

**GEO 302c Climate: Past, Present and Future  
Review Questions for Exam 2**

**Note that Exam 2 will have 50 multi-choice questions. The contents to be tested are mainly from the book (see below for specific chapters) plus some additional materials that have been emphasized in class. Most of the questions below are from the book.**

1. **Chapter 2** (p. 17-31) What are proxy climate data? How are they different from the instrumental data? Can a thermometer be exposed under sunlight when it is used to measure air temperature? Give your reasons.
2. What are the commonly used proxy data for climate studies? Where are they distributed? What climate information (or variables) can they tell us? What are their time spans and resolutions? How does the importance of each type of proxy data change according to the time scale being examined?
3. Why are ocean sediments and ice cores so important to study the past climate? Which two major groups of organisms are most important to climate reconstructions over the past several million years?
4. Why do we care about the past climate change?
5. What are greenhouse eras? What are icehouse eras? Give examples. How many icehouse eras have existed during the earth's history?
6. **Chapter 3** (pages 40-53) What factors explain why Earth has remained habitable for most of the 4.55 Byr history?
7. What is the faint young Sun paradox?
8. What climate factors affect the removal of CO<sub>2</sub> from the atmosphere by chemical weathering?
9. Be able to read (and explain in simple terms) a chemical reaction showing how chemical weathering remove CO<sub>2</sub> from the atmosphere. (p. 49)
10. Why is chemical weathering a plausible thermostat for Earth's climate?
11. If Earth's surface froze solid (i.e. the snowball earth), what would happen to CO<sub>2</sub> emissions from volcanoes and to CO<sub>2</sub> removal by chemical weathering?
12. **Chapter 4** Do glaciations *always* occur when continents are located in polar positions? (p. 64-67)
13. How could chemical weathering be both the driver and the thermostat of Earth's climate?
14. What explains the changes in Earth's climate over the last several hundred million years?
15. **Chapter 5** Why was Earth ice-free even at the poles 100 Myr ago?
16. What evidence shows that the world was warmer 100 Myr ago than today?
17. Why does higher CO<sub>2</sub> make sense as one explanation for this greater warmth?
18. How well do model simulations capture the distribution of temperatures 100 Myr ago?
19. What are the possible causes of mismatches between the models and geologic observations?
20. What regions of the continents were flooded by high seas 100 Myr ago?
21. **Chapter 6 Key terms:** Oxygen isotope ratios, fractionation (see also Appendix 1)

22. What caused Earth's climate to cool over the last 55 Myr?
23. What kinds of changes in vegetation and ice show that Earth has cooled in the last 55 Myr?
24. What do changes in  $\delta^{18}\text{O}$  values in the last 55 Myr tell us about climate changes?
25. What hypotheses are available to explain the last 55 Myr cooling?
26. Explain how chemical weathering could drive the cooling and at the same time moderate it.
27. **Chapter 7 Key terms:** tilt (obliquity), eccentricity, precession (axial precession, precession the ellipse), solstices, equinoxes, perihelion, aphelion, wavelength, period, frequency, amplitude, modulation, insolation
28. Why does Earth have seasons?
29. When is Earth closest to the Sun in its present-day orbit? How does this position affect the amount of radiation received by Earth?
30. What is modulation of a cycle?
31. What aspect of Earth's orbit changes in cycles of 41,000 years? Of 100,000 years? Of 23,000 years?
32. Which latitudes are most affected by changes in the tilt of Earth's axis?
33. Earth's tilt is slowly *decreasing* today. As the tilt decreases, are the polar regions receiving more or less solar radiation in summer? In winter?
34. How does axial precession differ from the precession of the ellipse?
35. Sketch a complete cycle of the precession of the March 20 equinox in an eccentric orbit?
36. How does eccentricity combine with precession to affect long-term insolation on Earth?
37. **Chapter 8** How do orbital variations drive the strength of tropical monsoons?
38. Why does the tropical monsoon vary at a cycle of 23,000 years?
39. Describe an evidence showing variations in the strength of the tropical North African monsoon over the last several hundred thousand years.
40. **Chapter 9 Key terms:** Ablation, Ice mass balance, Equilibrium line, Milankovitch theory, ice elevation feedback
41. What is the equilibrium line? Why is it important?
42. Why does the size of a growing or melting ice sheet lag well behind changes in insolation?
43. How does the delay in bedrock response to ice loading act as a positive feedback to ice volume?
44. What does the 2.75-Myr  $\delta^{18}\text{O}$  history tell us about ice sheets in the northern hemisphere?
45. Why are northern ice sheets more responsive to insolation changes than Antarctic ice?
46. Which parts of the Milankovitch theory have proved to be accurate? Which parts are insufficient?
47. How do orbital variations control the size of northern hemisphere ice sheets?
48. What controls orbital-scale fluctuations of atmospheric greenhouse gases?
49. What is the origin of the 100,000-year climate cycle of the last 0.9 Myr?
50. Which season determines whether or not ice sheets grow or melt? Why?
51. **Chapter 10** How are ice cores dated? (p. 176-177)
52. Why are air bubbles in ice cores younger than the ice in which they are sealed?

53. What features of the ice core CH<sub>4</sub> signal suggest a link to tropical monsoons?
54. To what extent does a cooler glacial ocean surface explain lower CO<sub>2</sub> in the glacial atmosphere?
55. Which reservoir has the most carbon: the atmosphere, vegetation, or the ocean?
56. Where did the carbon (CO<sub>2</sub>) removed from the atmosphere go during glaciations?
57. What effect does fractionation have on carbon-isotope values?
58. Explain how carbon isotopes ( $\delta^{13}\text{C}$ ) trace shifts of carbon from the land to the ocean?
59. **Chapter 11 Key term:** ice-driven responses
60. In what sense are ice sheets both a climatic response and a source of climatic forcing?
61. Name an ice-driven response and cite evidence that it originates from changes in ice sheet size.
62. How could responses driven by northern hemisphere ice sheets be found in the southern hemisphere?
63. Cite two kinds of evidence indicating that changes in northern hemisphere rather than Antarctic ice sheets are a major player in orbital-scale climate changes.
64. What evidence suggests that orbital-scale changes in northern hemisphere ice volume drive changes in atmospheric CO<sub>2</sub>, rather than vice versa?
65. **Chapter 12 Key terms:** Laurentide ice sheet, Cordilleran ice sheet, Scandinavian ice sheet, permafrost
66. How did Earth's surface at the last glacial maximum differ from its surface today?
67. What is the major uncertainty about the size of ice sheets at the glacial maximum?
68. In what ways did ice sheets make the glacial world a "dirty" place?
69. How does the composition of pollen in lake sediments tell us about climate?
70. How did the glacial climate of the southwestern United States differ from the climate there today? Why?
71. How did the glacial climate of Europe differ from the climate there today? Why?
72. How did the glacial climate of northern Asia differ from the climate there today? Why?
73. What caused the cooling of the tropics in the last glacial period?
74. Describe the evidence for a small versus a large tropical cooling during the glaciation, and explain why it is important for us to know the actual amount of cooling?