Meteorology: Climate

Names: _____

_____

Instructions:

This is the meteorology test booklet. Please fill out the information about yourselves and your school above. Then, write your responses directly into this test booklet. Bring the booklet to the front of the room when you are finished.

The breakdown of points for this event is as follows:
        Section 1: 13 Points
        Section 2: 20 Points
        Section 3: 32 Points

        Total Points 65

        Tie Breaker #1: 10 Points
        Tie Breaker #2: 5 Points

Keep these totals in mind when answering questions. Remember, you have **50 minutes**, so use your time wisely. If you don't know the answer to a question, you may wish to skip it and go on. An announcement will go out when 30 minutes, 15 minutes, and 5 minutes remain. If you finish early, you may wish to check over your answers. Do not forget to answer the tie-breaker questions! They will be graded only in the case of a tie.

You may use any references you have available, including notes and textbooks. You may only use a non-programmable calculator. If you have any questions, or are concerned about anything, please ask one of the event supervisors for help. Good luck and have fun!

The last page of your answer sheet can be torn off and used as scratch paper.

Section 1: Multiple Choice / Matching

To be a climate scientist, you need to have a good basic knowledge of climate. This section will test your knowledge and memorization. For each multiple choice question below, circle the letter of the answer you believe is correct. For questions which involve matching, write the letter of your answer on the space provided.

(13 points in this section: 1 per multiple choice answer, 1 per blank in matching)

Sunspots are generally _____ the sun's photosphere.
   a) warmer than
   b) colder than
   c) about the same temperature as

As the number of sunspots increases, the sun's energy output also increases. Why?
   a) The sunspots are hot, so the sun's output is higher.
   b) Sunspots are great storms that bring energy up out of the sun's core.
   c) Bright spots on the sun occur at the same time, making a hotter sun.
   d) This is wrong. The sun's energy output would decrease!

Which reason is NOT likely to have caused the Norse settlements in Greenland to die out during the Little Ice Age?
   a) Increasing ice made trade outside of Greenland nearly impossible.
   b) Famine occurred, because permafrost made growing crops difficult.
   c) Rising sea levels made settlements unlivable.
   d) Competition over resources with the Inuit people led to hostility.

An increase of _____ in the atmosphere would generally lead to a decrease of temperature at the surface.
   a) carbon dioxide
   b) methane
   c) sulfur gases / sulfates
   d) water vapor

Köppen's climate classification system is based on average monthly temperature and precipitation. What is Thornthwaite's classification system based on?
   a) Latitude and distance from the nearest upwind ocean
   b) Water balance (potential evapotranspiration)
   c) Average yearly number of thunderstorms
   d) Chemical composition of topsoil

Place the following events in order, from the earliest to the most recent.
   a) Younger Dryas, Medieval Warm Period, Little Ice Age
   b) Younger Dryas, Little Ice Age, Medieval Warm Period
   c) Medieval Warm Period, Younger Dryas, Little Ice Age
   d) Little Ice Age, Medieval Warm Period, Younger Dryas

When is the Earth closest to the sun?
   a) Winter
   b) Summer
   c) Aphelion
   d) Perihelion

Match the following Milankovitch cycles to their definitions, by writing A, B, or C next to each of the words below.

_____   Eccentricity

_____   Obliquity

_____   Precession

   A) This refers to how extreme the tilt of the Earth's axis is. The tilt varies between approximately 22.1° and 24.5° through a 41,000 year cycle.
   B) This refers to the direction that the axis of the earth points, relative to other objects in space. This results in summer and winter being "switched" in a 23,000 year cycle.
   C) This refers to how circular (vs. elliptical) the orbit of the Earth is. The earth goes through this cycle every 100,000 years.

Which year was known as "The Year Without A Summer" in the Northeast United States, Eastern Canada, and Europe?
   a) 1741
   b) 1816
   c) 1932
   d) 1983

Which of the following is the most likely reason for "The Year Without A Summer"?
   a) The atmosphere was adjusting to a surge of industrial pollution in the Northeastern United States, Canada and Europe.
   b) Clearing of land in the United States and Canada led to a higher surface albedo, which reflected solar radiation away and made the earth colder.
   c) The eruption of Mount Tambora loaded the stratosphere with volcanic ash, scattering sunlight away from the earth.
   d) The earth was in a highly eccentric orbit, so less sunlight reached Earth that year.

A "nuclear winter" is a massive cooling of the earth that could occur after a major nuclear war. Which of the following reasons best explains why the earth would cool immediately after a nuclear war?
   a) Massive fires would inject smoke into the atmosphere
   b) Radiation fallout would reflect sunlight back out to space
   c) Cloud cover would increase dramatically from the nuclear explosions
   d) Desertification of the surface would increase the surface albedo

Section 2: Fill-In-The-Blank / Geography

Another part of being a climate scientist is having a well-rounded knowledge of geographical areas. How do climate changes affect different parts of the globe? Which places on earth have the most extreme climates? Follow the directions for each question in this section.

Influence of El Niño: *(15 Points)*

Look at the list of atmospheric phenomena below:
If an event is usually associated with El Niño, write an A next to the item.
If an event is usually associated with La Niña, write a B next to the item.

_____   Strong equatorial counter-current

_____   Strong Peruvian Current

_____   Stronger upwelling of ocean waters along the coast of Peru

_____   Higher sea levels in the western Pacific

_____   Strong Trade Winds

_____   Intensified Walker Circulation over Equatorial Pacific

_____   Pronounced ridge in polar jet over western North America

_____   Stronger than normal subtropical highs in Pacific Ocean

_____   Wetter than average winter over Florida

_____   Drier than average over Indonesia and Australia

_____   Lower than average pressure over Indonesia and Australia

_____   Increased snowfall in the Northwestern United States.

_____   More hurricane activity.

_____   Causes a pattern similar to the years 1997-1998.

_____   Causes a pattern similar to the years 1998-1999.

Most Extreme on Earth: *(5 Points)*

Some places on Earth are known for their extreme climates. Use the map below to identify some of these locations:

We will accept either of the top two answers for each of these categories. But only choose one location for each of the following. Do not choose Antarctica for any of your responses:

1) Write an "H" in the place that has the hottest temperature ever measured.

2) Write a "C" in the place that has the coldest temperature ever measured (outside of Antarctica)

3) Write a "W" in the place that has the highest average annual precipitation.

4) Write a "D" in the place that has the lowest average annual precipitation.

5) Write an "X" in the place that has the highest recorded surface wind speed

Section 3: Application of Knowledge

Some day, you might need to use your climate knowledge. Maybe you'll be helping your fellow classmates understand climate, have a job where you can use your climate knowledge, or even have an exciting new career in climate science. You never know when you might need to use what you have learned. Follow the directions for each question in this section.

Mentoring: (11 Points)

Your friend, Jacob, is in high school taking a class on *Weather and Climate*. His final exam is next week, and he's only getting a D in the class! He wants to pass his class. He knows that you just studied climate for the National Science Olympiad tournament, so he's hoping you'll help him study for the test. Help Jacob study for the test by circling the letters of the answers you believe are right:

Jacob: "I need to explain the Indian Summer Monsoon. I remember that during the summer, the ground gets really hot. That makes the air above the ground hot too. So, a column of air over India will expand as it gets hotter? Or shrink as it gets hotter?"
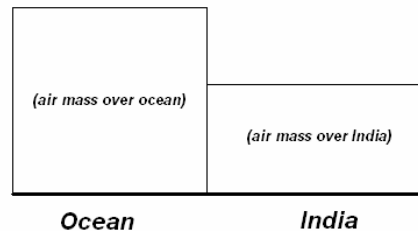   a) shrink
   b) expand

Jacob: "I don't understand. Could you sketch me a picture?" (circle the letter above the correct diagram)
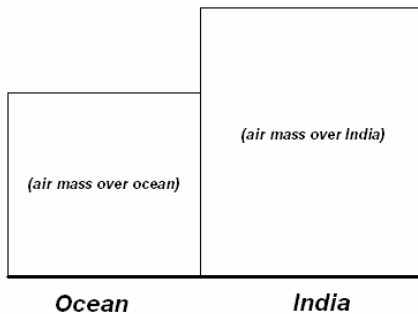
a)   b)
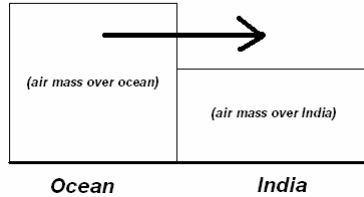

Jacob: "OK. I get it now. Next, the air at the top of the columns starts to move horizontally, because of the difference in pressure between the two columns. How does that work?"
   a) The air at the top of the column over India moves towards the ocean.
   b) The air at the top of the column over the ocean moves in towards India.
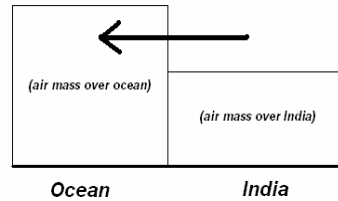
(Question continues on next page)

Jacob: "Huh. I think I need another picture. Starting with that picture you drew before, where would you put the arrow to show how the wind blows?" (Circle the letter above the right diagram)
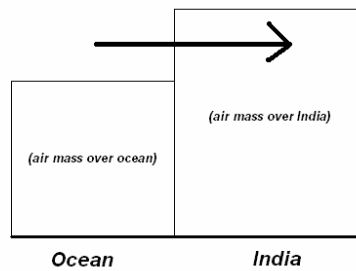
a)

(air mass over ocean)

(air mass over India)

Ocean   India

b)

(air mass over ocean)

(air mass over India)

Ocean   India

c)

(air mass over India)

(air mass over ocean)

Ocean   India

d)

(air mass over India)

(air mass over ocean)

Ocean   India
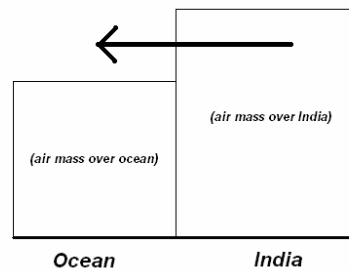
Jacob: "In my textbook, a big low-pressure region forms over the surface of India during the Summer Monsoon. Why does that happen?"
  a) There's less air in the column over India after the air moves at the tops of the columns. Because there's less air, there's lower pressure at the surface.
  b) There's more air in the column over India after the air moves at the tops of the columns. Because there's more air, there's lower pressure at the surface.

Jacob: "Oh. So, the low pressure at the surface of India causes air from the ocean's surface to move. Which way does the air move at the surface?"
  a) From the ocean towards India
  b) From India towards the ocean
  c) From the ocean's surface up towards the top of the air column over the ocean

(Question continues on next page)

Jacob: "OK. So, the air then rises over India. Let's put this together. Sketch the same diagram that we did before, and draw arrows that show how the air moves. Show the air rising over India, the air moving at the top of the air columns, and the air moving at the surface. I'll do the same thing, and then we'll compare notes. I hope I get it right!"

Draw the diagram Jacob asked for in the space below. Start with the graph you selected earlier in this question, and draw ALL of the arrows that Jacob asked for. You should have 3 arrows on your diagram.

(draw diagram in space below) – diagram worth 5 Points

The Stradivarius Violin *(5 Points)*

You are walking with a group of friends through the Museum of Music. In front of the violin display, you see a plaque with the following write-up:

Stradivarius violins are among the most celebrated violins in the world. Musicians believe that these violins have a distinctive sound that can not be recreated by today's violin-makers.

Burckle and Grissino-Mayer suggest that the high quality of these violins may be climate-related. Stradivari was born just one year before the Maunder Minimum, and made most of his violins during the Little Ice Age. The spruce trees during the Little Ice Age had a much higher density than at any other time in history, which made them far more efficient at transmitting sound.

Your friends look confused. They don't understand the jargon, or why trees would change density. Can you help answer their questions?

What was the Maunder Minimum?
   a) This was a time when the ice sheets covered the least area on the Earth.
   b) This was a time when sunspot activity was at an all-time low.
   c) This was a time when pollution was at an all-time low.
   d) This was a time when snow covered the entire globe.

Stradivari was alive during the Maunder Minimum. So, when did Stradivari live?
   a) 974-1054
   b) 1189-1263
   c) 1399-1487
   d) 1644-1737

Where were the effects of the Little Ice Age most dramatically felt?
   a) Europe
   b) Asia
   c) South America
   d) Australia

If you took a sample of the spruce trees during Stradivari's lifetime, how would they compare to today's spruce trees in the same area?
   a) The rings would be more spread out in Stradivari's trees.
   b) The rings would be closer together in Stradivari's trees.

How would the growth rate of spruce trees during Stradivari's lifetime compare with today's spruce trees?
   a) Stradivari's trees would grow faster.
   b) Stradivari's trees would grow slower.

Ice Core Assignment *(6 Points)*

You've just been given a job as a staff clerk in the Greenland Geological Office. Congratulations! Your division is in charge of ice analyses throughout Greenland.

Your first job as the new staff clerk is as follows: Four scientists have set up missions to study Greenland. Your job is to assign each scientist's mission to the location which will best help them accomplish their goals. Here are the scientists you will be assigning:

Brett Matteson has proposed a mission to study the effects of radiation fallout from Chernobyl, a nuclear reactor which exploded in Ukraine in 1986. He requires an ice core record extending back 20 years to study the radiation's effects in Greenland, plus an additional 20 years to study Greenland's conditions before the explosion. He needs a high-snowfall location, so that traces of fallout will be easier to detect. He can handle some melting, as long as the ice doesn't melt completely.

Linda Wright has proposed a mission to compare the most recent Greenland ice to older records. She suggests that global warming may be more severe than current ice cores show, because older ice may mix with the new ice. She wishes to collect an ice sample that only contains ice from this year's winter, for comparison to other, more-extensive ice-core samples from other missions. She needs a place where it snows each winter, and melts completely each summer.
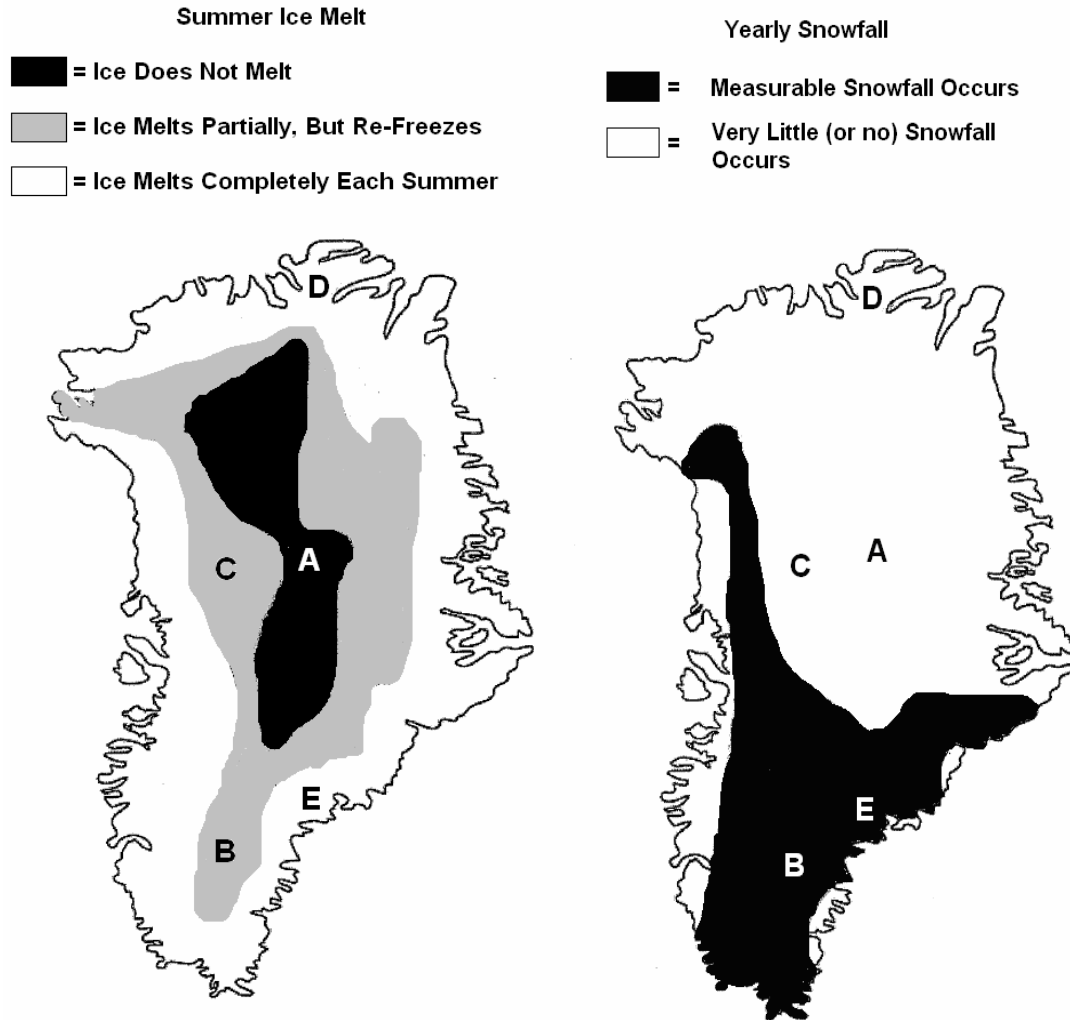
Jeff Monsigne has proposed a mission to study motion on the Greenland Ice Sheet. Melting water from the top of the ice sheet is thought to drain through crevasses in the ice to the underlying bedrock, where it makes the ice slide outwards towards the Greenland coast. He wishes to place a GPS unit on top of the Greenland Ice Sheet, and measure movement over a number of years. If the ice doesn't melt, his GPS won't move. On the other hand, if the ice melts completely, his GPS won't move either. He also doesn't want snow to fall, because his GPS device will get buried.

Rebecca Holloway has proposed a mission to collect an ice core that will give us a general idea about conditions before the last ice age, more than 120,000 years ago. She wants a location that doesn't snow much, if at all. That way, each year's layer will be thinner, and she won't have to drill as far down to get into ancient history. At the same time, melting ice may lead to missing data in her record, which she doesn't want.

You have five locations in Greenland labeled A, B, C, D and E. Your job is to assign the appropriate location to each scientist. Using your knowledge of each scientist's requirements and the Greenland maps on the next page, write A, B, C, D, or E next to each scientist's name below. Do not use any letter more than once. One letter will not be used.

Brett Matteson	_____	Linda Wright	_____
Jeff Monsigne	_____	Rebecca Holloway	_____

Summer Ice Melt

■ = Ice Does Not Melt

▨ = Ice Melts Partially, But Re-Freezes

□ = Ice Melts Completely Each Summer

Yearly Snowfall

■ = Measurable Snowfall Occurs

□ = Very Little (or no) Snowfall Occurs

Linda Wright noticed that her sample of ice had higher than average values of Oxygen-18, while ocean sediment samples near Greenland have had lower than average values of Oxygen-18 in recent years. What does this suggest about air temperatures over Greenland and over the surrounding ocean?
   a) Greenland has been warm, but the surrounding ocean has been cold.
   b) Greenland has been cold, but the surrounding ocean has been warm.
   c) Greenland and the surrounding ocean have both been warm.
   d) Greenland and the surrounding ocean have both been cold.

Rebecca Holloway wants to assign dates to the different layers in her ice core. Which method is NOT useful for dating ice cores?
   a) Counting layers (like you would on a tree).
   b) Relating measurements of Beryllium-10 in the ice core to known climate events.
   c) Measuring the boiling point of different portions of the ice core.
   d) Comparing the ice core to other ice and sediment cores to find things in common.

Destination: Unknown *(10 Points)*

You've taken a summer job with the Unique Travel Agency. They specialize in recommending unusual and exotic travel destinations to their clients.

The travel agency just received four new locations, and the travel agents want to tell their clients about these exciting additions to their destination list! But, they don't know anything about these locations beyond their name.

Your boss remembers that you studied climate at one point, and she comes to your desk with a book titled Climates of the World. She asks you if you can explain what these places might be like, based on this book. You're willing to give it a try, anyway, so you open the book and find the following Köppen classifications:
A) Luanda, Angola: Aw
B) Alice Springs, Australia: BWh
C) Stanley, Falkland Islands: Cfb
D) Yellowknife, Canada: Dfc

Based on those classifications, what can you say about the new locations? Below is a list of statements you could tell your boss. Next to each statement, write A for Angola (Aw), B for Australia (BWh), C for the Falkland Islands (Cfb), and D for Canada (Dfc):

_____ Almost always dry. Very little rain falls here.

_____ The temperatures average below -3ºC (27ºF) in the winter.

_____ The winter is dry, but the summer is very wet.

_____ The average monthly temperatures don't get above 22ºC (72ºF), but they don't drop below -3ºC either.
_____ The average *annual* temperature is above 18ºC (64ºF).

_____ *Every month* is above 18ºC (64ºF) on average.

_____ This location is most influenced by a marine climate, but not the ITCZ.

_____ This location is most influenced by the ITCZ, but it is also near the coast.

_____ This location is most affected by the subtropical high.

_____ This location is most affected by a continental climate.

Section 4: Tie-Breaker Questions

These questions will only be graded in the event of a tie. Save these questions until the very end, but try to answer as much as you can of them. Ties happen more frequently than you might think! The multiple choice portion of Tie Breaker #1 will be graded first. If the tie still can not be broken, then we will grade the essay portion of Tie Breaker #1. Any remaining ties will be broken with Tie Breaker #2.

Tie Breaker #1: *(5 Points Multiple Choice + 5 Points Essay)*

You work for a famous ecologist, who gives lectures throughout the country on the effects of acid rain and deforestation. Because you participated in the Meteorology Event in the National Science Olympiad tournament, he asks you to put together a weather forecast for the following locations:

May 22nd, 2007: Cape Disappointment, WA.

May 23rd, 2007: Paradise, WA.

May 24th, 2007: Yakima, WA.

Wait a minute…2007?!? Does he expect you to make a 365-day forecast?!? You decide to go back to your *brilliant* boss and explain why you can't make a <u>weather</u> forecast for next year. On the lines below, explain what you say to your boss. Be sure to explain the difference between weather and climate, at least one reason why weather models don't work a year in advance, and at least one reason why you can't just assume the weather forecast will be the same a year from now as it is today.

_____

_____

_____

_____

_____

_____

_____

_____

(Space for answering question continues on next page)

Your boss listens to your argument, and says, "Fine! If you can't give me a forecast, then just answer a few questions for me." Your boss writes down a list of questions and hands you the following topographic map:

Answer the following questions for your boss:

Which city do you expect to be climatologically the coldest during my trip?
   a) Cape Disappointment
   b) Paradise
   c) Yakima

Which city do you expect to be climatologically the warmest during my trip?
   a) Cape Disappointment
   b) Paradise
   c) Yakima

Which city will receive the least rain?
   a) Cape Disappointment
   b) Paradise
   c) Yakima

Paradise is located on the windward side of the mountain, at a high elevation. But, I'm thinking of taking a daytrip that day. Which of these places would be the hottest in the mountains?
- a) Windward side of the mountain, low elevation
- b) Windward side of the mountain, high elevation
- c) Leeward side of the mountain, high elevation
- d) Leeward side of the mountain, low elevation

Also, I don't want it to rain on me during my daytrip. Where should I go to avoid rain?
- a) On the western edge of the Cascade Mountain chain
- b) On the eastern edge of the Cascade Mountain chain

Tie Breaker #2: *(5 Points)*

The average high temperature for Bloomington, Indiana is 76ºF, and the average low is 52ºF. The average precipitation for the entire month of May is 4.2 inches, and rain only falls about 7 days during the month.

Based on that information, have you been experiencing climatologically normal conditions during your stay in Bloomington? Why do you say it is/isn't normal?