Solution Manual for Good Earth Introduction to Earth Science 3rd Edition by McConnell and Steer ISBN 0073524107 9780073524108

CHECKPOINT ANSWER KEYS

CHAPTER 1: INTRODUCTION TO EARTH SCIENCE

Self-Reflection Survey: Section 1.1, p. 7
These questions are designed to allow students to recognize that they already know something about Earth science, even though they probably did not learn this information in the context of an Earth science course. Consequently, these questions don't have any "right" answers but begin to build a foundation for later conceptual understanding.

- Which of the following Earth science phenomena have you experienced? Which would you most like to experience? Can you think of three more things to add to the list?
  Individuals who have traveled extensively may have experienced several items on the list, but the whole class is more likely to be able to check off most items and provides the instructor with information for later discussions. Asking students to add material to the list provides them with an opportunity to signal their interests.

- What three questions about Earth would you like to be able to answer by the end of this course?
  Students are more motivated to participate in a class if they believe that they have made a contribution to determining the direction of the course. The responses to this question provide the instructor with an opportunity to highlight topics students are already interested in.

Checkpoint 1.1, p. 6
Good questions often produce answers that lead to yet more questions. Review the statement and suggest some related questions that could clarify or expand the topic.

Students who work together in groups often learn more than students in the same class

who work alone.
This open-ended, non-content specific question is intended to help students recognize that they already know how to frame good questions. This will support their learning later as they apply that skill to content-specific scenarios. Student responses will vary widely from rather low cognitive level questions (e.g., How big are the groups? How much more do they learn?) to more advanced levels (e.g., Do these trends vary with subject? What type of exercises yield the greatest gains?).

Instructors have the opportunity to guide students toward better questions by listing all the student responses and asking the class to identify which questions can be answered by citing a single fact and which require more information that might inspire additional questions. Students could then be encouraged to consider focusing on the deeper level questions in the future. Finally, this could also lead to a discussion of which are the best, or most interesting, three questions. Such a discussion sharpens students' evaluation skills, a key critical thinking skill.

Checkpoint 1.2, p. 8
Make a list of the multiple ways that you interact with each of the four components of the Earth system.
Possible answers might include:

- Atmosphere: breathing, flying, sky-diving, observing clouds, weather forecasting
- Hydrosphere: swimming, surfing, fishing, ice in drinks, sailing (also with atmosphere), drinking water, showering, raining
- Biosphere: eating, drinking, pets, visit zoo, admire scenery, gardening, mowing the grass, agriculture, cotton clothes
- Geosphere: oil, gas, coal, precious metals and minerals, industrial minerals (e.g., aggregate gravel on driveway), elements in food

Checkpoint 1.3, p. 9
Three of the big ideas listed near the start of this section detail the interaction of humans and the earth system: (1) Humans depend on Earth for resources; (2) natural hazards pose risks to humans; and (3) humans significantly alter Earth. Take a few minutes and write what you can in support of each of these statements. Consider revising your responses as you progress through the semester to see if you can add more items and/or more information.

This is an open ended question that will receive a range of responses depending upon students pre-existing knowledge about the earth system. There are no "wrong" answers to this question as it is intended to encourage students to reflect on what they already know, or think they know. However, responses will inevitably contain some misconceptions. There are no

Checkpoint 1.4, p. 10
Go to the US Geological Survey site (www.usgs.gov) and find an example of an earth science topic that USGS scientists have investigated.
1. Briefly describe the research using no more than six sentences.
2. Identify:

- The types of questions the scientists investigated.
- The types of tools the scientists used.
- An example of the data they collected.

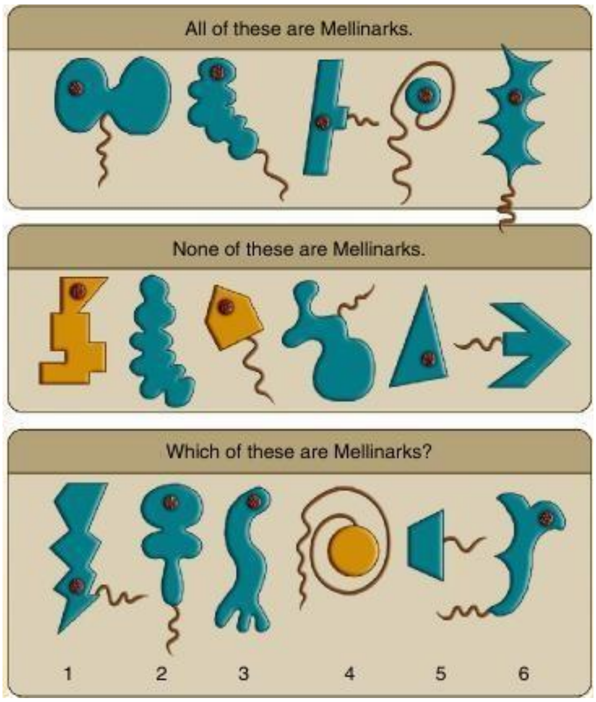
This is an open-ended, information literacy question requiring students to research a geoscience topic using an authoritative source of information. Students should be advised to read about the research topic, close the browser and then summarize the information as to not plagiarize the source.

Checkpoint 1.5, p. 11
Scientists suggested the dinosaurs became extinct when an asteroid collided with the Earth. They noted that *the rare element iridium was present in 65 million year old rock layers around the world*. The text in italics an example of:
a) a hypothesis b) a prediction c) an observation d) a theory

This is a comprehension-level question. Correct answer c).

Checkpoint 1.6, p. 12
Examine the images below. Based on your observations, form a hypothesis as to how many of the images in the bottom row represent Mellinarks.

What was the thought process you went through to arrive at an answer? Try to separate out the “thinking steps” that you took, identifying observations, predictions, and hypotheses. On a separate sheet of paper, briefly describe the steps.



This is an open-ended analysis question that requires that students know the differences between observations, hypotheses, and predictions. There are likely to be a variety of responses, one possible answer sequence is provided below.

Observation 1: All Mellinarks in the top row have large dots.
Hypothesis 1: Mellinarks have a large dot.
Prediction 1: Creatures in the middle row should not have a dot.

Observation 2: Some non-Mellinarks in the middle row do have a large dot.
Conclusion: Large dots are not necessarily distinguishing features of Mellinarks.

Observation 3: Top row Mellinarks have tails and shading.
Hypothesis 2: Mellinarks have tails, shading, and large dots.
Prediction 2: Creatures in the middle row will lack all three features.

Observation 4: Non-Mellinarks don’t have this combination.
Hypothesis 3: Creatures 1, 2, and 6 in the bottom row are all Mellinarks.

Checkpoint 1.7, p. 13
Identify the application of the four characteristics of good science in the passage that follows.

To answer this question, students must review the case study of the Hutchinson gas explosions. This is an analysis question were students are examining the information presented to them and determining how or where the characteristics of good science are represented.

- Scientific explanations are provisional and can and do change – the rock layer that was thought to be the conduit for the escaped gas was initially considered to be a rubble layer then interpreted as a layer of fractured dolomite.
- Scientific explanations should be predictable and testable – geologists from the survey reviewed what they knew about the geology of the area and made testable predictions about which layers served as conduits for the gas. They also used technology to predict where to look for pockets of gas trapped below ground.
- Scientific explanations are based on observations or experiments and are reproducible - scientists used previous observations of the area's geology to generate an explanation of what had happened under Hutchinson.
- A valid scientific hypothesis offers a well-defined natural cause or mechanism to explain a natural event – the gas explosions at Hutchinson were linked to the leak at the Yaggy facility that traveled to the city through underground rock layers.

Checkpoint 1.8, p. 16
Employees at the Ripley's Believe It Or Not! Museum in Myrtle Beach, South Carolina, declare that female visitors who come in contact with a pair of African fertility statues have consistently become pregnant. The statues, from the Boule Tribe of the Ivory Coast, stand near the museum's entrance. Some visitors have volunteered the information that they gave birth nine months after touching the statues, and credit the statues. The museum notes that some couples travel from as far away as Texas to rub the statues.
a) What is the hypothesis presented in the story?
b) Is the hypothesis supported by sufficient observations? Explain.
c) What prediction could be made to verify or falsify the hypothesis?

This is an application question with an open-ended response necessary for the final part. Students apply their understanding of the process of science in this exercise.
a) Hypothesis: Touching the fertility statue increases chances of becoming pregnant.
b) No: Not enough data presented. Only indicate "some" reported becoming pregnant and does not account for all those who touched the statue but did not become pregnant.
c) This part of the question is open-ended. Students should make a prediction that can be empirically tested. For example, survey a sample of women who touch the statue to see if they become pregnant (introduces concept of appropriate sample size).

Checkpoint 1.9, p. 17

Read the following summary of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, 1980). Does this law involve the measurement of physical and/or chemical characteristics of the environment or did it arise from social and/or cultural concerns? Explain your answer.

See p. 17 of the text for the summary of the CERCLA text.

The correct answer here could be narrowly defined as the measurement option but a fairer answer is probably both. This question is an application of issues associated with science and society. CERCLA deals with measurement (and remediation) of physical and chemical materials in the environment and who should pay for the remediation. The law likely arose from social concerns (e.g., Love Canal example), but it is specific to the chemicals.

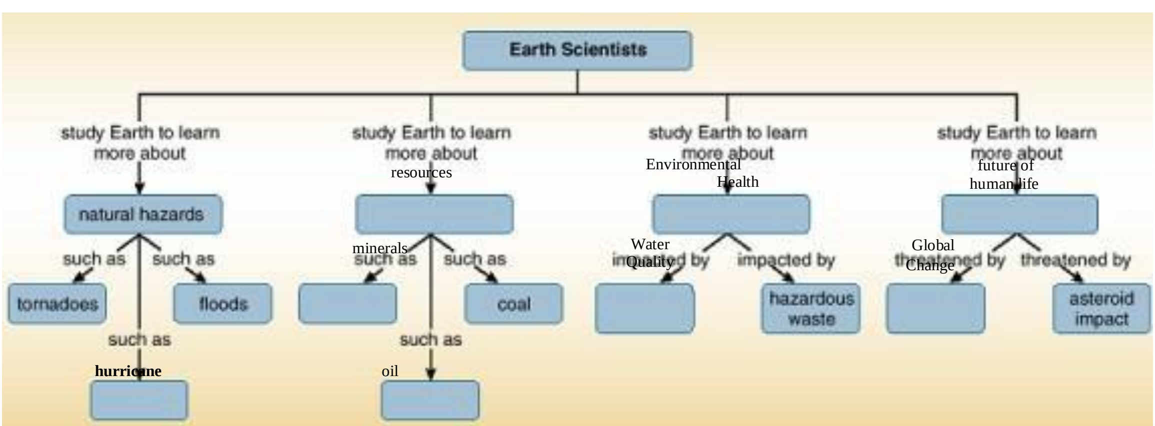
Checkpoint 1.10, p. 18
Is the evacuation of a city in advance of a hurricane an example of prevention or adjustment?
a) prevention b) adjustment

What other examples of prevention or adjustment have been described in the chapter so far?

This is a comprehension-level question. The correct answer is b) because society is changing to accommodate nature, not trying to stop the hurricane. Other examples:

- Tsunami: adjustment;
- Hutchinson Gas explosion: prevention;
- Mid-continent earthquake: adjustment.

Checkpoint 1.11, p. 21
Complete the concept map below to summarize the characteristics of the four principal roles that Earth scientists play in society.



Some possible answers are provided above. Students could be asked to complete this on their own or instructors could place these answers in a list and ask students to place them in the correct location.

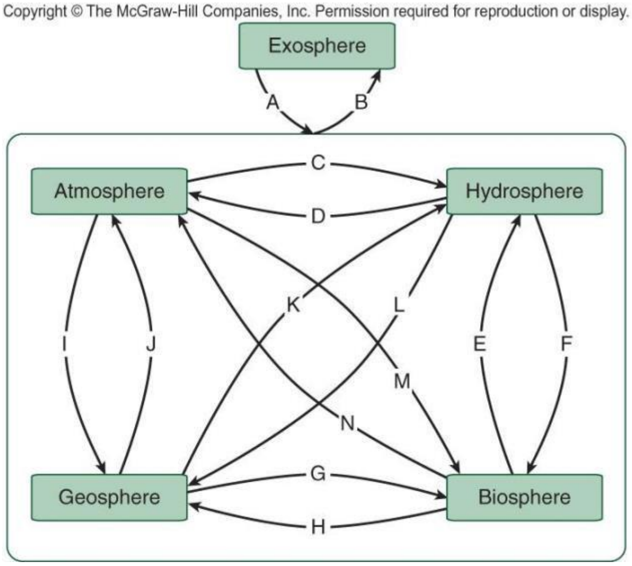
Checkpoint 1.12, p. 21
Read the following quote. Discuss why you agree or disagree with the statement.

> *This is the first generation in the history of the world that finds that what people do to their natural environment may be more important than what the natural environment does to and for them*.
>
> Harlan Cleveland, former United States Secretary of State.

Although the students probably will not realize it, this quote is a few decades old. The generation being discussed actually represents their parents.
This is an open-ended synthesis/evaluation-level question. Students must combine various concepts mentioned in the first chapter, determine how those concepts relate to the quote, frame an argument, and make a judgment. Good answers will discuss the various issues mentioned in the introduction, how those issues relate to the nature of science and how science and society interact. Poor answers will simply cite examples in the text that might bear on the quote without making a judgment or supporting their answer.

Introduction to Earth Science: Concept Map, p. 23
To evaluate your understanding of the interactions between the components of the Earth system discussed in this chapter, complete the following concept map exercise.

Examine the following list of interactions between pairs of components in the Earth system. Match each interaction with one of the lettered links in the concept map provided.



Interaction	**Letter**

Plants absorb carbon dioxide gases.	M
Earthquake destruction causes deaths.	G
Wind blows sand.	I
Spacecraft explore deep space.	B
Continents deflect ocean currents.	K
Plants release oxygen.	N
Fish live in oceans.	E
Asteroid impacts Earth.	A
Volcano emits toxic gases.	J
Animals drink water.	F
Water evaporates from the oceans.	D
Humans mine coal.	H
Winds generate waves.	C
A stream carves a canyon.	L

In later chapters we will expect students to make these connections themselves. These chapter summary exercises are designed as practice sessions in the first couple of chapters.

CHAPTER 2: EARTH IN SPACE

Self-Reflection Survey: Section 2.1, p. 27
These questions are designed to allow students to begin recognizing they are part of a large system that includes the earth in space.

Answer the questions below as a means of uncovering what you already know about Earth's position in space.
1. Explain how we are influenced by Earth's position in space on a daily basis.
2. If you could make one trip into space, where would you most like to visit and why?
3. Think about some situation in your life where you changed how you thought about something. What circumstances were required for you to change your mind or point of view?

Checkpoint 2.1, p. 28
List these cosmic features in order of size, beginning with the largest.
a) Universe, galaxy, star, planet
b) Star, galaxy, universe, planet
c) Universe, planet, star, galaxy
d) Galaxy, universe, star, planet
This is a comprehension-level question to see if students have any idea of the relative scales of these objects.

Checkpoint 2.2, p. 29
Suppose the light spectrum from a distant star shifted toward the blue end of the spectrum. What would this imply?
a) The star is moving away from us.
b) **The star is moving away toward us**.
c) The star is stationary compared to us.
This is an application-level problem. Students frequently want to calculate an answer without understanding the underlying concepts. Here they must apply their understanding to an example not discussed in the text.

Checkpoint 2.3, p. 30
Scientists often suggest that the expansion of the Universe is similar to the expansion of raisin bread as it bakes in an oven. As the loaf increases in size, individual raisins move farther apart in the expanding bread. During a homework assignment, two students suggest the following two analogies for the universe, but these are not considered as good as the raisin bread analogy. Why?
a) The universe expands similarly to the concentric ripples formed when a rock is thrown into a pond.
b) The universe is similar to a Jell-O mold enclosing pieces of fruit (galaxies).

This is an open-ended evaluation-level question. Students must understand the concepts, and use that understanding to make a judgment. Good student responses will note that the pond exists before the ripples, that the ripples will eventually disappear, and that the pond is essentially a two-dimensional surface in contrast to the three-dimensional shape of the raisin bread loaf. In the second case, the mold (universe) does contain clumps of material (fruit) but there is no expansion involved in the formation of the Jell-O mold. It is likely that students will come up with additional responses that are equally appropriate.

Checkpoint 2.4, p. 31
Explain how the development of concepts in this section exhibited the key characteristics of scientific explanations. Explanations are 1. Provisional (tentative); 2. Based on observations; 3. Predictable and testable; 4. Offer natural causes for natural events.

This question requires students to recall the meaning of, and apply, the characteristics of good science explained in Chapter 1. Good student responses will discuss that:

1) Several ideas about the solar system (and universe) existed, but changed over time (e.g., geocentric vs. heliocentric solar system; extrasolar planets, number of planets).
2) Those changes to prevailing ideas were driven by observations (e.g., relative size of sun vs. Earth, phases of Venus, luminosity of cepheid variables, sunspot cycle, UB313).
3) Better ideas predicted the characteristics of the planets and nature of the universe (e.g., heliocentric orbit and phases of Venus, red shift and the age of the universe, cosmic microwave radiation and the big bang).
4) All the explanations discussed rely on the known physics of matter and energy rather than a supernatural event (e.g., Doppler effect, wavelengths of light, nuclear fusion in the sun, greenhouse effect).

Checkpoint 2.5, p. 32
Construct a timeline diagram that illustrates the life cycle of the sun. This will look different for each student but it should include some or all of the following stages: nebula, sun, red giant, white dwarf, and black dwarf.

Checkpoint 2.6, p. 33
Which of the following statements is most accurate? Explain the reason for your answer as well as why you did not choose either of the other two statements.

a) All stars and planets are about the same age.
b) Stars are approximately the same age as their orbiting planets.
c) The number of stars is declining as stars burn out.

This is a synthesis-level question for which students should be able to come up with empirical evidence to rule out a) and c) and argue for b).

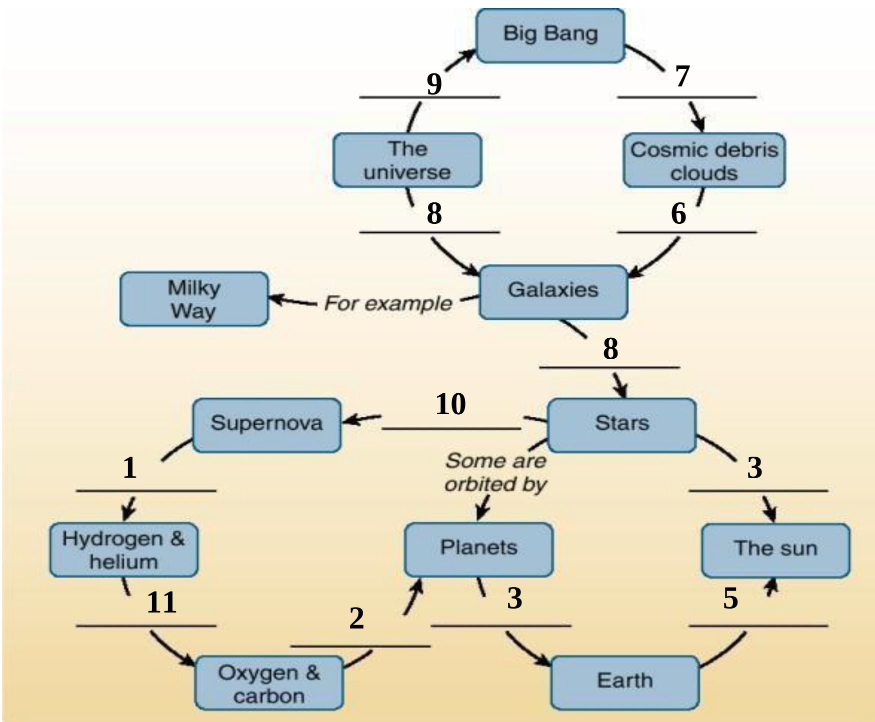
Students should recognize that a) cannot be correct because some stars have already been through a complete life cycle (supernova) and big stars are typically much more short-lived than smaller stars. Likewise, c) is wrong because stars are being born in the universe just as others are dying. Students who understand the origins and workings of the universe will realize that we have no way of knowing how many stars exist and there is no way of knowing whether death or birth or stars dominates. Students will have difficulty selecting b) because it is less definitive than a) or c) (that seem to be a “right” or “wrong” answer). They should cite the process of planet formation as evidence that stars and their planets are about the same age.

Checkpoint 2.7, p. 33

Characteristics of the Universe Exercise

Complete the following concept map by correctly adding the connecting phrases or terms provided to the appropriate locations. Some items may be used more than once; others may not be applicable to this diagram.

1. *converts simple elements such as*
2. *present in*
3. *for example*
4. *extrasolar planets such as*
5. *orbits*
6. *formed early versions of*
7. *gas and dust formed*
8. *contains billions of*
9. *began to expand rapidly following the*
10. *destroyed in an explosion known as a*
11. *to more complex forms such as*
12. *are examples of red giants*



This is a comprehension summary question requiring students to combine content and comprehension. This exercise can be used as an in-class gaming exercise as a good way to engage students. Have students complete this exercise in class (together or individually) and then stand. Answers can be shown sequentially. Students who miss answers sit down.

Checkpoint 2.8, p. 34
What planetary characteristics would you look for in an extrasolar planet that might have the potential to harbor life similar to that found on Earth?

This is an analysis-level question that requires students to think about the characteristics of Earth's position in space relative to the sun, our nearest star. Good student responses should discuss the type of star (long-lived smaller star rather than short-lived giant star), the size of the planet (Earth-sized rather than Jupiter-sized), the planets location relative to the star (not too close, not too far, just enough for liquid water), and the chemistry of the atmosphere (gases similar to Earth). Some students might take the extra step and argue that, currently, we can only make such observations within our own solar system.

Checkpoint 2.9, p. 35
What are the principal components of the sun? (*Hint:* See Section 2.3.)
a) Hydrogen and helium
b) Carbon and oxygen
c) Silicon and sodium
d) Nickel and iron

This is a knowledge-level question but relies on students having learned this material in the previous section dealing with stars. They need to take the (small) extra step of recognizing that the sun is just an example of a star.

Checkpoint 2.10, p. 35
Sunspots, flares, and other emissions from the sun's surface can have a negative impact on electrical systems on Earth. What would be the implications for this type of solar activity if the sun did *not* experience differential rotation?
a) There would be less sun spot activity.
b) There would be more sun spot activity.
c) There would be no change in sun spot activity.
This is a comprehension-level question. Since sunspots are hypothesized to result from differential rotation, no rotation would imply less (or no) sunspot activity.

The sun is located approximately 150,000,000 kilometers (93,000,000 miles) from Earth. How long would it take for charged particles ejected from the sun to affect electrical systems on Earth, assuming the particles traveled at 1.6 million km/h?
a) A few minutes b) A few hours **c) A few days** d) A few weeks

This is an application-level question that requires students to estimate the time interval based on the velocity of the particles leaving the Sun (1.6 million km/hr) and the travel distance. Note that the correct answer can be estimated quite accurately without the need for an actual calculation.

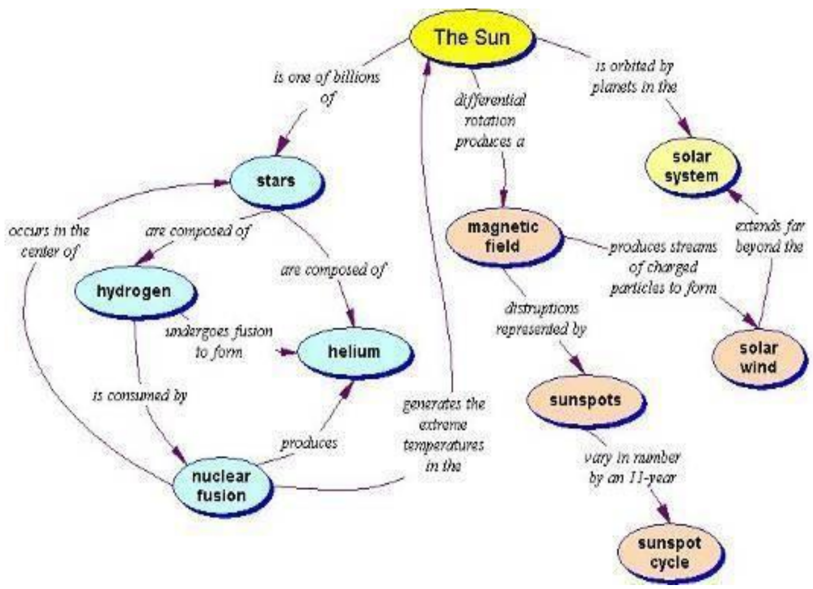
Checkpoint 2.11, p. 36
Use the graph of sunspot numbers (Fig. 2.12) to answer the following questions.
1. When was the most recent solar maximum (month/year)? **January 2001**
2. When was the most recent solar minimum (month/year)? **January 2008**
3. On a slow day in the lab, two graduate students made a bet about how many sunspots would occur 2 months later in spring semester, 2013. Chad estimated there would be 90 sunspots; Julie thought there would be 30. When the day rolled around, 63 sunspots were recorded. Does this mean that Chad and Julie do not understand the sunspot cycle? Explain your reasoning.

This is collection of comprehension or analysis questions. Depending upon how readily students can interpret graph data, some may find these questions more challenging than others. The last question of the exercise is designed to have students consider how much natural variation should be expected in natural systems. This is a key consideration we will discuss later in the book when we compare past climate data to the predictions of climate models. Students frequently have difficulty reading and interpreting graphs. Answers shown are approximate, but students should obtain similar results.

Checkpoint 2.12, p. 37
Create a concept map that links together the principal characteristics of the sun using the terms listed here, as well as any linking phrases you wish to create.

The sun	Helium
Solar wind	Nuclear fusion
Solar system	Sunspots
Magnetic field	X-rays
Star	Sunspot cycle
Hydrogen	Differential rotation

This is a synthesis level exercise requiring students to organize and relate various concepts associated with the sun. Poor concept maps will simply connect terms without connecting phrases, usually in a linear or circular fashion. Those maps will usually have multiple conceptual errors. Average concept maps will show how concepts relate to one another and include appropriate linking terms. These maps usually include one or two conceptual errors or inappropriate links. Good concept maps will correctly organize and link concepts. A sample map is provided as an example.



Checkpoint 2.13, p. 38
Which of the following sequences of planets is out of order?
a) Mars, Jupiter, Saturn, Uranus, Neptune
b) Venus, Mars, Earth, Jupiter, Saturn
c) Neptune, Uranus, Saturn, Jupiter, Mars
d) Jupiter, Mars, Earth, Venus, Mercury

This is a knowledge/comprehension level question that requires students to recall the order of the planets.

Checkpoint 2.14, p. 39
Make four generalizations about the 8 planets in our solar system using the information in Table 2.1. For example, planets closer to the sun are smaller than those farther away.

Table 2.1 Characteristics of the Eight Planets

Planet	Size (radius), km	Orbital period	Distance from sun, million km [AU]	Principal atmospheric gases
Mercury	2,440	88 days	58 [0.4]	Helium, sodium
Venus	6,052	225 days	108 [0.7]	Carbon dioxide
Earth	6,378	365 days	150 [1]	Nitrogen, oxygen
Mars	3,397	687 days	228 [1.5]	Carbon dioxide
Jupiter	71,492	11.9 years	778 [5.2]	Hydrogen, helium
Saturn	60,268	29.5 years	1,427 [9.5]	Hydrogen, helium
Uranus	25,559	84 years	2,871 [19]	Hydrogen, helium
Neptune	24,746	165 years	4,497 [30]	Hydrogen, helium

This is a comprehension-level question that asks students to take information from one format (table) and present it in another format (written summary). Some possible answers are:

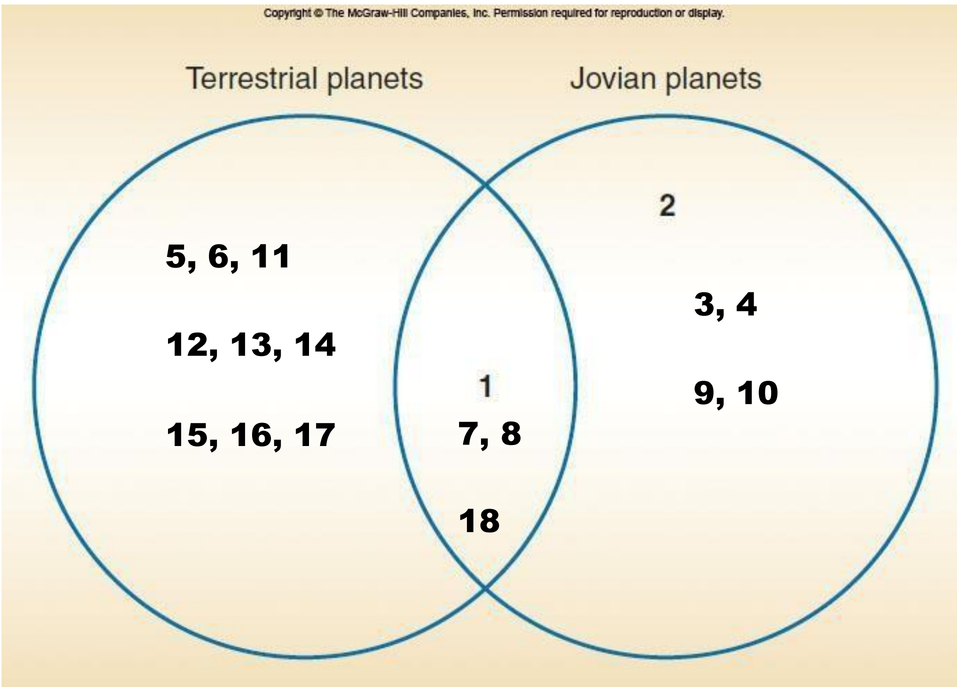
- Terrestrial planets have orbits that are measured in days; Jovian planets have orbits measured in decades or centuries.
- Terrestrial planets have atmospheres with heavier elements while Jovian planets have lighter elements.
- There is much greater variety in the atmospheres of the terrestrial planets.
- Orbital period increases with increasing distance from the sun.

Poorer answers will repeat information from the text such as Jovian planets are larger than terrestrial planets.

Checkpoint 2.15, p. 42
Venn Diagram: Terrestrial versus Jovian Planets
Complete the following Venn diagram to compare and contrast the similarities and differences between the two major groups of planets in our solar system. Identify 12 characteristics that are either shared by both terrestrial and Jovian planets or are unique to one of the two groups. Then, place the numbers corresponding to each characteristic in the diagram. Characteristics 1 and 2 have been plotted on the diagram for you.

1. Orbit around sun	7. Have atmospheres	13. Closer to Sun
2. Gas giants	8. Spherical	14. Shorter orbits
3. Strong gravitational fields	9. Have rings	15. Compositional layers
4. Larger	10. Multiple moons	16. More closely spaced
5. Smaller	11. Had/has a hot interior	17. Variable atmospheres
6. Rocky surfaces	12. Earth-like	18. Formed at same time

This is an analytical exercise that requires students to compare and contrast differences between the two major classes of planets. A sample solution is displayed though there are other possible characteristics. Note that students are only asked to identify twelve characteristics.



Checkpoint 2.16, p. 42
In 2006, the IAU defined a new class of planets, dwarf planets. Explain why this is consistent with nature of science described in Chapter 1.

This is an application-level question related to the nature of science. Good student responses will cite the tentative nature of science and the impact of technology resulting in identification of many more planet-like bodies in the solar system. Poor student responses will indicate that scientific hypotheses cannot explain all things (miss-apply idea).

Checkpoint 2.17, p. 43
How do we define the length of a year on Earth?
a) A year is related to the revolution of Earth around the sun.
b) A year is related to the rotation of Earth on its axis.
c) A year is related to the rotation of the sun on its axis.
d) A year is related to the revolution of the sun around Earth.

This is a comprehension-level question that addresses student confusions regarding the difference between rotation and revolution. It appears simple but there will be a significant number of students who will not be able to differentiate between several of these statements on their own. Consequently, this serves as a good warm-up question to get everyone started from the same place.

Checkpoint 2.18, p. 44
How would the amount of incoming solar radiation change at the equator if Earth's axis were vertical instead of tilted?
a) Incoming solar radiation would decrease.
b) Incoming solar radiation would be the same as present.
c) Incoming solar radiation would increase.

This comprehension-level question again addresses student difficulties understanding of Earth's orbit, rotation axis, and their effect on insolation. If the axis were vertical, the insolation would simply be latitude dependent. The equator would receive the same amount all year (a maximum) that it now receives only on the spring and fall solstice days. Therefore, the total insolation integrated across a year would be greater than it is now.

Checkpoint 2.19, p. 44
Mars has a more asymmetric orbit of the sun than Earth. Mars is 20 percent closer to the sun during its winter than during its summer. How would Earth's climate be affected if Earth had a similarly eccentric orbit, being 20 percent closer to the sun during winter months in the Northern Hemisphere?

This is an opened-ended synthesis-level question that requires students to understand and apply their understanding of seasons, while predicting consequences to the biosphere. Students must first recognize that Earth is already ~3% closer to the sun in winter than during summer in the Northern Hemisphere. If Earth were 20% closer, temperatures would be significantly higher than they are currently in winter in the Northern Hemisphere and in summer in the Southern Hemisphere. An orbit that took us closer to the sun would also be a shorter orbit, making the length of the year shorter. Students should recognize that this would result in changed growing seasons, significant differences in native vegetation, changes in precipitation, melting of ice caps, and greatly impact where humans' lives and how they live.

Checkpoint 2.20, p. 44

Imagine that it is your job to explain to a group of middle school students how the distribution of incoming solar radiation varies daily and seasonally on Earth's surface. Assuming you have a basketball and flashlight to use as props, write a description of how you would have the students use the props in a demonstration.

This is an open-ended, synthesis-level question that is very appropriate for students who intend to become teachers and is most appropriate for a homework assignment. The lesson should include a description of what each prop represents and the limitations of that model. Their plans should show how they intend to use the ball to discuss the rotation axis tilt and orbit. It should also indicate how the flashlight is used to demonstrate where sunlight hits Earth most directly and when.

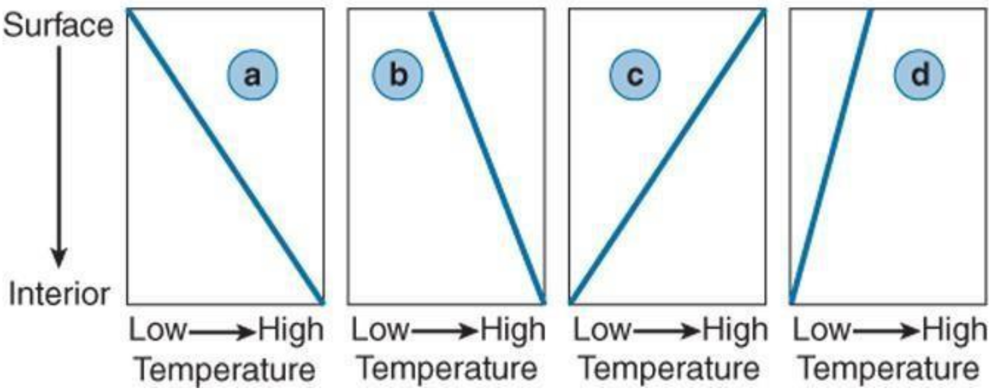
Checkpoint 2.21, p. 45
What are the three compositional layers in the Earth's interior?
a) Asthenosphere, lithosphere, core
b) Oceanic crust, continental crust, asthenosphere
c) Lithosphere, mantle, core
d) crust, mantle, core

This is a knowledge-level question that addresses student misunderstandings about the differences between compositional and physical (or mechanical) layers.

Checkpoint 2.22, p. 46
Much of our understanding of the character of Earth's interior comes from analyzing seismic waves that travel through Earth. As these waves move through Earth's interior they may pass through, bounce off (reflect), and/or bend (refract) at boundaries between different rock types. The time it takes a seismic wave to travel from a source in one location to a recording station at another can be used to decipher the internal structure of Earth. Identify three similar methods that are commonly used to view the interior of objects in daily life without cutting or breaking them open.

This is an open-ended, comprehension-level question. Students generally cite x-rays and ultrasound because they have experienced them at some time in their lives. Others may be familiar with magnetic resonance imaging (MRI) or positron emission tomography (PET).

Checkpoint 2.23, p. 47
The following graphs illustrate four idealized geothermal gradients for Earth.



Bearing in mind that Earth is 4.6 billion years old, which line plot is most likely to represent the present-day gradient?
a) b) c) d)

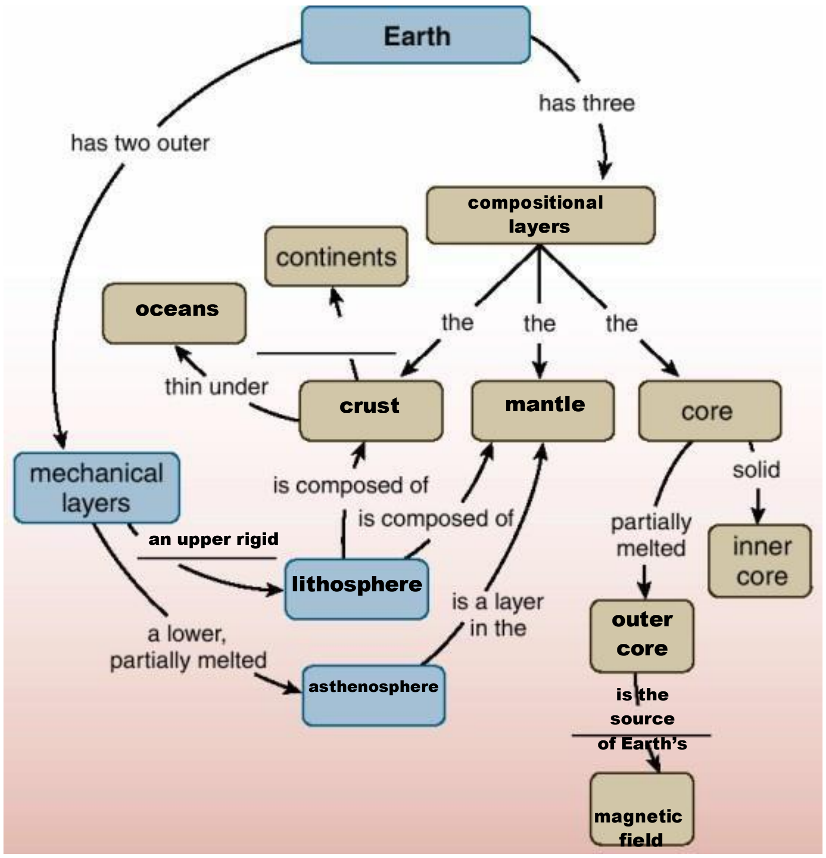
Which line plot is most likely to represent the gradient 2 billion years ago?
a) **b)** c) d)

This is a comprehension exercise that requires students to translate what they understood from the text into a graphical format, and asks them to reflect on the differences between an early Earth and a more recent Earth.

Checkpoint 2.24, p. 47
Complete the following concept map by writing the correct terms in the appropriate blank locations as key terms or connecting phrases/terms. A partial list of terms that you will need is provided here, but some of them may not be applicable to this diagram.

1. Compositional layers
2. Crust
3. One of three
4. Oceans
5. Is the source of Earth's
6. An upper rigid
7. Characteristic of terrestrial planet

This is a synthesis-level exercise that requires students to reorganize the content provided and determine how various concepts are related to one another. This would be a comprehension-level exercise if there were just enough terms to fill the blank spaces. However, providing some incorrect terms and leaving out a few others makes this a more challenging exercise and requires that students really understand the connections between concepts.



Checkpoint 2.25, p. 48
Defining Earth's Characteristics
Read the sentences in the following table and circle the appropriate term in the right-hand columns that could be used to complete the sentence or fill in the blank. Explain the reason for your choices.

If Earth was farther from the sun the planet would be____.	warmer	**cooler**
If Earth was a little closer to the sun the oceans would be ____.	**smaller**	larger
If Earth did not have a biosphere, the composition of Earth's atmosphere would be____.	the same	**different**
If Earth's biosphere were younger we would have ________ oxygen in the atmosphere.	**less**	more
If Earth did not have an atmosphere its surface would have ________craters formed by meteorite impacts	fewer	**more**

If Earth did not have an atmosphere, life on the land surface would be_________developed than it is today.	**less**	more
If Earth were larger its gravity would be_________.	weaker	**stronger**
If Earth were smaller its atmosphere would be__________.	thicker	**thinner**
If Earth were smaller it would have a_________interior.	hotter	**colder**

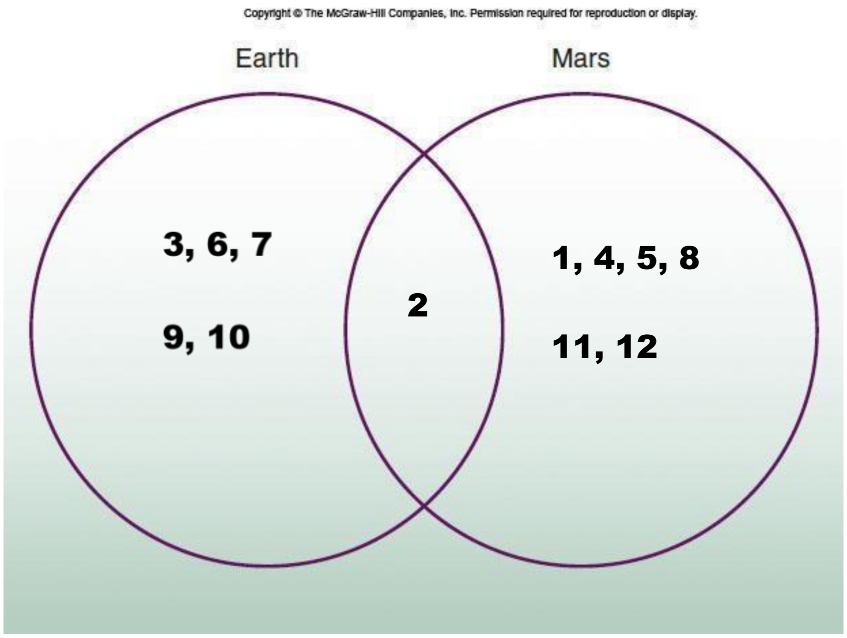
This is a summary comprehension-level exercise that requires that students directly confront several of the concepts described in this section of the chapter. While these types of exercises often appear straightforward to the instructor, they can reveal student misconceptions. For examples, students typically have difficulty with the last three items.

Checkpoint 2.26, p. 49
Venn Diagram Exercise: Earth versus Mars
Complete the following Venn diagram to compare and contrast the similarities and differences between Earth and Mars. Identify 12 characteristics that either are shared by both planets or are different for each planet. Then place the numbers corresponding to the characteristics in the most suitable locations on the diagram.

Sample answers are provided that could be used with this exercise.

1. Smaller planet
2. Orbits the sun
3. Closer to sun
4. Receives less solar energy
5. Thinner atmosphere
6. Thicker atmosphere
7. Stronger magnetic field
8. Colder Interior
9. Composition Layers
10. Liquid water at Surface
11. No Biosphere
12. Craters Common on Surface

This is an analysis-level exercise that involves students identifying the characteristics of two similar planets with very different conditions.



Checkpoint 2.27, p. 50
Which of the two following scenarios would be more likely to support life on Earth?

1. Earth is the same size as at present but has the orbit of Mars.
2. Earth has the same orbit as at present but is the size of Mars.

Explain the reasons you used to support this interpretation. Discuss how the 4 key characteristics of Earth (liquid water, gravity and atmosphere, life-sustaining gases, magnetic field) described in this section would vary in each scenario.

This is an evaluation-level exercise where students must apply their conceptual understanding to make a judgment. While it is unlikely that life would flourish in either scenario, the first option is a better choice as a larger Earth would have sufficient gravity and a protective magnetic field that would sustain a thicker atmosphere. More gases in a thicker atmosphere can absorb more heat providing a greater opportunity to have liquid water. Good student responses would weigh each of the four characteristics relative to size and distance from the sun. The best answers may recognize that it is the interaction of these characteristics in the Earth system that is important for sustaining life on Earth. Some students may point out that an atmosphere in scenario #1 that is enriched in carbon dioxide would increase the greenhouse effect and partially offset the loss of heat due to increasing distance from the sun.

A scoring rubric using the five key characteristics (below) could be used to illustrate that conditions would be worse in each scenario but not as bad in the first option. The rubric indicates that Earth in a Mars orbit would be better than a Mars-size planet in an Earth orbit.

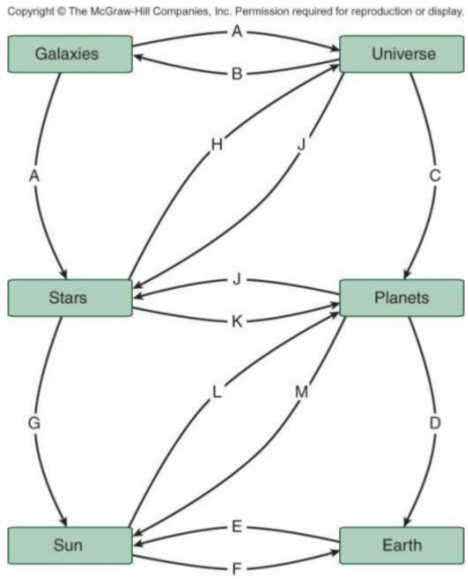
Factor/Score	-1	0	1
1. Water	Less available	No change	More available
2. Atmosphere	Reduces	No change	Increases
3. Biosphere	Negative effect	Little/ none	Enhances
4. Greenhouse Effect	Less balanced	no change	More balanced
5. Magnetic Field	Weaker	No change	Stronger

Option/Factor	1	2	3	4	5	Total
Option 1	0	0	-1	0	0	-1
Option 2	-1	-1	-1	0	0	-3

Checkpoint 2.28, p. 50
Much space science research is concerned with what we would consider to be basic science: finding out information about the origin of the universe, exploring other planets, studying how space phenomena affect Earth, and investigating the potential for life elsewhere in the universe. Often, space program research yields new discoveries with applications elsewhere. Each year the federal government spends approximately $4 billion (0.15 percent of the total budget) on space science research. If you were in charge of the federal budget, would you increase or decrease funding for space science or continue to fund it at its current level? What are some aspects of this research where you would place greater emphasis?

This is an open-ended, evaluation-level question that encourages students to take a position on federal funding of space exploration. Weak answers will be short and rely on simple arguments ("I would cut funding and give the money to poor people.") Stronger answers will weigh the potential benefits of funding basic science against opportunities to fund other programs and would incorporate multiple concepts from the chapter.

Earth in Space: Concept Map
Examine the list of interactions between pairs of components in the following concept map. Match each interaction with one of the labeled links in the concept map. At least one interaction should be used twice.



Interaction	Letter
Revolve around	*J*
Clumps of gas and dust formed	*B*
Gravity controls orbit	*E/F*
Produces heliosphere that contains	*L*
Produce heavier elements	*H*
For example	*Not used*
Billions present in	*A*
Only example with biosphere	*D*
Age partially defined by light from	*B*
Intermediate sized example	*G*
Supply light, heat for	*K*
Magnetosphere protects from solar wind	*E/F*
Expanding outward from	*A*
Forms solar system	*M*