; 13 pp.)

Also read: Emiliani, section 11.8 and ch. 12

VIII. Climate and the Human Impact

1. C. Emiliani (1958), Ancient Temperatures (Scientific American 198, 54-63; in Cloud, 891-900; 10 pp.)
2. J. Zachos (2001), Trends, Rhythms, and Aberrations in Global Climate 65 Ma to Present (Science 292, 686-693; 8 pp.)
3. W. F. Ruddiman (2003), The Anthropogenic Greenhouse Era Began Thousands of Years Ago (Climatic Change 61, 261-293; 33 pp.)
4. S. B. Carroll (2003), Genetics and the making of *Homo sapiens* (Nature 422, 849-857; 9 pp.)

Also read: Emiliani, ch. 24

Additional recommended readings

R. Fortey (1999), *Life: A Natural History of the First Four Billion Years of Life on Earth.* A well-written popular overview of the history of life on Earth.

J. McPhee (1998), *Annals of the Former World*. A beautifully written, Pulitzer Prize-winning tale of geologists and the geology of North America.

P. D. Ward and D. Brownlee (2000), *Rare Earth: Why Complex Life is Uncommon in the Universe.* Ward and Brownlee explain the circumstances that make the Earth special.

More books you should read

D. Dennett (1996), *Darwin's Dangerous Idea*.
J. Diamond (1999), *Guns, Germs, and Steel*.
C. de Duve (1996), *Vital Dust: Life as a Cosmic Imperative.*
G. Galilei (1615), *The Starry Messenger*, tr. Stillman Drake (1957).
J. Imbrie and K. P. Imbrie (1986), *Ice Ages: Solving the Mystery*.
T. S. Kuhn (1957), *The Copernican Revolution*.
K. Popper (1985), *Popper Selections*.
W. Ryan and W. Pitman (2000), *Noah's Flood: The New Scientific Discoveries About The Event That Changed History*.
J. Swift (1726), *Gulliver's Travels*.
G. Walker (2003), *Snowball Earth*.

KEY TOPICS

Ge 11b and Ge 104, Winter 2006

Ordering Principles in Earth History

Steno's Laws

uniformitarianism, Hutton, Siccar Point

Time scale

- biostratigraphy
- global standard type sections
- Ediacaran period

Radiometric dating

Cratering rates

Habitable zones

Early Earth

Formation of the Earth and Moon

- Hadean zircons
- Core formation
- Komatiites

Evidence for water in Archean sediments

- Early Earth temperature and atmosphere
- Pillow basalts
- Ripple marks

Evolution of environmental oxygen levels

- Upside-down biosphere
- Three-stage model of atmospheric oxygen
- Paleosols, BIFs, pyrite

Age of the continents

- Greenstone belts
- Cratons

Abodes for life

- Evidence for water on early Mars
- Martian magnetism
- Structure of Europa, evidence for an ocean
- Redox gradients

Origin of Life

Prebiotic chemistry

- Miller-Urey experiments
- Borate stabilization of ribose
- Lipid bilayer membranes

Metabolism and phylogeny

- Electron transport
- SSU rRNA tree of life

Early evidence for life

- microfossils (esp. Apex chert)
- stromatolites
- molecular clocks, last common ancestor
- carbon isotopic fractionations

Panspermia and ALH84001

- identification of SNC meteorites as Martian
- geologic history of ALH84001
- SQUID microscopy demonstrating low-T transfer of ALH84001
- biomarkers

magnetofossils

Snowball Earths
sedimentological evidence for glaciations
- diamictities
- dropstones, multiply striated cobbles

Neoproterozoic Snowball model
- geographic spead of late Proterozoic glaciation
- paleolatitude and fold tests
- banded iron formations
- geochemical cycles during Snowballs and the "Snowball Earth cycle"
- ice-albedo run-away
- cap carbonates
- carbon isotope stratigraphy

Paleoproterozoic Snowball and the rise of oxygen
- Transvaal and Huronian sections
- Ongeluk paleomagnetic results
- dropstones in the Hotazel BIF
- Kalahari Mn field and evidence for free oxygen (redox potentials of Fe and Mn)
- Lorrain siltstone fold test
- Mass independent fraction of sulfur
- Organic biomarker evidence for cyanobacteria and eukaryotes
- Survival of life during Snowballs
- Superoxide dismutase

post-Snowball life
- 1.9 Ga eukaryotes and magnetofossils
- Ediacaran fauna

Bacterial evolution
Prokaryotic cell structure
SSU rRNA tree of life
Stromatolites
- Shark Bay
- Warawoona Group

Microfossils
- post-2.0 Ga
- Schopf/Apex chert controversy

Photosynthesis
Pigments and absorption spectra
Photosystems I and II
carbon fixation, RuBisCo

Eukaryote Evolution
eukaryotic cell structure vs. bacterial cell structure
- endosymbiosis

stromatolites in the Proterozoic
fossil record
- microfossils: acritarchs, Bangiomorpha
- carbonaceous macrofossils (e.g. Grypania)
- Ediacaran fauna
- evolution of bilateria: Doushantuo, White Sea biota

Cambrian Explosion

Burgess Shale fauna
the changing base of the Cambrian
magnetite biomineralization
    "Grand Unified Theory of Biomineralization"
Cambrian carbon cycles
    Inertial Interchange-True Polar Wander
    IITPW-driven methane fuse for the Cambrian explosion?

Population Genetics and the Fossil Record
the Neo-Darwinian synthesis and gradualism (Dawkins)
punctuated equilibrium (Gould)
allopatric vs. sympatric speciation

Mass Extinctions
Permo-Triassic extinction
change in sediment character (meandering -> braided river deposits, green -> red) at the P/T in the Karoo
impacts as possible extinction triggers
flood basalts as possible extinction triggers
iridium enrichment at the K/T boundary (Alvarez et al.)

Plate Tectonics
magnetic reversals
seafloor magnetic lineations
Wilson cycle

Climate
oxygen isotope records
hothouse v. icehouse worlds, and ties to supercontinent assembly & breakup
Milankovitch cycles

Human Evolution
chromosome number (46 in humans vs. 48 in other hominids)
"mitochondrial Eve"
distinctive human features
predation upon early humans
late Pleistocene-Holocene megafaunal extinction
human influence of Holocene (Anthropocene?) climate

Labs: Precambrian
komatiites
stromatolites
drop stones
cap carbonates
diamictites
ripple marks
zircons
ALH84001 carbonate globules
barite
manganese ore
BIF
uranium mobility
quartz-pyrite conglomerates
Ediacaran fauna

the difficulty of microfossils

Labs: Phanerozoic
trilobites
trace fossils
mammal-like reptiles
nautoloids v. ammonoids
reef-builders throughout Earth history
coprolites

Field trip
Punta China section - volcanic atoll
Peninsular Range batholith and accretion of Baja
microbial mat environments
tidal flats
Salton Sea