



How do accurate maps lie to us?

Eratosthenes, Cartography, and the History of Longitude

Booklet One: Ancient Greece



Geography has been studied since the time of Ancient Greece. It takes an interdisciplinary approach to understanding the world around us, in all of its human and natural complexity.



The quality of maps and communicating location has improved over time. In times of war, these improvements are driven by the military. In times of peace, these improvements are driven by trade.



We have invented imaginary lines running from North to South, and East to West, but no projection is perfect. Every type of map is a compromise between showing true location, size, shape, and distance.



We begin our study of Geography in Ancient Greece, an empire centred on the Mediterranean sea.

In Ancient Greece, we will study how Eratosthenes invented:

- the word Geography
- Latitude and Longitude
- the Equator and Tropics
- a way of measuring the circumference of the Earth



Mediterranean

Medi / terra / nean

Medi, midi,
middle.

Terra, land

nean, having
the nature of

“The sea in middle, which separates the land”

Lesson 1: Geography



The story of Eratosthenes and the word Geography

1 The word Geography was first written down
2 in an empire called Ancient Greece. The
3 man in Ancient Greece who first wrote it
4 down was called Eratosthenes. We don't
5 know exactly when Eratosthenes first wrote
6 down the word Geography. We estimate it
7 was 220 B.C. That would mean the word
8 Geography was written down for the first
9 time over 2239 years ago.

10 Eratosthenes lived in the city of Alexandria in
11 the country of Egypt. Egypt was part of the
12 empire of Ancient Greece in 220 B.C.
13 Alexandria was a coastal city in the North of
14 Egypt next to the Mediterranean Sea. The
15 city of Alexandria was founded by a greek,
16 Alexander the Great; he named the city after
17 himself.


18 The city of Alexandria was home to the
19 Great Library. The Great Library was home
20 to knowledge and information from across
21 the Greek Empire. Eratosthenes worked in
22 the Great Library as the Chief Librarian. Like
23 many of you here, Eratosthenes wanted to
24 understand the world around him. Just like
25 you, Eratosthenes studied many different

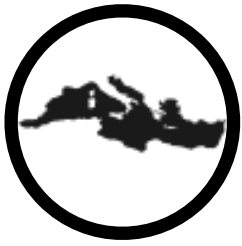
26 subjects. In Ancient Greece, these subjects
27 were called disciplines.

28 Eratosthenes studied Mathematics,
29 Astronomy, Poetry, History, and Philosophy.
30 Because he studied these different
31 disciplines, Eratosthenes began to see the
32 links between the disciplines and how they
33 were connected. Thinking like this is called
34 interdisciplinary.

35 Eratosthenes made a new word called
36 Geography. In Ancient Greek, *Geo* means
37 'the Earth' and '*graphy*' means 'to write'.
38 Geography means 'to write about the Earth'.
39 We still 'write about the Earth' in Geography
40 today. It is still an interdisciplinary way of
41 thinking. Students, like you, have studied
42 Geography in schools since Eratosthenes
43 first wrote it down in the Great Library of
44 Alexandria.

45 Eratosthenes wrote three books about
46 Geography. In his third book, Eratosthenes
47 created a map of all the places mentioned in
48 the Great Library. Sadly, all the copies that
49 were made have since been lost.

 Draw a neat line, using a ruler, to show the location of these on the map of the Mediterranean below.



Mediterranean




Egypt



Eratosthenes



The Great Library

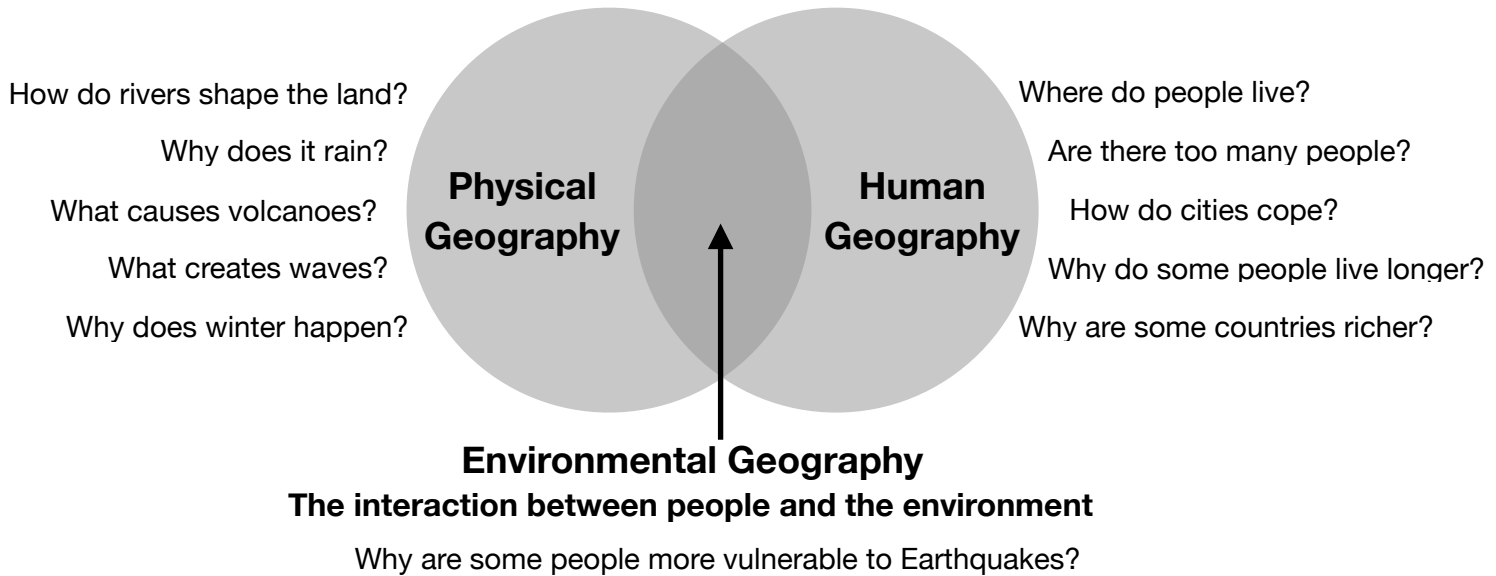
 Answer the questions below

1. Which empire was the word Geography first written down in?	
2. What was the name of the man that first wrote down the word Geography?	
3. What was the word that Eratosthenes first wrote down?	
4. In which year do we estimate the word Geography was first written down?	
5. Which city did Eratosthenes live in?	
6. What does the word Geo mean?	
7. What does the word graphy mean?	
8. What does the word Geography mean?	
9. Which sea was Alexandria next to?	

10. What were subjects called in Ancient Greece?	
11. What job did Eratosthenes have in the Great Library?	
12. What is it called when you study many disciplines and see the connections between them?	
13. When the word Geography was first written down, what empire was Egypt in?	
14. Which city was home to the Great Library?	
15. Where did Eratosthenes work?	
16. Who was the first person to write down the word Geography?	
17. How many books of Geography did Eratosthenes write?	
18. Are there any copies for us to read today?	

The meaning of the word Geography today

- 1 The way we use the word Geography has changed since Eratosthenes first wrote it down.
- 2 Today, we say that there are two main *branches* of Geography. The two main branches are
- 3 Physical Geography and Human Geography. The two main branches of Physical and Human
- 4 Geography ask different types of questions. However, some of the questions that Geographers
- 5 ask don't belong to just one branch of Geography, they belong to both:



We still use a lot of the same words in Geography that Eratosthenes would have used in Ancient Greece. Like the word Geography, they are made of a prefix, like *Geo*, and a suffix, like *graphy*. Use the meanings opposite to match up the words below with a ruler.

Geo = Earth	Graphy = To write
Hydro = Water	Metry = To Measure
Carte = Paper	Logy = To Study
Demos = People	Morph = Shape

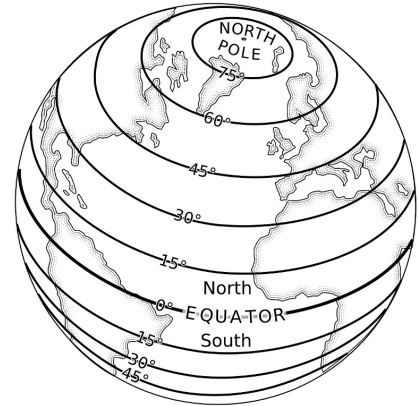
Geology	Studying the Earth's Shape	Checking the quality of water in a lake that the residents of a city drink
Hydrology	Writing it down on Paper	Reporting on how many children live in an area so the right number of schools are built
Hydrometry	Measuring the Earth	Designing a map that shows tourists where the rides are in a theme park
Cartography	Studying the Earth	Studying the shape of the coastline and explaining why it's like that
Demography	Measuring water	Although it started as a type of Geography, it's now the measuring of all shapes, and it a type of Mathematics.
Geomorphology	Describing the people	Measuring the volume of water in a river after rainfall
Geometry	Studying the water	Studying the type of rocks under the surface to know where to drill for oil

Lesson 2: Latitude

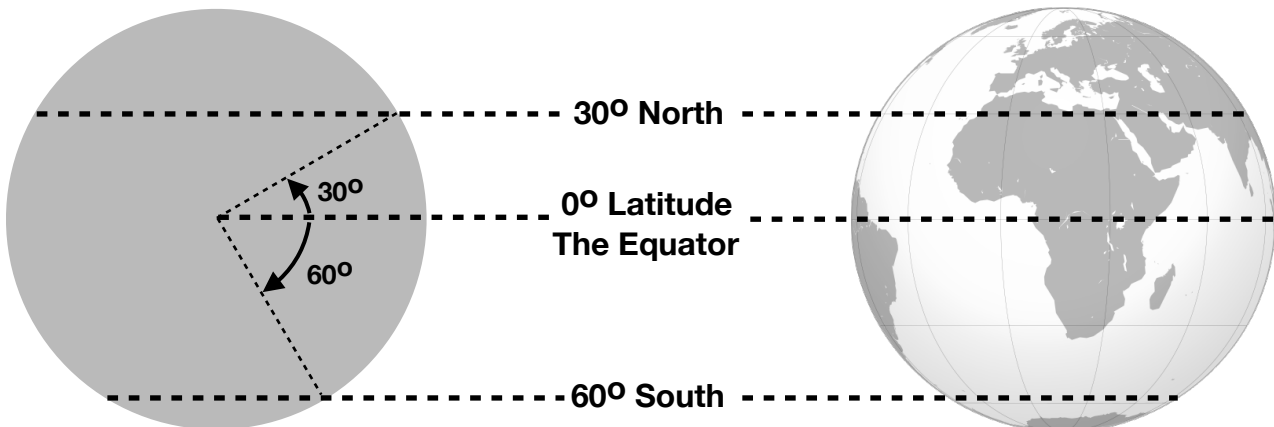
The story of why latitude is measured in degrees

1 Eratosthenes wanted to make a map that was as
2 accurate as possible. To make a map that was as
3 accurate as possible, Eratosthenes invented lines
4 of latitude. Eratosthenes invented lines of latitude
5 so that anyone could use the map to see how far
6 North or South a place was on the Earth's surface.

7 Lines of latitude run horizontally around the
8 surface of the Earth. The line that runs horizontally
9 around the surface of the Earth in the middle is
11 called the Equator. The line of latitude that runs
12 horizontally around the surface in the middle is
13 called the Equator because it separates the
14 surface of the Earth into two *equal* halves. You
15 can remember its name is the equator by thinking
16 that it acts like an *equaliser*.



17 The point at the very top of the surface of the Earth is called the North Pole. The point at
18 the very bottom of the surface of the Earth is called the South Pole. Every other line of
19 latitude is measured as either being North, or South, of the Equator.

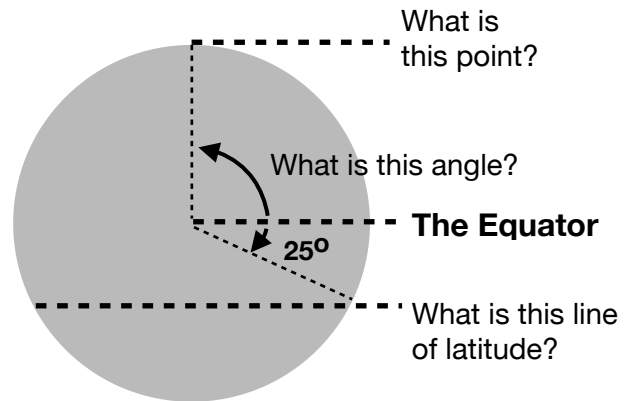
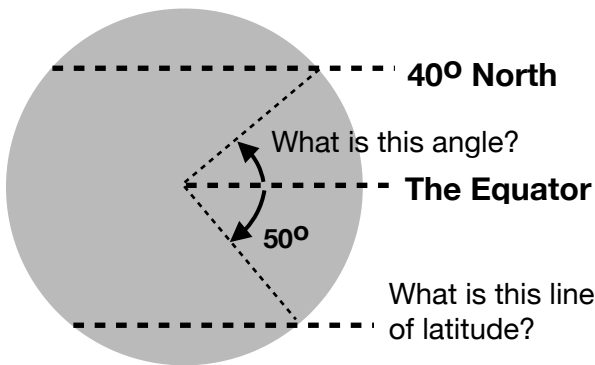
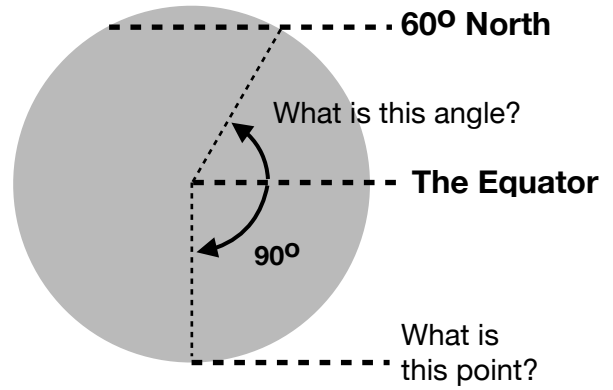
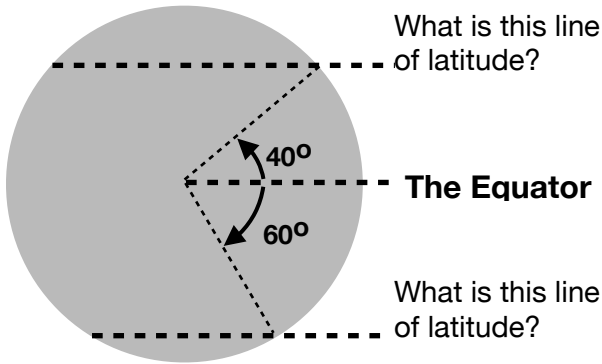


20 The diagram above shows how the unit of measurement for latitude is degrees. Latitude is
21 measured in degrees because of the angle measured from the centre of the Earth. The line
22 of latitude runs horizontally around the Earth's surface at the place where the angle from
23 the centre of the Earth reaches the surface.

24 The angle from the centre of the Earth has range from 0° to 90° . The Equator is at 0° . The
25 North Pole is at 90° North, and South Pole is at 90° South.

26 On the diagram above, the line of latitude that runs horizontally around the Earth at 30°
27 North is at the surface where the 30° angle from the centre of the Earth meets the
28 surface. The line of latitude that runs horizontally around the Earth at 60° South is at the
29 surface where the 60° angle from the centre of the Earth meets the surface.

 **Lines of Latitude Practice**

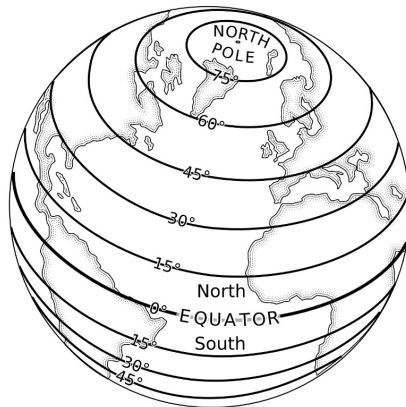


 **Answer the questions below**

21. What is the name of the line that runs horizontally around the surface of the Earth in the middle?	
22. What is the unit of measurement for lines of latitude?	
23. What is the name of the place 90° North?	
24. Which is further from the Equator, 20°N or 40° S?	
25. Do lines of latitude run horizontally or vertically around the Earth?	
26. What is the name of the point 90° South?	
27. What is angle from the centre of the Earth at the Equator?	
28. What is angle from the centre of the Earth at 20°N?	

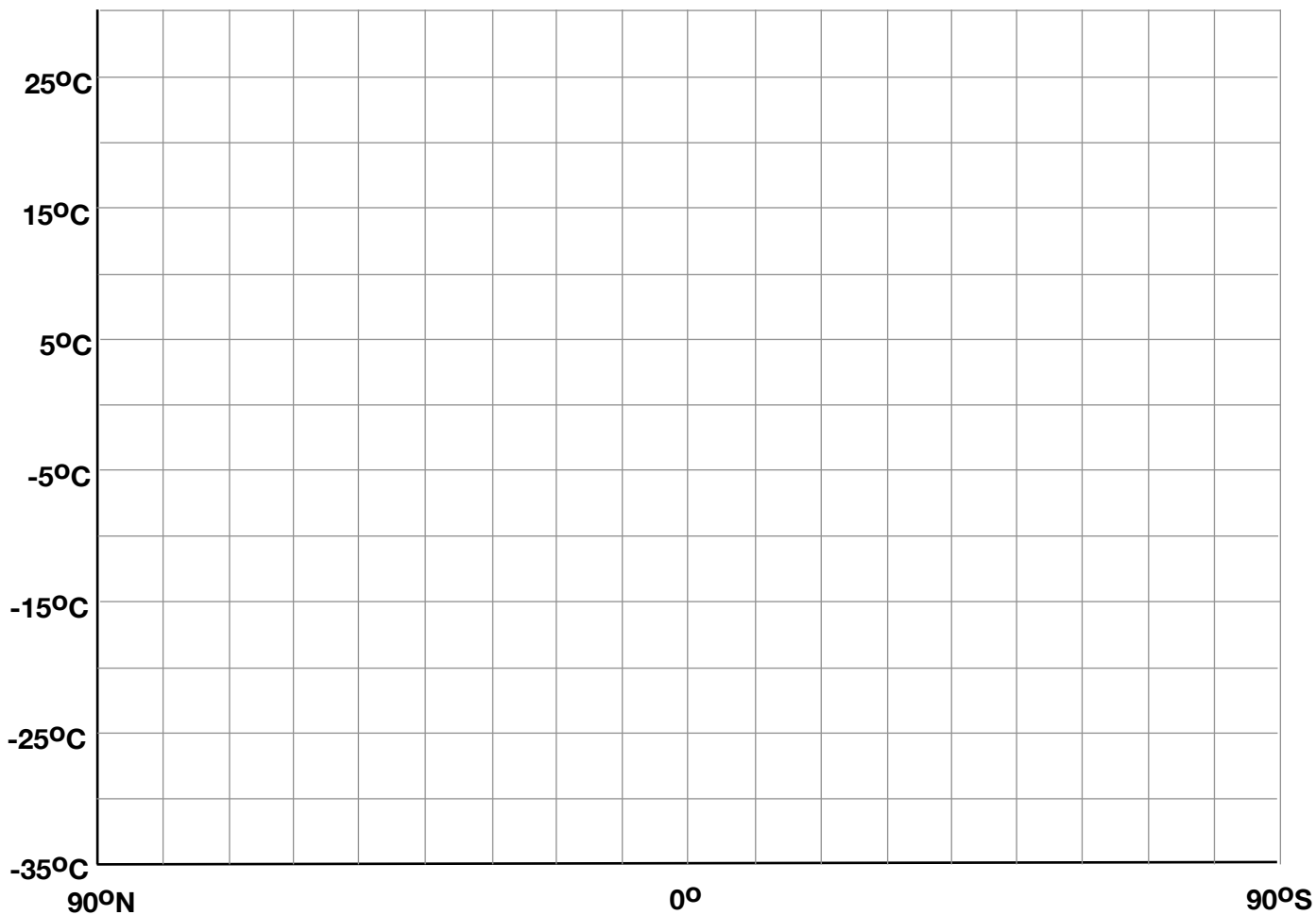
29. What is the name of the lines that separates the surface of the Earth into two equal halves?	
30. What is the range of the angles of latitude?	
31. Which is near the South Pole, 20°N or 40° S?	
32. Which line of latitude is longer, 20°N or 40° S?	
33. Can we see lines of latitude when we're standing on the surface of the Earth?	
34. Can we see lines of latitude from space?	
35. Which line of latitude is longer, the Equator or 20°N?	
36. Which line of latitude is shorter, 60°N or 20°N?	

Latitude	Average Air Temperature
87° North	-32
80° North	-25
75° North	-17
70° North	-23
60° North	-11
52° North	-5
40° North	5
30° North	16
20° North	20
16° North	24
10° North	27
0°	27



Latitude	Average Air Temperature
90° South	-19
80° South	-10
70° South	-5
60° South	0
55° South	3
50° South	7
40° South	15
30° South	20
25° South	22
20° South	27
10° South	27

37. Use the data in these two tables, to plot a graph below showing the relationship between temperature and latitude



Lesson 3: Latitude & Temperature

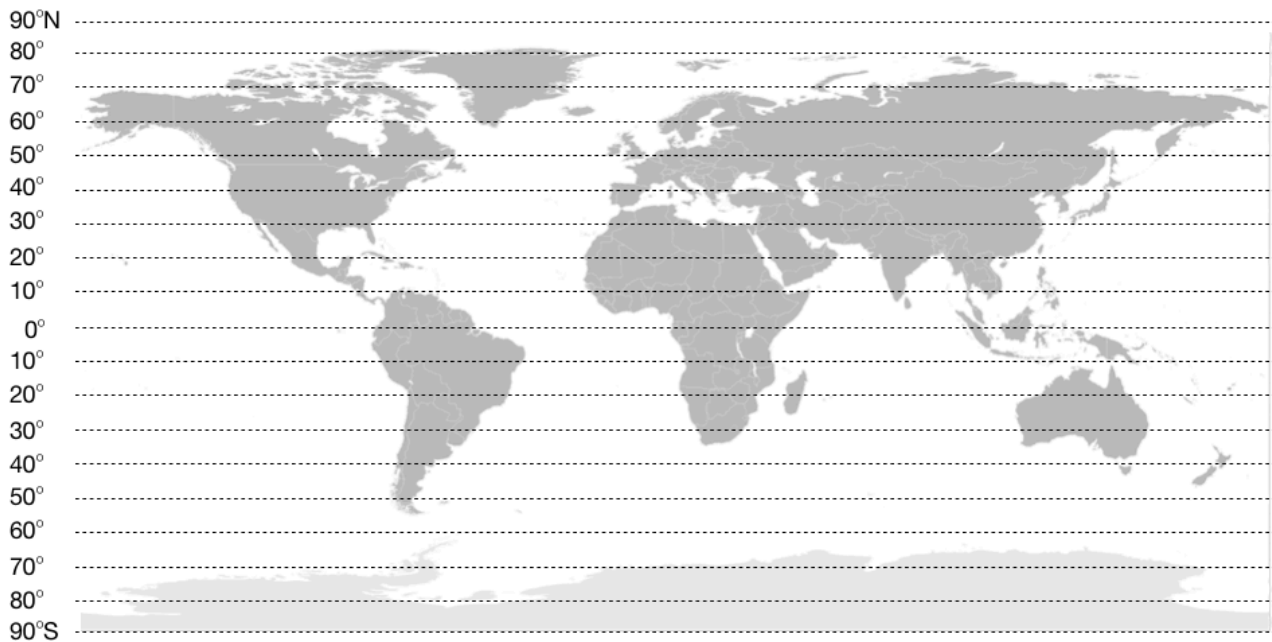


Retrieval Practice: Answer these questions

38. Which empire was the word Geography first written down in?		42. What is it called when you study many disciplines and see the connections between them?	
39. What was the name of the man that first wrote down the word Geography?		43. Do lines of latitude run horizontally or vertically around the Earth?	
40. In which year do we estimate the word Geography was first written down?		44. What is the name of the lines that separates the surface of the Earth into two equal halves?	
41. What is the name of the sea that separates Athens from Alexandria?		45. Which is near the Equator, 20°N or 40° S?	



Use this map showing lines of latitude to answer the questions below



North America



Europe



South America



Africa



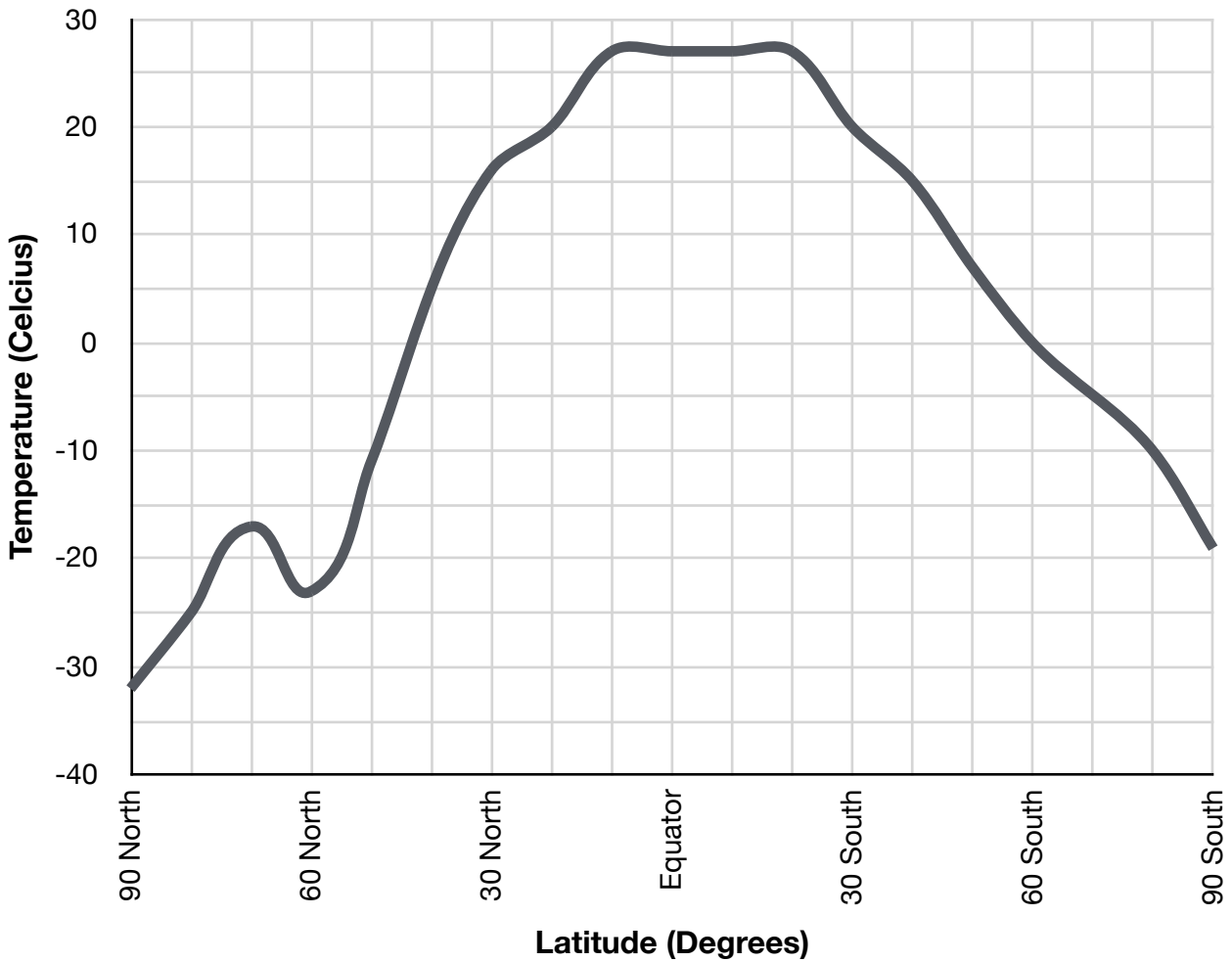
Asia



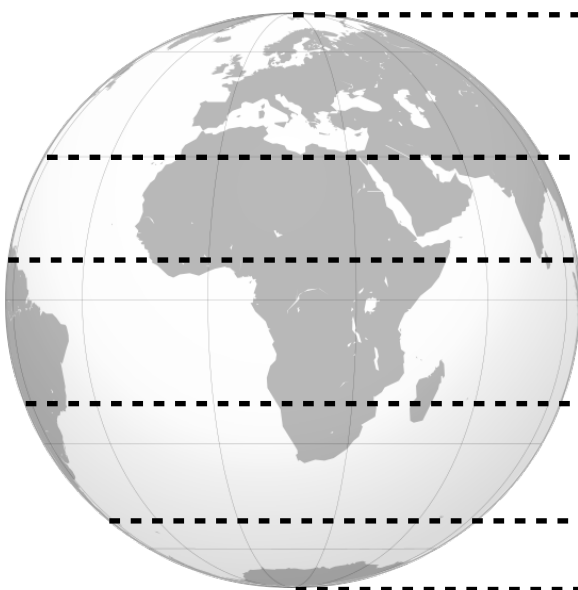
Oceania

46. Which continents does the Equator cross?	
47. Which continents does the 50° North line cross?	
48. Which continents does the 20° South line cross?	
49. Which continents does the 60° South line cross?	

Average Air Temperature and Latitude



Use the graph above to answer the questions on the globe below



50. What's the average air temperature at the North Pole?

51. What's the average air temperature at 30N?

52. What's the average air temperature between 10N and 20S?

53. What's the average air temperature at 50S?

54. What's the average air temperature at the South Pole?

First Draft: Describe the relationship between temperature and latitude

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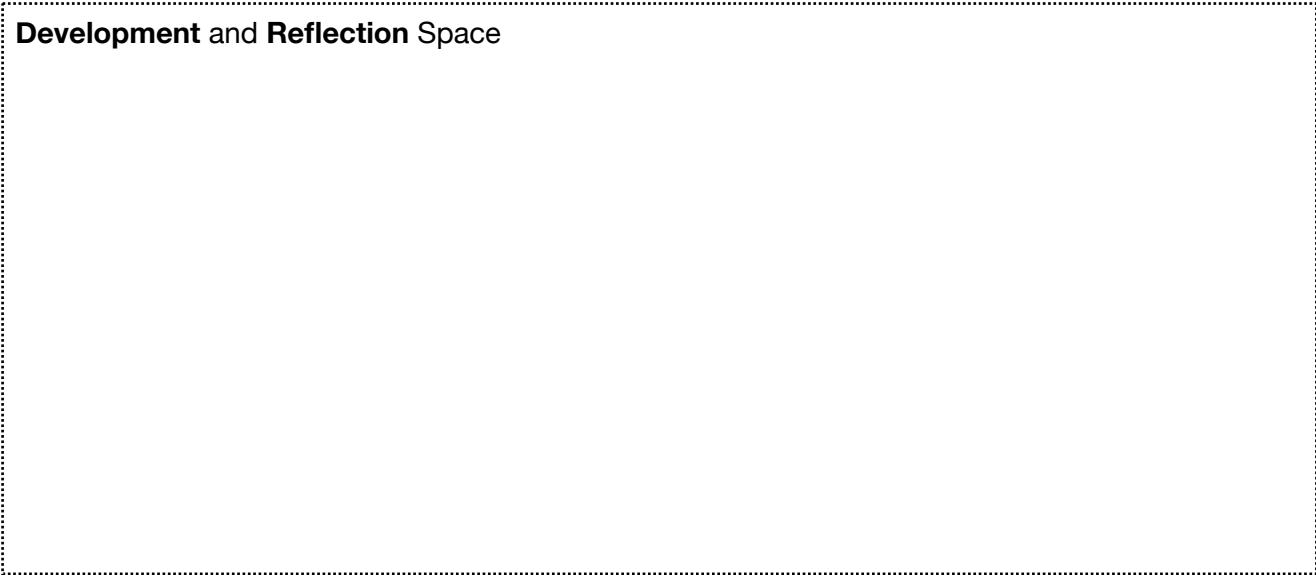
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Development and Reflection Space



Second Draft: Describe the relationship between temperature and latitude

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55. Use an Atlas to complete the map at the bottom of the page

Countries

Egypt

Greece

Turkey

Spain

France

Italy

Morocco

Algeria

Libya

Water

The Black Sea

The Mediterranean

The Red Sea

The Atlantic Ocean

Mountains

The Atlas Mountains

The Pyrenees

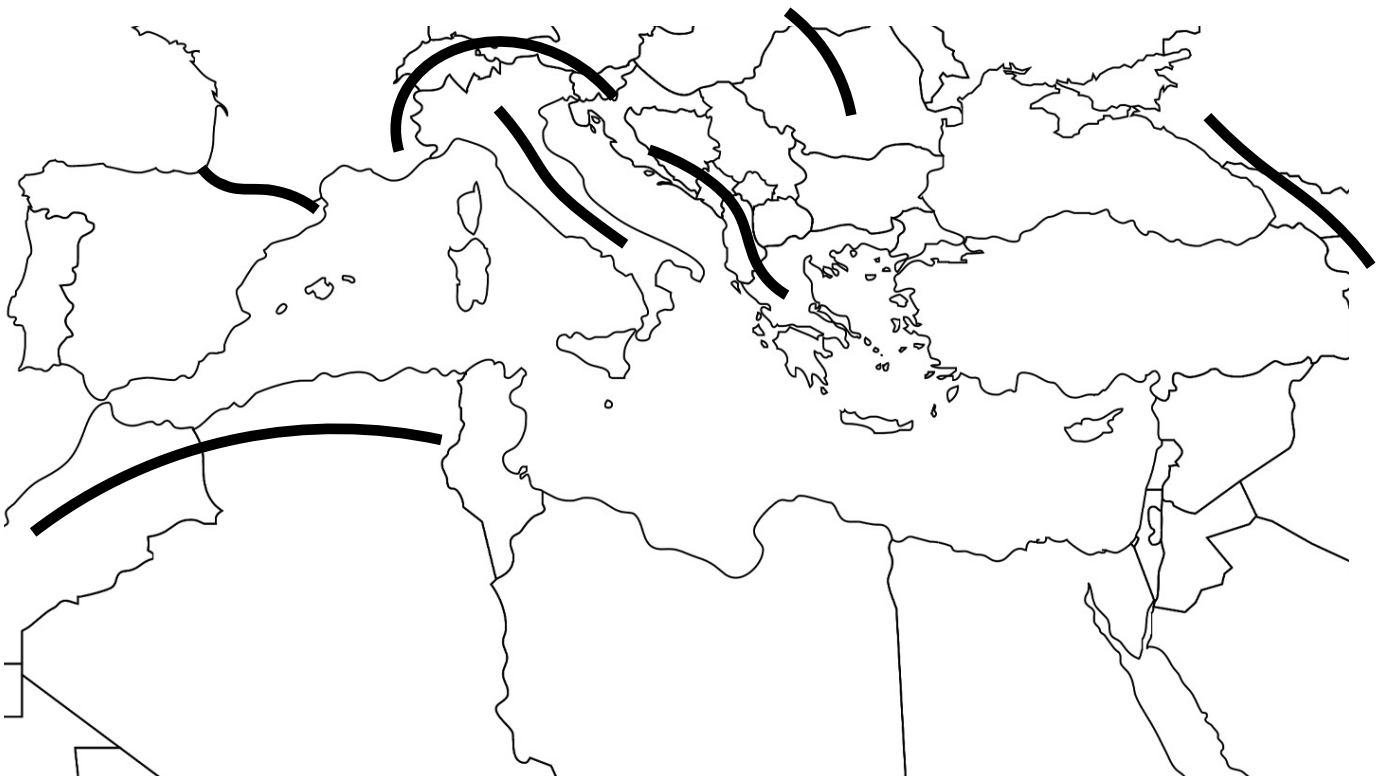
The Alps

The Appennini

The Carpathian Mountains

The Caucasus

The Dinaric Alps

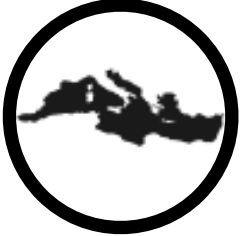


Lesson 4: Atlas

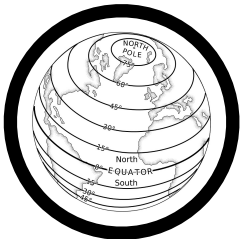


Retrieval Practice

56. Outline Eratosthenes' contribution to Geography



57. Explain why the sea was called the Mediterranean



58. Explain what lines of latitude are



The story of the Titans and the Olympians

1 Many people in Ancient Greece would
2 have believed in religion, like many people
3 believe in religion now. Eratosthenes, like
4 many people in Ancient Greece would
5 have believed in the Titans and the
6 Olympians. The Titans and the Olympians
7 were the gods of Ancient Greece.

8 The Titans were the older gods. The
9 Olympians were the younger gods. There
11 were twelve Titans and there were twelve
12 Olympians. The Titans came first, the
13 Olympians were like their children.

14 Eventually the Olympians wanted to be in
15 charge, and rule instead of the Titans. The
16 Titans were strong and powerful. We use
17 the word Titan to describe strong and
18 powerful things, like the ship *Titanic*. The
19 *Titanic* was supposed to be so strong and
20 powerful that it wouldn't sink. We describe
21 people who are very successful in
22 business as *titans* of industry.

23 Zeus was the leader of the Olympians.
24 When Zeus and the Olympians decided

25 that they wanted to rule, they started a
26 war. The war Zeus and the Olympians
27 started against the Titans was called the
28 Titanomachy. The Olympians and the
29 Titans were very evenly matched during
30 the Titanomachy.

31 Cronus was the leader of the Titans.
32 Fighting alongside Cronus was Atlas.
33 Each of the gods in Ancient Greece were
34 in charge of something. Cronus was the
35 Titan in charge of time. The words
36 *chronology* and *chronological order*, which
37 means to put things in the order of when
38 they happened, come from the name of
39 the leader of the Titans, Cronus.

40 After ten years of fighting, the Olympians
41 narrowly defeated the Titans. The
42 Olympians defeated the Titans by trapping
43 ten of them in a prison called Tartarus.
44 Cronus was one of the ten Titans trapped
45 in Tartarus, but Atlas was not. Zeus, the
46 leader of the Olympians, came up with a
47 special punishment for Atlas.



48 Atlas was punished by Zeus to stand at
49 the Western edge of the Earth, and hold
50 up the celestial spheres. In Ancient
51 Greece, the theory of celestial spheres
52 was used to explain the orbit of planets
53 around the sun.

54 The oldest surviving statue of Atlas is
55 called the Farnese Atlas. The oldest
56 surviving statue of Atlas is called the
57 Farnese Atlas because it is owned by the
58 Farnese family. The Farnese Atlas shows
59 the celestial spheres being carried on
60 Atlas' shoulders. Since Ancient Greece,
61 many people have mistaken the celestial
62 spheres on the Farnese Atlas for the
63 Earth.

64 Mistaking the celestial spheres for the
65 Earth has led many people to believe a
66 common misconception. A misconception
67 is when people think they have
68 understood, but they haven't. The

69 common misconception created by the
70 Farnese Atlas is that Atlas was punished
71 by Zeus to carry the Earth on his
72 shoulders. There is a saying, caused by
73 this misconception, where people
74 performing a long and difficult task are
75 "carrying the weight of the world on their
76 shoulders".

77 In 1937 a new statue of Atlas was put
78 outside the Rockefeller Building in New
79 York. The statue of Atlas outside the
80 Rockefeller Building in New York is called
81 the Rockefeller Atlas. The Rockefeller
82 Atlas doesn't have this misconception, it
83 shows Atlas standing on the Western
84 edge of the Earth, holding up the celestial
85 spheres.

86 The ocean to the West of the
87 Mediterranean is called the Atlantic
88 Ocean; this is the Ocean of Atlas. The
89 mountains in the North West of Africa are
90 called the Atlas Mountains. Both the
91 ocean and mountains have Atlas' name
92 because they are the furthest West the
93 Ancient Greeks ever travelled.



94 The name of the Atlantic Ocean and the
 95 Atlas Mountains tell us a lot about the way
 96 places are named. They tell us a lot about
 97 the stories that maps can tell us.

98 After trapping the titans in Tartarus, and
 99 punishing Atlas to stand at the Western
 100 edge of the Earth and hold up the celestial
 101 spheres, Zeus and the Olympians
 102 because the ruling gods in Ancient
 103 Greece.

104 The Ancient Greeks believed that the
 105 Olympians lived on Mt Olympus. Mt
 106 Olympus is the highest mountain in the
 107 empire of Ancient Greece, and the modern
 108 country of Greece. As Mt Olympus is the
 109 highest mountain in Greece, it has a high
 110 frequency of thunderstorms.

111 Zeus was the Olympian in charge of
 112 thunder and lightening, in the same way
 113 that Cronus was the Titan in charge of
 114 time. In Ancient Greece, many people
 115 believed that the frequent thunderstorms
 116 on Mt Olympus were because that was
 117 where Zeus and the other Olympians
 118 lived.

119 The Olympians were smart and athletic, in
 120 the same way that the Titans were strong
 121 and powerful. Many people in Ancient
 122 Greece wanted to be smart and athletic
 123 like the Olympians. To demonstrate that
 124 they were smart and athletic, like the
 125 Olympians on Mt Olympus, people held
 126 competitions to see who was the best
 127 among them. These competitions still take
 128 place, and are called the Olympic Games.

129 In Ancient Greece, the person considered
 130 most like the Olympians on Mt Olympus
 131 was the person who won the pentathlon.
 132 The pentathlon involved five different
 133 events; long jump, javelin, discus, running,
 134 and wrestling. The word *pente* means five,
 135 and *athlon* means competition.

136 Eratosthenes was often called a
 137 pentathlete. A pentathlete is someone
 138 who competes in a pentathlon.
 139 Eratosthenes was often called a
 140 pentathlete because he was very good at
 141 the five disciplines of Mathematics,
 142 Astronomy, Poetry, History, and
 143 Philosophy, as well as the discipline he
 144 invented; Geography.



Answer the questions below

59. What is the name of the first generation of Gods in Ancient Greece?	
60. What is the name of the second generation of Gods in Ancient Greece?	
61. What is the name of the war between the two generations of gods?	
62. What was Cronus considered in charge of?	
63. What was Zeus considered in charge of?	
64. Where did the Olympians trap the Titans?	
65. What was Atlas punished to carry?	

66. Where was Atlas punished to stand?	
67. What is the name of the oldest surviving statue of Atlas?	
68. Where is the Rockefeller Atlas located?	
69. What is the name of the ocean to the West of the Mediterranean?	
70. What is the name of the mountains in North West Africa?	
71. Where did Zeus and the Olympians live?	
72. How many sports are there in a pentathlon?	

73. What misconception did the Farnese Atlas help create?

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74. Why do the Atlas Mountains and the Atlantic Ocean have those names?

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75. Why did many Ancient Greeks believe that the Olympians lived on Mt Olympus?

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Lesson 5: Seasons



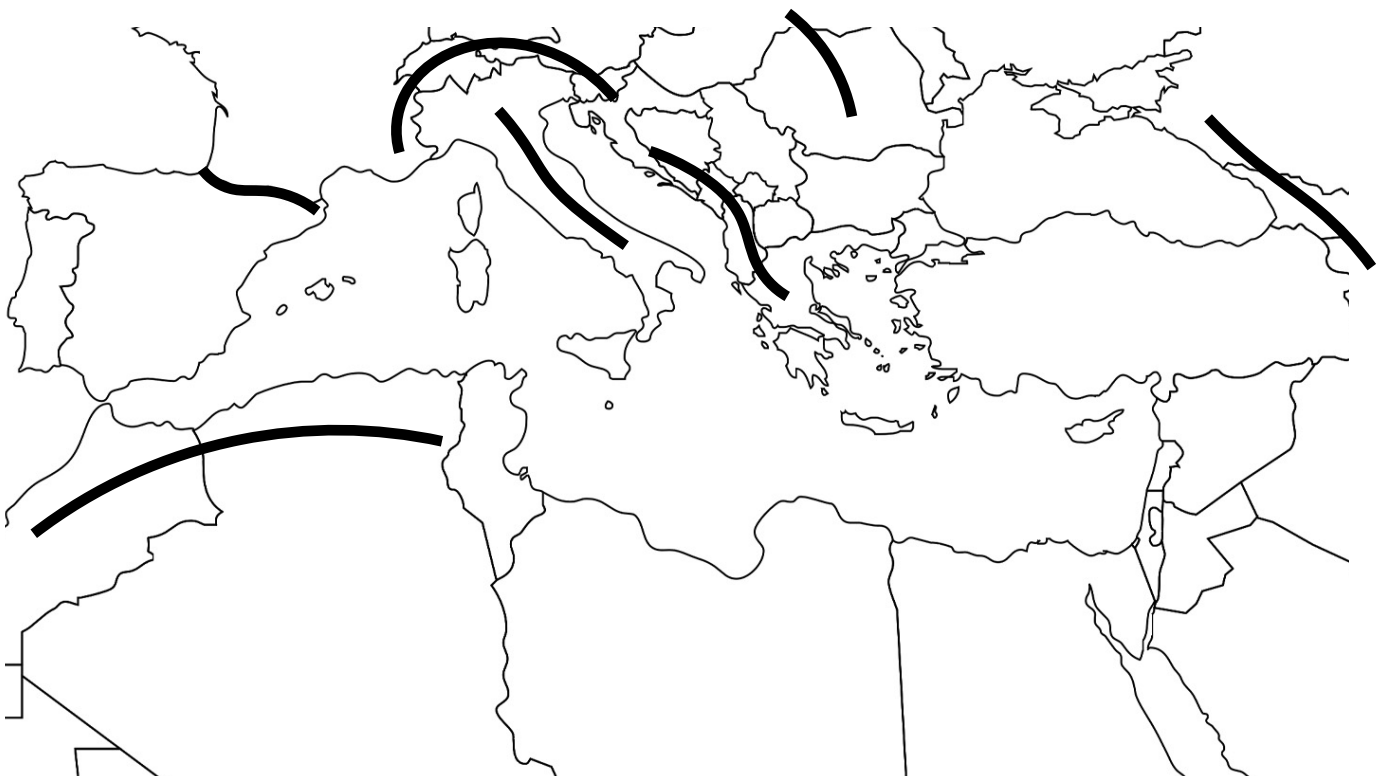
Retrieval Practice: Write down whether these mountains and countries are North or South of the Mediterranean

76. Egypt	
77. Greece	
78. Turkey	
79. Spain	
80. France	
81. Italy	
82. Morocco	

83. The Atlas Montains	
84. The Pyrenees	
85. The Alps	
86. The Appennini	
87. The Carpathian Mountains	
88. The Caucasus	
89. The Dinaric Alps	



Practice: Add any that you got incorrect to the map below:



Understanding why there are seasons

- 1 There are four main seasons in the U.K.
- 2 The U.K. has four main seasons because
- 3 the Earth is **tilted**, and because the Earth
- 4 **orbits** the sun.

90. How long does it take for the Earth to orbit the sun?

91. How long does it take for the Moon to orbit the Earth?

92. How long does it take for the Earth to rotate 360 degrees on its axis?

- 5 The way that we measure time now is the
- 6 same way that Eratosthenes would have
- 7 measured time in Ancient Greece. The
- 8 people of Ancient Greece would have
- 9 measured their ages in years, months, and
- 11 days, just like we do.

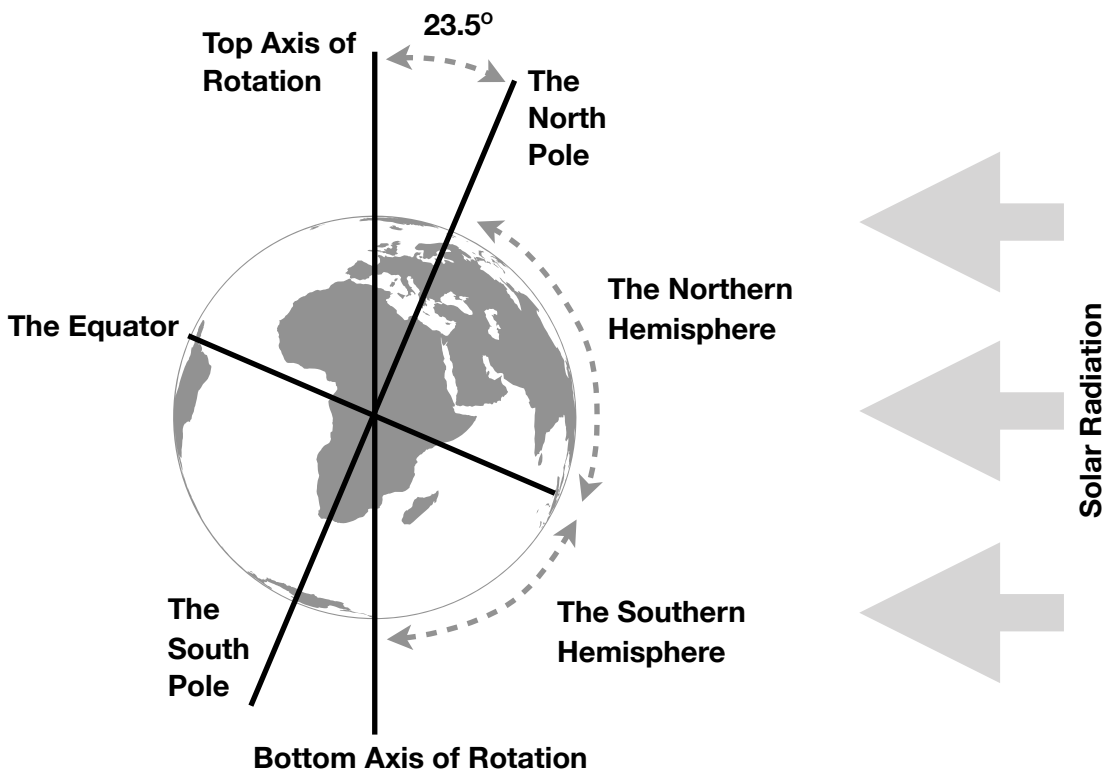
- 12 The Earth is tilted. This means that the
- 13 North Pole is not at the 'top' of the Earth,

- 14 and the South Pole is not at the 'bottom'
- 15 as the Earth spins on its axis. The Earth is
- 16 tilted by 23.5 degrees.

- 17 Because the Earth is tilted at 23.5 degrees
- 18 the North Pole is never pointed directly at
- 19 the sun. However, for half the year the
- 20 North Pole is tilted towards the sun and
- 21 for half the year the North Pole is tilted
- 22 away from the sun.

- 23 For the six months that the North Pole is
- 24 tilted towards the sun, the Northern
- 25 Hemisphere is in summer. The Northern
- 26 Hemisphere means the half of the Earth
- 27 that is North of the Equator. The word
- 28 hemi, means half, and the word sphere,
- 29 refers to the Earth. Whilst the North Pole is
- 30 tilted towards the sun and the Northern
- 31 Hemisphere is in summer time, the
- 32 Southern Hemisphere is in winter time.

- 33 Whilst the North Pole is tilted towards the
- 34 sun, more of the light and heat hits the
- 35 Northern Hemisphere. We call this heat
- 36 and light from the sun **solar radiation**.



 **Answer the questions below**

93. What is the name of the heat and light from the sun?	
94. What does the word hemi mean?	
95. In the word hemisphere, what does the 'sphere' refer to?	
96. What is the axis of tilt of the Earth?	

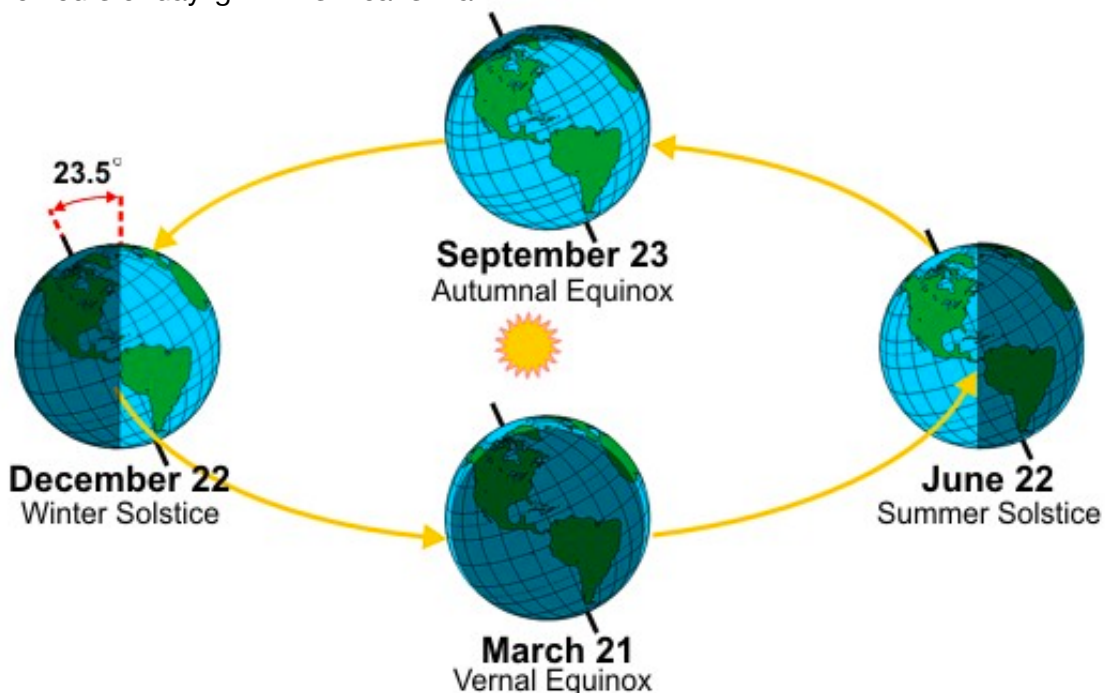
97. When the North Pole is tilted towards the Sun, will it be summer or winter in the Northern Hemisphere?	
98. When the North Pole is tilted towards the Sun, will it be February or August?	
99. When it is summer in the Northern Hemisphere, what season will it be in the Southern Hemisphere?	
100. When it is Autumn in the Northern Hemisphere, what season will it be in the Southern Hemisphere?	

37 Whilst the South Pole is tilted towards the
 38 sun, it is summer in the Southern
 39 Hemisphere. This is because more of
 40 Southern Hemisphere is facing the sun.
 41 Because more of the Southern
 42 Hemisphere is facing the Sun, the
 43 southern hemisphere receives more solar
 44 radiation.

45 We know that the number of daylight
 46 hours is higher in the summer. We can
 47 think about the times of sunrise and
 48 sunset, and how long it takes until it is
 49 dark when we get home from school.
 50 During the summer months, there are
 51 more hours of daylight. This means that

52 there are more hours when the surface of
 53 the Earth is being heated up by solar
 54 radiation from the sun.

55 The same is true in reverse. This means
 56 that in the winter the number of hours of
 57 daylight is shorter. This is because the
 58 North Pole is tilted away from the sun
 59 during the winter time. With fewer hours of
 60 daylight, the surface of the Earth is not
 61 warmed up for as long by solar radiation
 62 by the sun. With less solar radiation from
 63 the sun, the temperature does not get as
 64 high, which is why it is colder in the winter
 65 time and then in the summer time.





Let's review. Answer the questions below.

101. What is the axis tilt of the Earth?		105. Which way is the North Pole tilted during summer in the Northern hemisphere?	
102. What is the Northern Hemisphere?		106. Why is the temperature higher in the summer time?	
103. What is solar radiation?		107. What season is it in the Southern hemisphere when it's summertime in the Northern hemisphere?	
104. Why are the number of daylight hours higher in the summer time?		108. What season is it in the Northern hemisphere when it's Spring in the Southern hemisphere?	

109. Explain how summertime is caused by the **tilt** and **orbit** of the Earth

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110. Explain why the Northern and Southern Hemispheres can't have the same season at the same time

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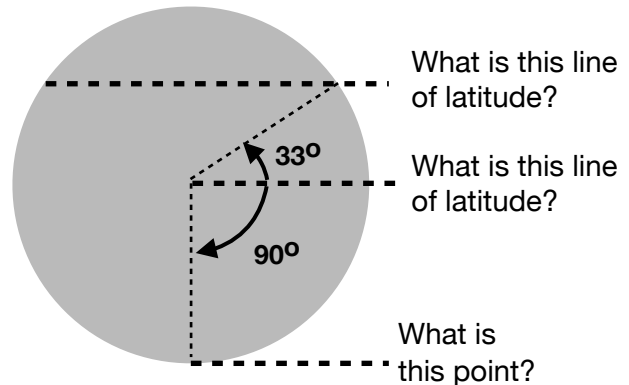
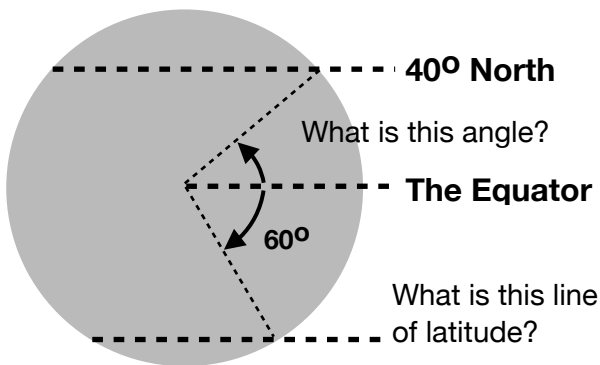
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Lesson 6: Circumference

111. What was the word first written down by Eratosthenes?	
112. How many sports are there in a pentathlon?	
113. Which were younger, Titans or Olympians?	
114. What is the name of the sea that separates Athens from Alexandria?	

115. What do we call the imaginary lines running horizontally around the Earth?	
116. What is the name of the sea to the West of the Mediterranean?	
117. Which is near the Equator, 45°N or 26°S ?	
118. As you travel from Equator to Poles, will the temperature increase or decrease?	

119. Answer these questions about latitude:



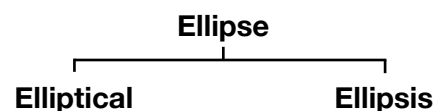
The story of how Eratosthenes calculated the circumference of the Earth

1 As we have been studying, Eratosthenes
 2 is responsible for a lot of geography,
 3 including the name of the discipline. We
 4 know that many people called
 5 Eratosthenes a pentathlete because he
 6 was so good at so many different
 7 academic disciplines. Eratosthenes
 8 studied maths while working as the Chief
 9 Librarian at the Great Library of
 11 Alexandria.

12 In 220 BC, Eratosthenes was working on
 13 the most difficult maths that anyone was
 14 working on in the world. Our
 15 understanding of mathematics has come
 16 so far in the 2000 years since Ancient
 17 Greece that you are going to learn about
 18 the maths that Eratosthenes was doing
 19 whilst you are still in Year 7.

20 Eratosthenes was very interested in circles
 21 and spheres. A sphere is a 3D circle, and
 22 a circle is a 2D sphere. Eratosthenes
 23 thought that spheres were the perfect
 24 shape. Eratosthenes believed that the
 25 Earth was a perfect sphere because he
 26 believed that the Earth would be the
 27 perfect shape.

28 We now know that the Earth is not a
 29 perfect sphere. The Earth is elliptical. The
 30 word elliptical comes from the root word
 31 ellipse. The word ellipsis, which is three
 32 full stops in row like this ... also comes
 33 from the same root word ellipse.



34 An ellipse is a circular shape but it is not a perfect
35 circle. In a perfect circle the diameter is the same
36 length everywhere you can measure it. In a
37 perfect circle the diameter is a constant.

38 In an ellipse, one axis is longer than the other. An
39 ellipse does not have a constant diameter. The
40 Earth does not have a constant diameter, excuse
41 the Earth is not a perfect sphere, the Earth is
42 Elliptical.

43 The Earth is larger across the Equator than it is
44 from the North Pole to the South Pole. The word
45 Elliptical describes the shape of the Earth. To help
46 people understand the shape of the Earth it is
47 sometimes compared to a tangerine. A tangerine
48 is a small elliptical citrus fruit. A tangerine looks
49 like someone has squished it slightly as it is flatter
50 at the top and the bottom than it is in the middle.
51 Because the Earth is elliptical, it is flatter at the
52 North Pole and the South Pole than it is at the
53 Equator.

105. Annotate the diagram of the Earth to show which of the axis is shorter and which is axis is longer.

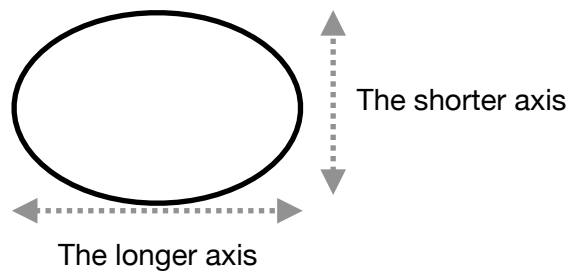
106. Annotate the diagram of the Earth to explain that it is flatter at the poles than at the Equator.

54 Working in the Great Library in Alexandria,
55 Eratosthenes had read something interesting
56 about a city called Syene. Syene was a city in
57 Egypt, in the empire of Ancient Greece, to the
58 south of Alexandria. Syene was a city built on the
59 side of the River Nile. The rive Nile flowed North,
60 into Alexandria, and then into the Mediterranean.

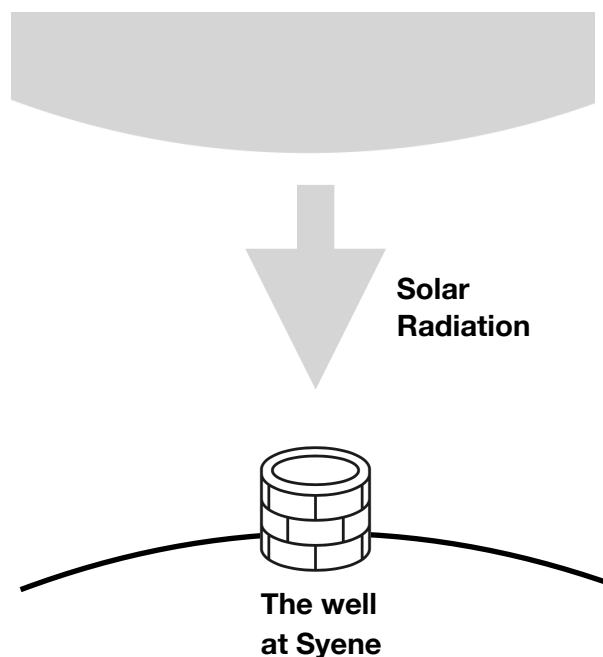
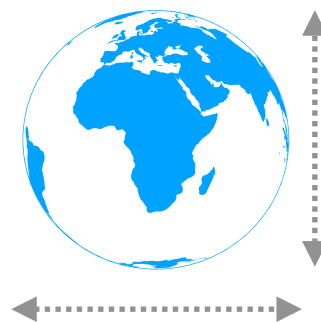
61 Eratosthenes had read that in the city of Syene
62 there was a well. This was a deep well that
63 provided the city with its water supply. On the
64 summer solstice, there was no shadow in the well.
65 This meant that on the day of the year with the
66 most daylight hours, often called the 'longest day
67 of the year' the sun was directly above the city of
68 Syene.

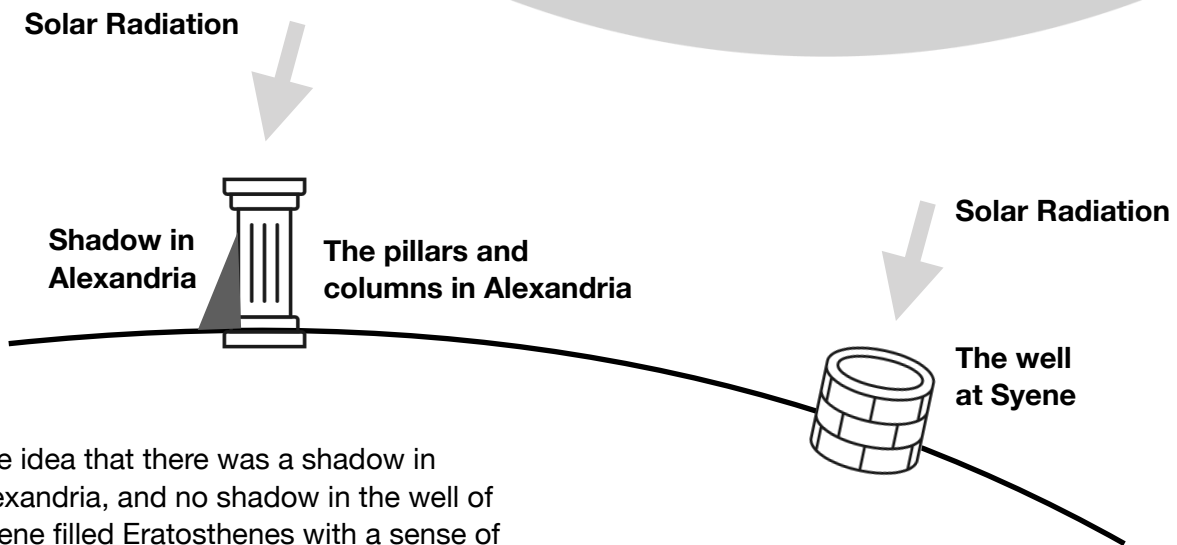
70 Eratosthenes knew that on the same day, the
71 summer solstice, the columns, pillars, and wells in
72 the city of Alexandria did cast a shadow.

An Ellipse



The Elliptical Earth





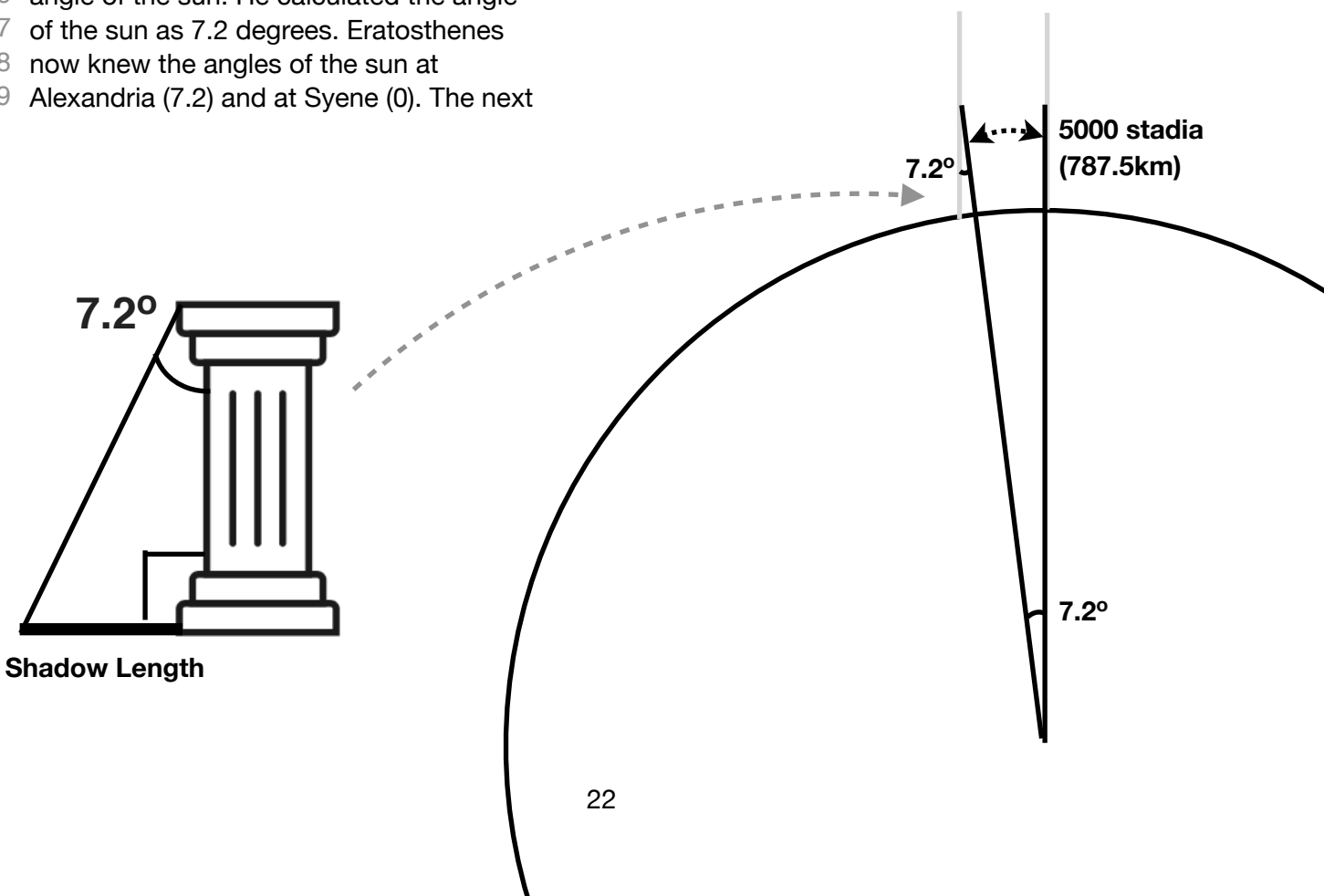
73 The idea that there was a shadow in
 74 Alexandria, and no shadow in the well of
 75 Syene filled Eratosthenes with a sense of
 76 wonder - finally, he had a way to calculate
 77 the circumference of the Earth.

78 Eratosthenes waited until the summer
 79 solstice. During the summer solstice the
 80 midday sun was shining down on the city
 81 of Alexandria. Eratosthenes measured the
 82 length of the shadow cast by the sun on
 83 the pillars of the city.

84 By measuring the length of the shadow,
 85 Eratosthenes was able to calculate out the
 86 angle of the sun. He calculated the angle
 87 of the sun as 7.2 degrees. Eratosthenes
 88 now knew the angles of the sun at
 89 Alexandria (7.2) and at Syene (0). The next

90 step was for Eratosthenes to calculate the
 91 distance between them. Setting off on
 92 horseback, Eratosthenes calculated the
 93 distance to be 5000 stadia (787.5km).

94 Eratosthenes knew that there were 360
 95 degrees in a circle, and he had calculated
 96 the distance for 7.2 degrees of them. By
 97 multiplying 787.5km by 50, he could
 98 calculate the circumference of the Earth.



99 Eratosthenes believed that the Earth
 100 would be a perfect sphere. The Earth is
 101 elliptical. Because the Earth is elliptical,
 102 Eratosthenes calculations were not quite
 103 correct. Eratosthenes calculated the
 104 circumference to be 39,375km.

105 We have since calculated the
 106 circumference of the Earth to be

107 40,008km. Though incorrect, Eratosthenes
 108 was within 2% of the correct answer when
 109 working calculating the Earth's
 110 circumference more than 2000 years ago.

111 As well as helping calculate the
 112 circumference of the Earth, the sun being
 113 directly overhead in Syene helps to
 114 explain the tilt of the Earth, you'll learn
 115 more about this next lesson.



Let's review. Answer the questions below.

120. What were the two places Eratosthenes measured the distance between?	
121. What distance did Eratosthenes measure?	
122. Which day did Eratosthenes measure the angle of the shadow?	
123. What was the angle of the sun in Syene on the day Eratosthenes measured?	
124. What was the angle of the sun in Alexandria on the day Eratosthenes measured?	
125. How many degrees are there in a circle?	

126. How many multiples of 7.2 are there in 360?	
127. What did Eratosthenes calculate as the circumference of the Earth?	
128. Is the Earth a perfect sphere?	
129. What shape is the Earth?	
130. What parts of the Earth are flatter?	
131. Where does the Earth have its widest diameter?	

Lesson 7: Cancer & Capricorn



Retrieval Practice: Write whether these mountains and countries are North or South of the Mediterranean

132. Egypt	
133. Greece	
134. Turkey	
135. Spain	
136. France	
137. Italy	
138. Morocco	

139. The Atlas Montains	
140. The Pyrenees	
141. The Alps	
142. The Appennini	
143. The Carpathian Mountains	
144. The Caucasus	
145. The Dinaric Alps	



Retrieval Practice: Match the heads and tails of the sentences below, neatly, using a ruler.

146. The word Geography was first written down by...

147. Lines of latitude run horizontally..

148. Atlas...

149. Including Antarctica, there are...

150. The Atlantic Ocean is named...

151. Lines of latitude can be used to...

152. The Earth isn't a perfect sphere...

153. The circumference of the Earth was estimated by...

A...Eratosthenes using the cities of Alexandria and Syene.

B...measure how far North or South of the Equator you are.

C... it's elliptical.

D...after Atlas, because that's where Ancient Greeks believed he would have stood.

E...Eratosthenes in the city of Alexandria.

F...seven continents in total.

G...was a Titan, punished by Zeus.

H...around the Earth.



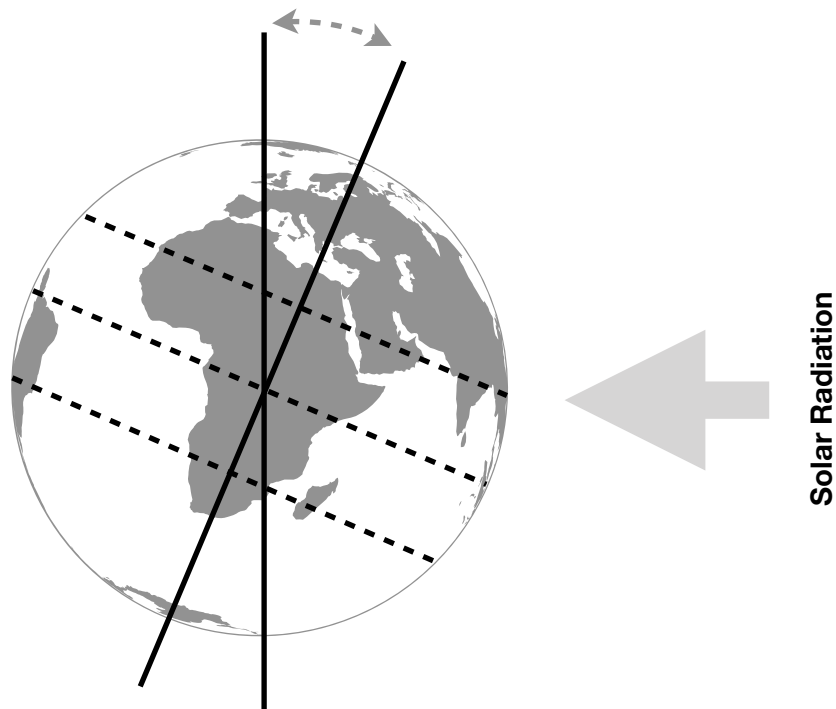
The story of the Tropic of Cancer and the Tropic of Capricorn.

- 1 The Tropic of Cancer is the most northerly
 2 line of latitude that at which the sun can
 3 be directly overhead. The city of Syene is
 4 almost exactly on the Tropic of Cancer
 5 which is why Eratosthenes was able to
 6 use it to calculate the circumference of the
 7 Earth.
- 8 The sun is directly overhead of the Tropic
 9 of Cancer during the summer solstice. The
 10 Tropic of Cancer has a southern
 11 hemisphere counterpart. The word
 12 counterpart means another person or
 13 thing that does the same job, but in a
 14 different place. For example, the head of
 15 an office in London for a large company
 16 with offices in different countries might
- 17 have a counterpart in New York, who runs
 18 that office.
- 19 The Tropic of Cancer's counterpart in the
 20 Tropic of Capricorn. The Tropic of
 21 Capricorn is in the Southern Hemisphere.
 22 The Tropic of Capricorn is the same
 23 distance from the Equator as the Tropic of
 24 Cancer. The sun is directly overhead of
 25 The Tropic of Capricorn during the winter
 26 solstice.
- 27 The Tropic of Cancer and the Tropic of
 28 Capricorn are both lines of latitude, they
 29 runs horizontally around the Earth.
- 30 The Tropic of Cancer is 23.5 degrees
 31 North, and the Tropic of Capricorn is 23.5
 32 degrees south.



154. Label the diagram below

Label the diagram to show **The North Pole**, **The South Pole**, **the Top Axis of Rotation**, **the Bottom Axis of Rotation**, the **23.5 degree angle**, the **Equator**, the **Tropic of Cancer**, and the **Tropic of Capricorn**.



33 The sun is directly above the Tropic of
 34 Cancer during the summer solstice. The
 35 summer solstice is during the month of
 36 June. The month of the summer solstice
 37 helps us to understand why the line of
 38 latitude is called the Tropic of Cancer.

39 In Ancient Greece, people could see the
 40 stars in the night sky more clearly than
 41 they can now. We cannot see the stars in
 42 the night sky as clearly as the Ancient
 43 Greeks could. The reasons we cannot see
 44 the stars as clearly as the Ancient Greeks
 45 is because of the light pollution. Light
 46 pollution is the effect of all the lights in the
 47 cities on Earth. The lights are important,
 48 they help keep us safe and make life
 49 easier for us, but they make it harder to
 50 see the stars in the night sky.

51 The stars in the night sky were so bright in
 52 Ancient Greece that the Ancient Greeks
 53 believed they could see patterns and

54 pictures in the stars. These patterns and
 55 pictures were called constellations. These
 56 constellations are still there, but they are
 57 harder to see because of light pollution.
 58 The constellations were given names. This
 59 helped people in Ancient Greece to know
 60 which direction they were travelling at
 61 night time.

62 Around 200 B.C., when Eratosthenes
 63 would have been alive and working as the
 64 Chief Librarian in Alexandria, the Tropic of
 65 Cancer was named. During the summer
 66 solstice, in the month of June, the sun
 67 was directly overhead of the Tropic of
 68 Cancer. In the Month of June the
 69 constellation Cancer was also directly
 70 overhead. The line of latitude is named
 71 after the constellation that was also
 72 directly overhead. Can you work out
 73 which constellation was overhead during
 74 the winter solstice to name the Tropic of
 75 Cancer's counterpart?



Let's review. Answer the questions below.

155. Which Tropic is in the Northern Hemisphere?	
156. Which Tropic is in the Southern Hemisphere?	
157. Which Tropic was the city of Syene closest to?	
158. Which constellation is the Tropic of Cancer named after?	
159. In which solstice is the sun directly overhead of the Tropic of Cancer?	
160. Which constellation is the Tropic of Capricorn named after?	
161. In which solstice is the sun directly overhead of the Tropic of Capricorn?	
162. Are the Tropics the same distance from the Equator?	
163. Which has a longer circumference, the Tropic of Cancer or the Equator?	
164. How many degrees North is the Tropic of Cancer?	
165. How many degrees South is the Tropic of Capricorn?	
166. What degrees is the Equator?	



167. Use an Atlas and answer the questions below.

Organise the following countries into the two columns in the table underneath: Algeria, Argentina, Australia, Bahamas, Bangladesh, Botswana, Brazil, China, Chile, Niger, Libya, Egypt, Saudi Arabia, United Arab Emirates, Oman, India, Myanmar, Taiwan, Madagascar, Mexico, Mauritania, Mozambique, Mali, Namibia, Paraguay, and South Africa.

Countries on the Tropic of Cancer	Countries on the Tropic of Capricorn

168. Explain how the tilt of the Earth means the sun will be directly overhead of the Tropic of Capricorn during the summer solstice

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169. Explain why the average temperature will be higher at the Tropic of Capricorn than at 70 degrees south.

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Lesson 8: Longitude



170. Retrieval Practice: Use the first letter to work out the missing word and complete the paragraph.

Lines of L_____ are imaginary lines run horizontally around the Earth. The E_____ splits the Earth into two equal halves. The two equal halves are called h_____. L_____ of latitude are measured in d_____. The N_____ P_____ is at 90 degrees North, and the Tropic of C_____ is at 23.5 degrees North.

The sun is directly overhead of the Tropic of C_____ during the w_____ s_____. Because the tilt of the Earth is 23.5 degrees, the Tropic of C_____ in the North, and the Tropic of C_____ in the south are 23.5 degrees away from the E_____.



Retrieval Practice: Match the heads and tails of the sentences below, neatly, using a ruler.

171. The longest line of latitude is...
172. A good example of an elliptical shape is...
173. The tilt of the Earth is...
174. The sun is directly above the Tropic of Capricorn on...
175. The two halves of the Earth, separated by the Equator are called..
176. The Tropic of Capricorn is...
177. The mountains of Northern Africa are called the...
178. To write about the Earth' is the meaning of the word...

A...23.5 degrees
B...the winter solstice.
C...the hemispheres.
D...a tangerine
E...Geography
F...the equator.
G...23.5 degrees South.
H...Atlas.



The story of Marinus of Tyre and his marvellous map

1 Marinus of Tyre is named after the place
2 he lived. Marinus lived in the city of Tyre.
3 The city of Tyre was in the Roman
4 Province of Syria. The Roman Province of
5 Syria was on the Mediterranean Coast
6 and is shown in the map opposite.

7 Tyre was a coastal city. Tyre was once
8 conquered by Alexander the Great, the
9 same Alexander who founded the city of
10 Alexandria and named it after himself. The
11 word conquered means that Alexander the
12 Great took control of the city by force.
13 Alexander the Great used his army to
14 defeat the soldiers protecting the city.

15 Marinus was born in 70AD and died in
16 130AD. Marinus of Tyre was a
17 cartographer and mathematician. Like
18 Eratosthenes, more than 200 years before
19 him, Marinus of Tyre studied many
20 different disciplines. Marinus of Tyre used
21 interdisciplinary thinking and improved the
22 quality of maps forever after.

23 Unfortunately we don't have a copy of the
24 map that Marinus of Tyre made. We do
25 have a copy that has been made of
26 Claudius Ptolemy's map. Claudius
27 Ptolemy published his map in 150AD; 20
28 years after Marinus of Tyre had died.
29 Claudius Ptolemy published his map in a
30 book called Geography. Claudius Ptolemy
31 called his book Geography because he
32 was writing about the Earth.

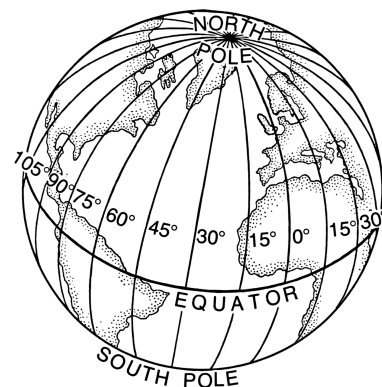
33 All the original versions of Geography by
34 Claudius Ptolemy have been lost. We no
35 longer have an original version. The oldest
36 version of Claudius Ptolemy's Geography
37 that still exists is a copy that was made in
38 the year 1295. The calculations by
39 Marinus of Tyre were used by Claudius
40 Ptolemy, and were still being copied over
41 1000 years after he died.



42 Marinus of Tyre realised that in order to be
43 able to locate cities, rivers, mountains,
44 and the coastline on his map, he needed
45 more than latitude.

46 Latitude was important for working out
47 how far North or South a location was.
48 However, latitude doesn't say how far East
49 or West a location was. Marinus of Tyre
50 improved new imaginary lines on the
51 Earth. Marinus of Tyre improved longitude.

52 Every line of longitude goes through the
53 North and South pole. Longitude is also
54 measured in degrees. This means that
55 Longitude and Latitude use the same unit
56 of measurement.



57 Marinus of Tyre had some challenges to
 58 overcome. Overcoming a challenge
 59 means that with lots of time, effort, and
 60 hard work, Marinus was successful.

61 Latitude is measured in degrees from the
 62 Equator. The Equator separates the Earth
 63 into the Northern Hemisphere and the
 64 Southern Hemisphere. The first challenge
 65 for Marinus of Tyre was creating a line of
 66 longitude as a counterpart to the Equator.

67 Marinus decided that the answer was to
 68 create the Prime Meridian. The Prime
 69 Meridian is the 0 degree line of longitude.
 70 The Prime Meridian is a counterpart to the
 71 the Equator, because they are both 0
 72 degree lines.

73 Longitude is measured in degrees East
 74 and West of the prime meridian. Latitude
 75 is measured in degrees North and South
 76 of the Equator. The Prime Meridian
 77 creates an Eastern Hemisphere and a
 78 Western Hemisphere. This is like the
 79 Northern Hemisphere and Southern
 80 Hemisphere created by the Equator.

81 Claudius Ptolemy gives the credit for
 82 longitude to Marinus of Tyre. When
 83 someone is given credit, it means that we
 84 are saying that they had the original idea.
 85 By crediting Marinus of Tyre, Claudius
 86 Ptolemy is making sure that everyone
 87 knows who performed the calculations for
 88 the map and who improved longitude.

 **Let's review. Answer the questions below.**

179. Where was Marinus of Tyre from?		188. Which imaginary lines on the Earth's surface did Marinus of Tyre invent?	
180. Which province was Tyre in?		189. What degrees is the Equator?	
181. Which coast is the city of Tyre on?		190. What degrees is the Prime Meridian?	
182. Who conquered the city of Tyre?		191. Which hemispheres does the Equator create?	
183. Which disciplines did Marinus study?		192. Which hemispheres does the Prime Meridian create?	
184. What do we call someone who studies many disciplines?		193. Does latitude run North-South or East-West?	
185. Who published Geography in 150AD?		194. Would you use longitude or latitude to measure how far East you were?	
186. How long after Marinus died was Geography published?		195. Would you use longitude or latitude to measure distance South?	
187. Which imaginary lines on the Earth did Marinus of Tyre invent?		196. Who credits Marinus of Tyre with creating lines of longitude?	

 **Label the map below.**

The map below shows a copy of the map in Claudius Ptolemy's Geography. Your challenge is to compare it to a modern map in an Atlas. Look for where Claudius Ptolemy's map is most accurate, and where it is most inaccurate.

197. Label the map to show the countries, seas, and oceans that are most recognisable, and identify the areas that are most inaccurate.



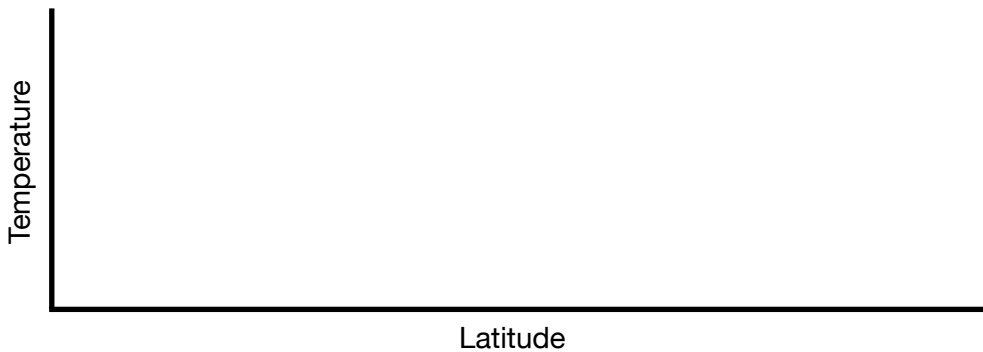
Lesson 9: Map Coordinates



Let's review. Answer the questions below.

198. Which Tropic is in the Northern Hemisphere?		203. What is the angle tilt of the Earth?	
199. What is the 0th line of latitude?		204. What is the name of the sea between Northern Africa and Europe?	
200. What point is 90o North?		205. What is the name of the ocean to the West of Europe and Africa?	
201. Are lines of longitude horizontal or vertical?		206. How many continents are there?	
202. What is the unit of measurement for latitude?		207. How often does the Earth rotate 360° on its axis?	

208. Draw a simple graph that models the relationship between temperature and latitude.



209. Explain the relationship between temperature and latitude.

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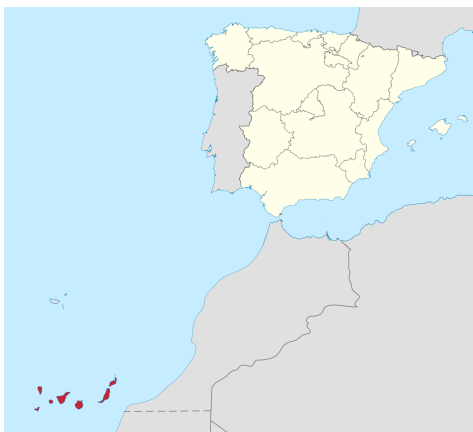
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How coordinates work on a map

1 You probably remember coordinates from
2 your Maths lessons. Did you know that
3 coordinates were first used in Geography?
4 We know that Eratosthenes, and Marinus
5 of Tyre, used interdisciplinary thinking.
6 Studying lots of different disciplines
7 helped them to see the links between
8 them more clearly. It was normal to study
9 both Geography and Maths in Ancient
10 Greece. We are all fortunate to attend a
11 school where we can study both
12 Geography and Maths.

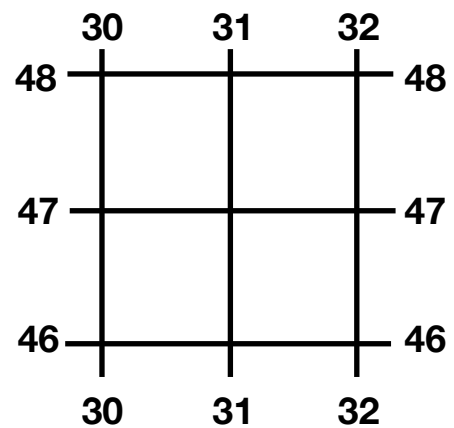
13 Marinus of Tyre is credited with improving
14 longitude. Marinus of Tyre used longitude
15 to work out coordinates for places.
16 Marinus wanted his map to be as accurate
17 as possible. Marinus wanted to know how
18 far North or South somewhere was from
19 the Equator, and how far East and West it
20 was from the Prime Meridian.

21 The maps drawn by Claudius Ptolemy in
22 Geography show the Prime Meridian
23 drawn in the Canary Islands. The Canary
24 Islands, where Claudius Ptolemy drew the
25 Prime Meridian is probably where Marinus
26 of Tyre drew his Prime Meridian. The
27 Canary Islands are West of Portugal. The
28 Canary Islands would have been the land
29 furthest West that had been discovered,
30 close to the Atlas Mountains. The Canary
31 Islands are now part of Spain.



32 Sailors still use latitude and longitude
33 today. In the future will learn how
34 important it became to measure longitude
35 at sea. For now, we want to learn how
36 locations are described as coordinates
37 using imaginary lines on maps.

39 Maps have lines that run horizontally and
40 vertically across them. These lines are like
41 longitude and latitude. The imaginary lines
42 on maps run North-South and East-West.
43 We can use them to determine location, in
44 a very similar way to coordinates.

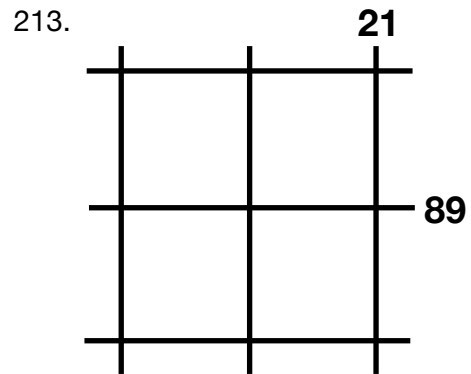
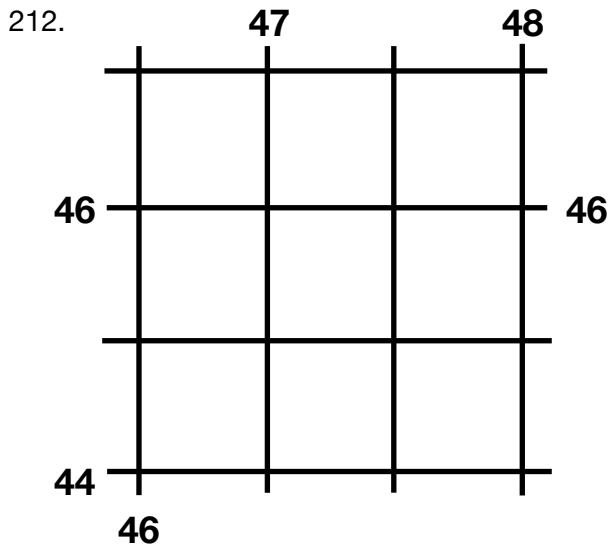
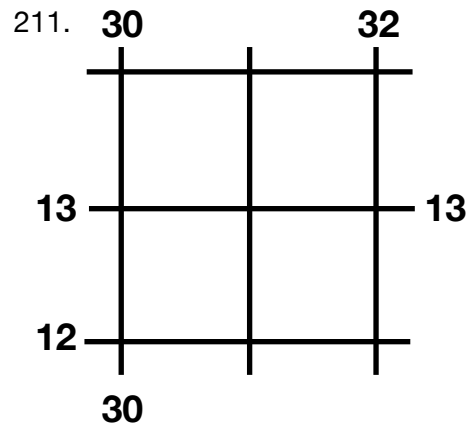
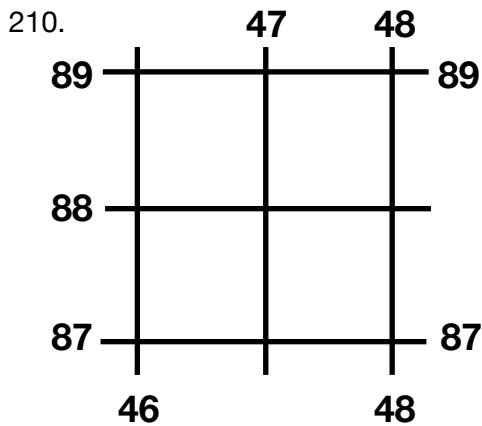


45 The lines on a map look like a grid. We call
46 them grid lines. We call the imaginary lines
47 on maps grid lines because they resemble
48 a grid. All of the grid lines are numbered.
49 Grid lines only use integers for numbers.
50 There are never fractions or decimal
51 places.

52 The numbers of the grid lines go up
53 sequentially. Grid lines go up sequentially
54 East and North. This means that each grid
55 line will always be one integer higher than
56 the grid line West or South of it.

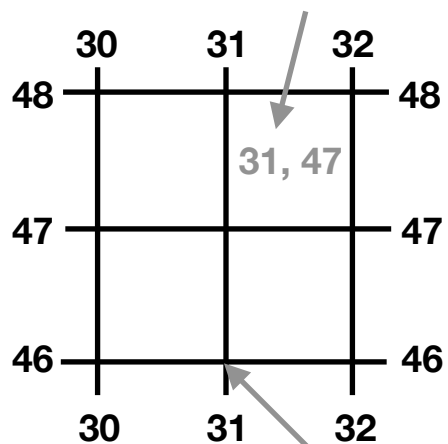
Deliberate Practice

Add the missing numbers to these grid lines. Remember they always go up sequentially in integers, Eastwards and Northwards.



The grid reference for this square area is (31, 47)

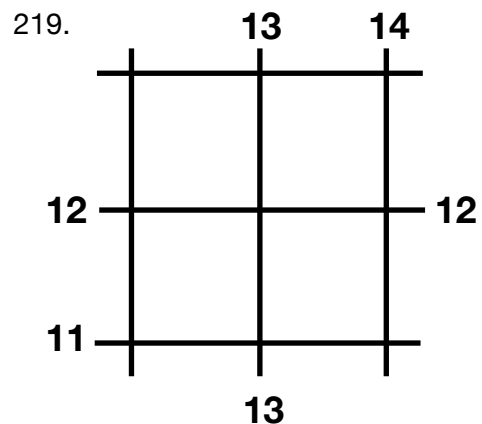
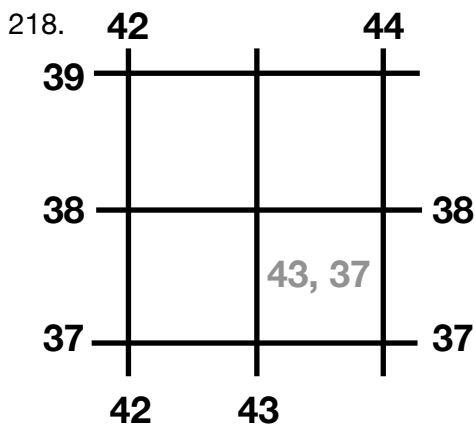
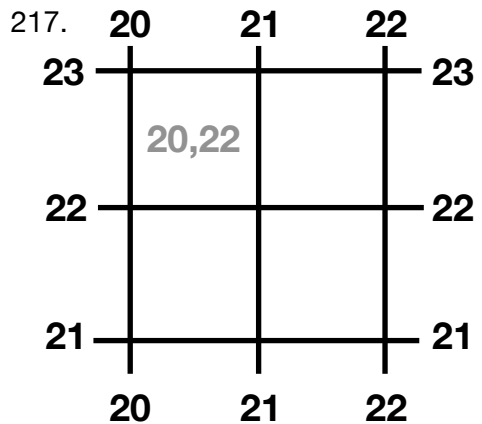
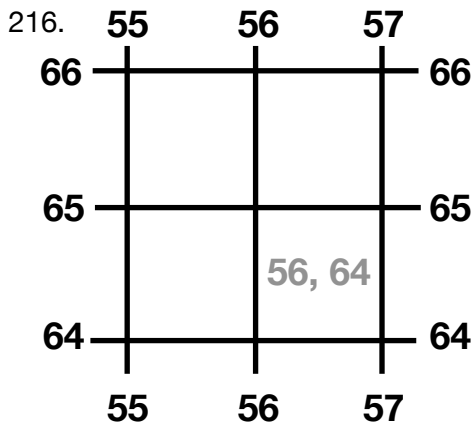
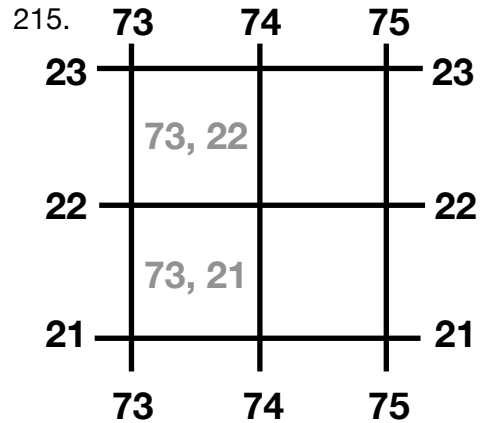
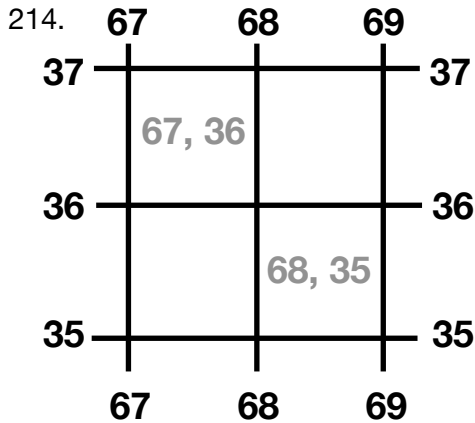
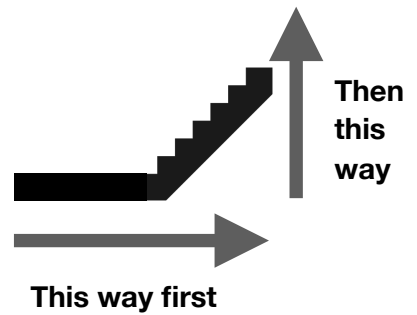
57 Coordinates help us to determine a
 58 point on a graph. The grid lines help
 59 us to identify square areas on a
 60 map. This is done in a similar way.
 61 Coordinates are written as two
 62 numbers, seperated by a comma.
 63 The numbers used to identify a
 64 square area on a map is called a
 65 grid reference. Every square on a
 66 map has its own grid reference. The
 67 grid reference for a grid square is
 68 similar to the coordinates for a point
 69 on a graph.



The coordinates for this point, are (31, 46)

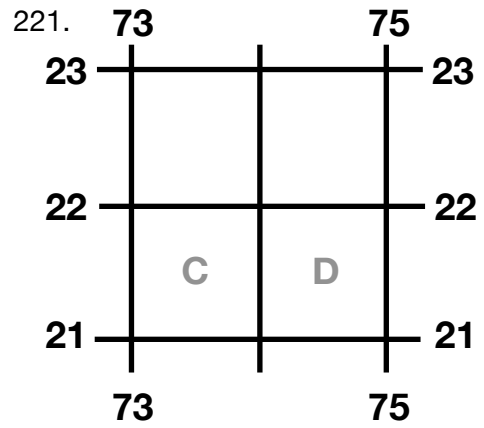
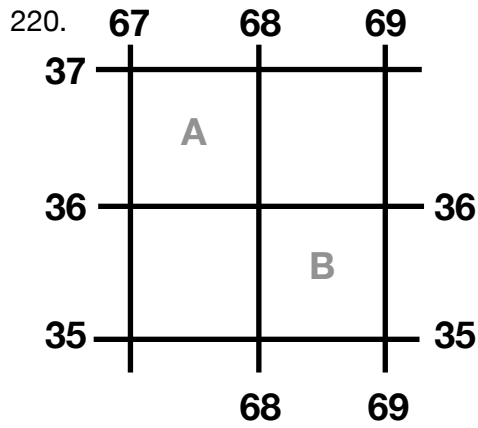
Deliberate Practice

Write the grid references for the square areas in the examples below. If the gridlines are missing numbers, you'll need to add them. Remember that it is similar to the coordinate system. The order is the x-axis first, then the y-axis second. The x-axis is the horizontal axis, and the y-axis is the vertical axis. Coordinates are written alphabetically, so x comes before y (x, y). One way people often remember this, is the saying 'you go along the hallway before you go up the stairs'.

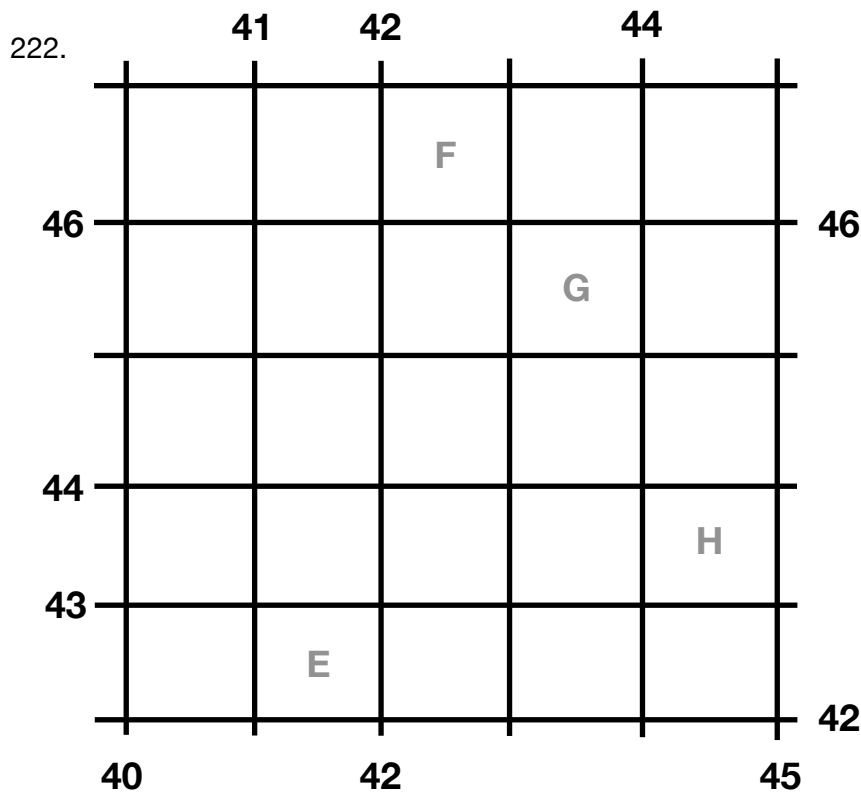


Deliberate Practice

Write the grid references for the square areas with the letter in them in the space provided. Where examples are missing number on the gridlines, add those as well.



A _____ B _____ C _____ D _____



E _____ F _____ G _____ H _____