

# The Earth System

Spring, xxxx  
Geology 230:  
Test # 1

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Time Begun: \_\_\_\_\_ Time Ended: \_\_\_\_\_

*Write Your People Soft (Not Social Security) Number  
on the Scantron Card*

This is a **CLOSED NOTE/CLOSED BOOK TEST**. You may have nothing with you while taking it except writing materials, and any snacks you need for the duration.

1. You *must* **SIT AND WORK ALONE** while taking the test.
2. You *must* **TAKE THE TEST IN ONE SITTING**. Pit stops allowed.

Other Conditions Include:

- You may **not** peek at these questions in any way until just at the moment you are ready to take the test.
- You have a several day period in which to take this test. You may take it any time during that several day period. The days available will be announced in lecture.
- You may start this test any time you want and may take as long as you wish to do
- Once you have taken the test you are **expressly forbidden talk about it in any way, shape, or form with anyone else**, except me, until everyone has finished taking the test.

## **HONOR: SCIENTIFIC AND PERSONAL**

Science and honesty must go hand in hand. Science is the search for a true understanding of the universe, not what we wish it to be, or need it to be. But the universe is complex and for all our success science has had to struggle mightily to learn what it has. Dishonesty thus is very detrimental. Not only does it deliberately lead us down the wrong path, actions taken on the basis of that false knowledge can be deadly. Besides good ideas are hard enough to discover even when struggling honestly. Dishonesty in science, when discovered, destroys a career, and ruins a reputation. And dishonesty is always discovered because science's goal is to uncover false ideas.

Because each of you take this test individually, and without supervision, whether you cheat or are honest is your very personal and private responsibility. Not cheating means no notes, and not talking with anyone until everyone has finished the test - following the spirit of the law rather than just the letter. Putting your name at the top of the test page is equivalent to signing the James Madison University Honor Pledge.

Total points \_\_\_\_\_

Name: \_\_\_\_\_

Test score \_\_\_\_\_

Date: \_\_\_\_\_

Grade/100 point scale \_\_\_\_\_

## Geology 230 - EVOLUTION OF THE EARTH - TEST # 1

# THE EARTH SYSTEM

Spring, xxxx

L. S. FICHTER - JAMES MADISON UNIVERSITY

*Write your People Soft (not social security) number  
On the Scantron card.*

**Multiple Choice questions are worth 3 points,  
Except where noted otherwise; All True/False are worth 2 point.**

**Your grade for the test is based on a curve drawn over the distribution of raw scores. I draw the curve by hand, but have no need to have a specific percentage of A's, B's, C's etc. In fact, we would like everyone to do well, but will draw the most fair curve I can based on how everyone in the class does. We ignore the computer generated percentages.**

## EVOLUTION OF THE EARTH - PART ONE: ORIGINS

### Multiple Choice

We talked about the Earth as a unique planet in the solar system for which of the following reasons (none, one, some, all that apply).

1. T/F. Has continents.
2. T/F. Has liquid water
3. T/F. Is out of equilibrium with the sun's luminosity.
4. T/F. Carbon dioxide rich atmosphere.
5. T/F. Revolves around the Sun differently than the other planets.
6. T/F. Contains a mantle of ultramafic rocks.
7. T/F. Maintains a magnetic field.
8. T/F. Formed from processes uniquely different from the Jovian planets.
9. T/F. For its size, contains more angular momentum than the other planetary bodies.
10. T/F. Is deficient in the inert (Noble) gasses, except argon derived from radioactive decay.

### True/False

11. T/F. The major reason the planets in the solar system all lie in the same plain is that gravity drew them together along that plain.
12. T/F. The major difference between the Jovian planets and the terrestrial planets is the fractionation that took place in the gas and dust cloud caused by the solar wind.
13. T/F. The abundance of elements in the bulk of the solar system are essentially the same as the composition of the universe as a whole.
14. T/F. The abundance of elements in the Jovian planets are essentially the same as those in the sun.
15. T/F. The composition of the Earth's atmosphere indicates that at some time in its—probably early—history it underwent a fractionation that removed most of the light materials.

16. T/F. Not only is the Earth fractionated from the rest of the solar system but within itself both the lithosphere and atmosphere are fractionated from their original compositions.
17. T/F. The rapid lowering of the Earth's temperature at the beginning was largely the result of water derived from degassing of the planet cooling it down.
18. T/F. The Earth's earliest crust and lithosphere composition was probably rich in anorthosite (calcium rich plagioclase) and ultramafic to mafic igneous rocks.
19. T/F. Looking at the moon's surface (picture to right) the uplands are anorthosite and the large flat crater areas are basaltic.
20. T/F. The Earth's earliest atmosphere was rich in sulfuric acid, hydrochloric acid and poisonous organic molecules such as cyanide and formaldehyde.
21. T/F. The absence of free oxygen in modern volcanic gasses argues that the oxygen present in the atmosphere today was probably derived from rock fractionation processes.
22. T/F. Except for one process—biological fractionation of atmospheric gasses—the temperature of the Earth's atmosphere would be much hotter today than it is.
23. T/F. The atmosphere the earth has today evolved from its Stage One Hadean atmosphere without significant additions from or losses to outside the planet.
24. T/F. A main reason that Mars does not have water today, although it did in the past, is that its gravity is not strong enough to hold the free hydrogen.
25. T/F. The Earth's earliest atmosphere was about 60 times heavier than today, and the main reason it is not so heavy today is because most of the carbon dioxide has been fractionated out.
26. T/F. Oxygen in the Earth's atmosphere derives primarily from photo disassociation of water by radiation from the sun.
27. T/F. Part of the reason that the Earth's atmosphere is less dense today than it was in the past is because nitrogen was sequestered in petroleum in sediments by biological fractionation processes.
28. T/F. Methane in the early atmosphere was derived almost solely from biological processes.



### Complex Systems - Their Philosophical and Practical Nature

#### *Laws of Thermodynamics and Teleology*

29. T/F. Both vitalism and finalism contain arguments of design and purpose.
30. T/F. Adam Smith's "invisible hand" argument is an example of finalist because it implies there is a guiding force in evolution.
31. T/F. When David Hume says, "***For aught we know a priori, matter may contain the source or spring of order originally within itself, as well as mind does***" he is saying that matter has a mind of sorts and that mind is the invisible hand.

#### *Computational Viewpoint*

32. T/F. The computational viewpoint includes the idea that the laws of nature are algorithms that control the development of the natural systems in time.
33. T/F. A premise of the computational viewpoint is that an algorithm itself is its own shortest description, meaning that the evolution of the universe is inherently unpredictable.
34. T/F. Complex systems cannot be understood deductively beginning with an a prior set of premises that logically lead to a deterministic end.

#### Multiple Choice:

35. **Select the three statements** below that represent the three basic laws of thermodynamics we explored. True = Yes; False = No.
- A Energy can be changed from one form to another, but it cannot be created or destroyed; it is conserved.

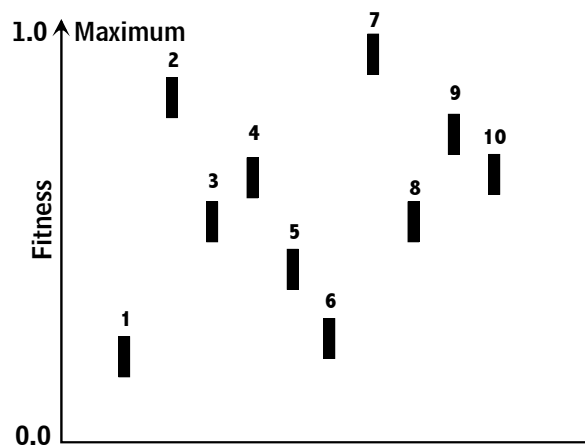
- B In all energy exchanges, if no energy enters or leaves the system, the potential energy of the state will always be less than that of the initial state.
- C Absolute zero cannot be attained by any procedure in a finite number of steps.
- D No heat will flow between any two bodies that are at the same temperature.
- E The universe keeps getting more complicated, and there are always more ways to combine things.
36. Which of the following are used to measure *entropy*? Choose all that apply. True = Yes; False = No.
- A The "r" value of the system.
- B The amount of disorder in the system.
- C The amount of energy available to do work.
- D How open or closed the system is.
- E How rapidly the system can evolve.

### Bak-Sneppen Evolutionary Model

The drawing to the right shows the layout of the Bak-Sneppen Model. Identify the specie(s) that will change at the next generation.

37. A=1 B=2 C=3 D=4 E=5
38. A=6 B=7 C=8 D=9 E=10

39. The critical threshold for the model is which?
- A Varies unpredictably with each run of the model.
- B Is about 0.50
- C Is about 0.66
- D Close to 1.0 but not at 1.0



True/false:

40. T/F. An avalanche is all the mutations from the rising of the threshold line to the next rising of the next threshold line.
41. T/F. Species above the threshold line, and out of the range of ongoing avalanches, are the parts of the system that maintain the system's stability and equilibrium.
42. T/F. A species caught up in an avalanche is the best chance the system has for changing in the future.
43. T/F. These change the rate of rising of the threshold: the size of avalanches, the number of mutations, the size of the mutations, follow power law distributions.

### The Logistic System ( $X_{next}$ )

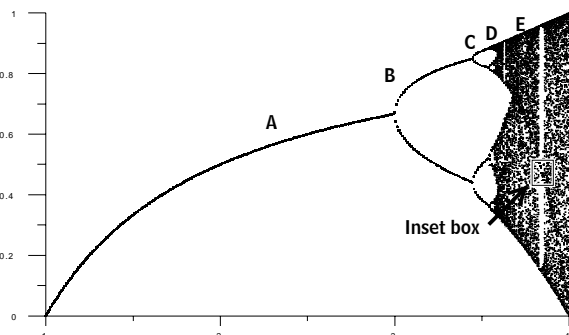
44. Which of the following is the correct equation for the model (only one)?
- A  $X_{next} = r(X + 1 - X)$
- B  $X_{next} = rX(1 - X)$
- C  $X_{next} = rX(-1)$
- D  $X_{next} = rX(X - 1)$
- E  $X_{next} = rX^2(1 - X)$

45. Although  $X_{next}$  is a deterministic system it is *not* which of the following (all that apply)?

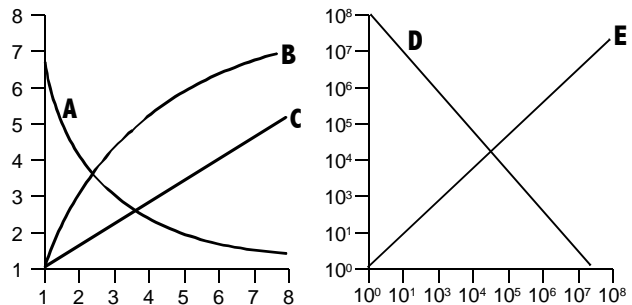
- A Iterated B Logistic C Predictive
- D Recursive E Linear

46. Identify by the letters in the bifurcation diagram to the right all those that represent a limit cycle attractor.

### Universality



47. T/F. *Sensitive dependence* means that minor changes in the input result in major changes in the output.
48. T/F. The *Feigenbaum ration* says that bifurcations come faster and faster at a constant ration.
49. T/F. The study of sandpiles (SOC) tells us that systems never go from one configuration to another gradually; changes are always catastrophic, deterministic and predictable.
50. T/F. All systems going through a bifurcation *must* go through a period of destabilization and chaos before they can complete the transition.
51. T/F. In the graph, curve **A** follows a power law.
52. T/F. In the graph, curve **C** follows a power law.
53. T/F. In the graph, curve **D** follows a power law.
54. T/F. A power law distribution tells us that the rarer the event the larger and more significant it will be.



Multiple Choice: At the back of the test is a page containing 15 illustrations dealing with complex systems. Of the **15 choices** in each box, **choose as many** as are appropriate and necessary to answer the questions in the boxes below. Note that some questions may end up with no answer at all, and some illustrations may answer more than one question.

**Fixed (point) Attractor:** mark one or more of the 15 choices directly exhibiting this property.

55. A=A    B=B    C=C    D=D    E = E  
 56. A=F    B=G    C=H    D=I    E = J  
 57. A=K    B=L    C=M    D=N    E = O

**Strange Attractor:** mark one or more of the 15 choices directly exhibiting this property.

58. A=A    B=B    C=C    D=D    E = E  
 59. A=F    B=G    C=H    D=I    E = J  
 60. A=K    B=L    C=M    D=N    E = O

**Fractal Geometry:** mark one or more of the 15 choices directly exhibiting this property.

61. A=A    B=B    C=C    D=D    E = E  
 62. A=F    B=G    C=H    D=I    E = J  
 63. A=K    B=L    C=M    D=N    E = O

**“Self Organized Criticality”:** mark one or more of the 15 choices which illustrate this phrase.

64. A=A    B=B    C=C    D=D    E = E  
 65. A=F    B=G    C=H    D=I    E = J  
 66. A=K    B=L    C=M    D=N    E = O

**“Power Law”:** mark one or more of the 15 choices which illustrate this phrase. .

67. A=A    B=B    C=C    D=D    E = E  
 68. A=F    B=G    C=H    D=I    E = J  
 69. A=K    B=L    C=M    D=N    E = O

Multiple Choice: To the right are 5 concepts/ principles we employed to study the behavior of various systems. For each system or component of a system below, select the one concept/principle that is most germane (relevant, applicable) to the system. In none apply, leave all blank.

Choose From Among These

A	Positive and/or Negative Feedback
B	Sensitive Dependence
C	Emergent Properties
D	Local Rules/Global Behavior
E	<i>None of these choices</i>

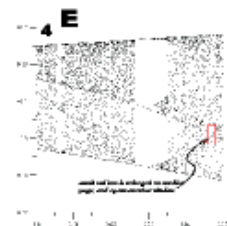
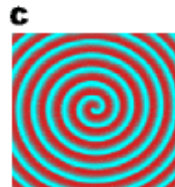
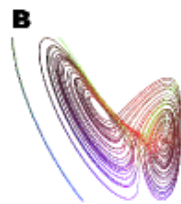
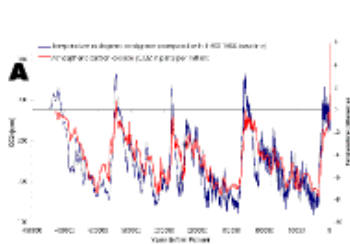
- 70. The controlling principle behind the behavior of **X-next**.  
A B C D E
- 71. The controlling principle behind the behavior of *cellular automata*.  
A B C D E
- 72. The behavior of merchants, like in a large city.  
A B C D E

## Hysteresis and Bistable Behavior

**MULTIPLE CHOICE; 2 POINTS EACH:**

**Hysteresis:** For the models below those that clearly exhibit or illustrate the property of hysteresis; *True* if you accept the choice, *False* if you do not.

73. <b>A</b> is T or F	74. <b>B</b> is T or F	75. <b>C</b> is T or F	76. <b>D</b> is T or F	77. <b>E</b> is T or F
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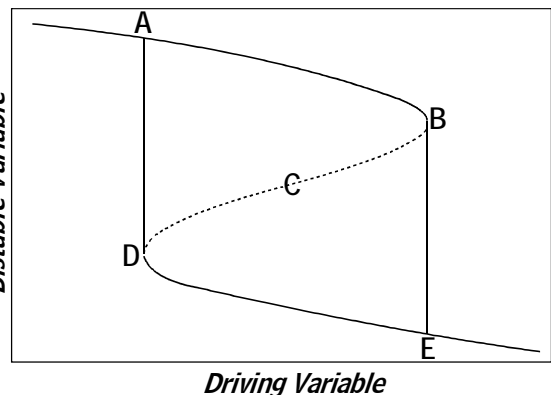
In the Hysteresis diagram to the right, the system is sensitive dependent (tipping point) at which point (more than 1).

- 78. A, B, C, D, E

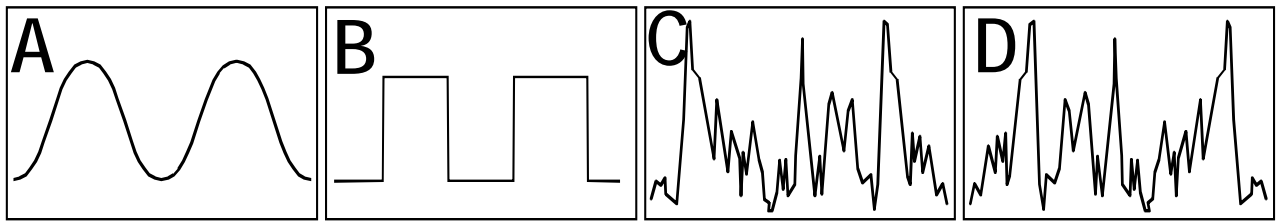
In the Hysteresis diagram to the right, the system is becomes increasingly unstable from (one choice):

- 79. A = **A → B**,      B = **B → A**,      C = **B → D**,  
       D = **D → E**,      E = **B → E**

- 80. At location C on the hysteresis diagram (1 choice):
  - A. Nothing ever exists here because the energy of the entire system is too high.
  - B. This area is unstable and the system passes through it quickly.
  - C. This is an equilibrium condition between two bistable states.
  - D. In the bistable system this is the bistable point.



81. In the Time- Series diagrams below a pattern, say for a glaciation, looks like which one; warm is up, cool is down).



### Self Organization in Cellular Automata

**MULTIPLE CHOICE - 8 POINTS:**

82. Below are four cellular automata worlds. Which one was generated by the following rules?

**Birth neighbors = 3, 3; Survival neighbors = 3, 3.**

A

B

C

D

**MULTIPLE CHOICE; 5 points:** Of the four cellular automata choices, and based on how the system is evolving:

83. In which does it appear *information is flowing the most easily* ("r" is highest), A, B, C, or D?

84. T/F. Local Rules/Global Behavior means that a system works best when each entity in the system follows the rules that work best for it.

Cellular Automata were used to illustrate which of the following ideas about systems (all that apply) Yes = True; No = False ?

- 85. T/F. Avalanche behavior
- 86. T/F. Feigenbaum ratio
- 87. T/F. Fractal organization
- 88. T/F. Limit cycle attractor
- 89. T/F. Point attractor
- 90. T/F. Power-law relationship
- 91. T/F. Self Organization
- 92. T/F. Sensitive dependence
- 93. T/F. Strange attractor

*We constructed the following definition of a complex system. Here it is divided into its individual elements. Identify the models we used to incorporate selected elements of the definition.*

- A A group of interacting, interrelated, or interdependent elements*
  - B existing far from equilibrium,*
  - C that have evolved together through time*
  - D (self-organized by bottom up processes),*
  - E forming a dynamic network where everything is connected to everything else such that a change in one component affects the states of the other components*
  - F by positive and negative feedback,*
  - G exhibiting sensitive dependence, fractal organization, and avalanche behavior that follows a power-law distribution.*
94. Part B - *existing far from equilibrium* - was authenticated and validated with which model?
- A Bak-Sneppen
  - B Self-Organized Criticality
  - C Xnext (logistic equation)
  - D Cellular Automata
  - E Zipf's Law
95. Part C - *that have evolved together through time* - was authenticated and validated with which model?
- A Bak-Sneppen
  - B Self-Organized Criticality
  - C Xnext (logistic equation)
  - D Cellular Automata
  - E Zipf's Law

***Double check Your People Soft Number On the Scantron Card to Make Sure The Bubbles are Filled***

