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FIELD AND LABORATORY NOTE BOOK

IN

PHYSICAL GEOGRAPHY

BY

F. A. MERRILL

DEPARTMENT OF GEOGRAPHY, STATE NORMAL SCHOOL, ATHENS, GEORGIA

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INTRODUCTORY NOTE

Laboratory work in Physical Geography has for some years been in a transitional stage that is now approaching but has not yet reached a regular routine similar to that of the chemistry or physical laboratory. Many teachers have been working out a series of laboratory exercises for their own classes. Some of these that have proven more or less successful have been published as an aid to other teachers.

Professor Merrill adds a manual to the list that appears to fill a need in the schools arising from the fact that some of the manuals already published are too elementary and some are too far advanced. That is, some of them require too much purely mechanical work, giving the impression that the object is to occupy the hands of the pupil regardless of whether the exercise illustrates any principles or leads to any conclusions. The other class of manuals presumes too much on the previous knowledge and experience of the pupil for the early years of the school.

This gap between the two kinds of manuals appears to be filled better by Professor Merrill's book than by any other that I have seen. It likewise is wider in its scope and covers the whole field of Physical Geography more thoroughly than any other. It is a step in the right direction and I hope it may prove serviceable to all who use it.

T. C. HOPKINS.
(Author of Hopkins' Physical Geography.)

SYRACUSE UNIVERSITY, January, 1911.

211261

APPARATUS

The following maps and apparatus are needed for the work outlined in the exercises given in this note book.

Topographic sheets

Donaldsonville (La.)
Camp Mohave (Ariz.–Nev.–Cal.)
Niagara Falls and Vicinity
Sea Isle (N. J.)
Evansville quadrangle (Wis.)
Wicomico (Md.–Va.)
Whitewater (Wis.)
Milwaukee quadrangle (Wis.)
Lykens (Penn.)
Harrisburg quadrangle (Penn.)
Bristol (Va.)
Gallatin (Wyo.)
Canyon (Wyo.)
Cucamonga (Cal.)
Mississippi river delta (Coast Survey chart)
Tacoma (Wash.) folio
Oak Orchard (N. Y.)
Charleston (W. Va.)
Princeton (Ind.–Ill.)
Mt. Mazama and Crater Lake (Oreg.)
Lake Geneva (Wis.)
Belchertown (Mass.)
Webster (Mass.)
Blackstone (Mass.)
Sierraville (Cal.)
Henry mountains (Utah)
Sevier desert (Utah)
Salton sea (Cal.)
Shasta special (Cal.)
Boothbay (Me.)
White Bear quadrangle (Minn.)
Caldwell (Kans.)
Fargo (N. Dak.–Minn.)
Modoc (Cal.)
Kaibab (Ariz.)
La Salle (Ill.)
Shamokin (Penn.)
Hummelstown (Penn.)
Boston bay (Mass.)
Tolchester (Md.)
Provincetown (Mass.)
Wellfleet (Mass.)
Talmalpais (Cal.)
Oceanside (Cal.)
Marysville (Cal.) folio
Lassen Park (Cal.)
Atlantic City (N. J.)
Sandy Hook (N. J.–N. Y.)
Haywards (Cal.)
Port Orford (Oreg.)
St. Louis (Ill.–Mo.)
Centerpoint (W. Va.)

Maps

Ocean temperature chart, wind zone map, current and trade route map of the world, thermal maps for July and January, mean annual isothermal map of the world, United States weather maps for seven consecutive days, average annual rainfall map of the United States.

Chemicals

Hydrochloric acid (HCl), sea water, limewater, mercury, alcohol.

MINERALS, ETC.

Till soil, marble, granite, rock, quartz, calcite, mica, hornblende, augite, magnetite, hematite, limonite, pyrite, gypsum, salt, ice, gneiss, shale, clay, trap, sandstone, limestone, iron ore, coal, slate, loam, volcanic rock, gravel, sand, glacial pebbles.

MISCELLANEOUS

Straw tube, scales, stirring rod, barometer tube 36 inches long, glass funnel, tube support, two thermometers, muslin, glass flask, barometer, cup for measuring precipitation, two tin cups, board with 2-inch square opening in center, test tubes, glass tumbler, hand magnifier, lamp chimneys, tin pans, small bottles, large-mouthed bottles, window glass, knife, glass tubing, rubber tubing, drawing compass, pencil, ruler, small globe, black colored ball, knitting needles, shadow post, cardboard, colored pencils, hoop of pasteboard, bar magnet, compass needle, dividers, modeling sand, modeling board, flat corks, candle.

CONTENTS

I. THE EARTH AS A PLANET

1 — The Solar System

Purpose — To understand what the solar system is.

Materials — Compass, pencil, ruler.

Give a definition of the solar system.

What different kinds of bodies compose this system?

Write the names of the planets in their order from the sun.

Where are the planetoids found?

Name the major planets.

Name the minor planets.

Which of these planets are plainly visible at certain times in the year?

Which of the planets have satellites?

How many satellites has Jupiter? Saturn? Mars? Earth?

What is the difference between a star and a planet?

With a scale of 3,000 miles to ¼ inch, draw circles showing the comparative sizes of the planets from the following table:

	Mean diameter.		Mean diameter.
Mercury	3,030	Jupiter	86,500
Venus	7,700	Saturn	73,000
Earth	7,917	Uranus	31,900
Mars	4,230	Neptune	34,800

The Solar System

Construct concentric circles to show the orbits of the planets from the following table:

Mercury's orbit	.1	inches	in	diameter.
Venus' orbit	.19	"	"	"
Earth's orbit	.26	"	"	"
Mar's orbit	.39	"	"	"
Jupiter's orbit	1.34	"	"	"
Saturn's orbit	2.46	"	"	"
Uranus' orbit	4.95	"	"	"
Neptune's orbit	7.75	"	"	"

2 — The Moon

Purpose — To study the phases of the moon.

Materials — Small globe or black colored ball, pencil, compass, ruler.

With the light entering from one side, hold the globe between the eyes and the light.
How much of the globe can you see?
Is the visible part, dark or light?

Move the globe a little to the left.
Is any of its surface illuminated?
What is the shape of this illuminated part?

Move the globe above the eyes.
How has the illuminated part changed?

Move the globe below the eyes.
How has the illuminated part changed now?
What do we call this phase of the moon?
When do the horns of the moon point upward?

Move the globe one-fourth way around the head.
How much of the surface is illuminated now?
What is the shape of this lighted part?
What do we call this phase?

Move the globe one-half way around your head.
How much of its surface is lighted now?
Can you see any of the darkened surface?
Is this what we call the full moon?

Move the globe three-fourths way around your head.
Which part is illuminated now?
Is this the same side that was illuminated in the first quarter?

Move the globe nearly to the position it first occupied.
What is the shape of its lighted surface?

Move the globe above and then below the eyes.
Describe all the changes in the lighted surface you may see.

The Moon

To illustrate the relative positions of the moon, the earth and the sun at the different phases of the moon.

In the center of the sheet below place a dot to represent the position of the earth. With this dot as a center, construct a circle with a radius of 2½ inches to represent the orbit of the moon around the earth. Upon the four quarters of this circle, beginning with the right hand side, draw small circles to represent the moon. Indicate the sun's rays as coming from the right. With your lead pencil darken the side of the moon that does not receive any sunlight. Name the four positions of the moon. Illustrate below each quarter of the moon as it would look from the earth.

3 — Shape of the Earth

Purpose — To establish the shape of the earth.

Materials — A small globe, a book.

Give such proofs as you can to show that the earth cannot be flat.

What is the shape of the horizon as you look about you?

Ascend a high building or tower: does the horizon expand or contract?

How does this prove that the earth is not flat?
Illustrate this by means of a diagram.

Trace an east and west path about your small globe.
Do you come back to your starting point?
Could you do this on a flat surface?

Place the globe and the book on your desk.
What is the shape of the shadow cast by your globe?
What is the shape of the shadow cast by your book?
Does the globe ever cast a shadow that is not circular?
Does the shadow of the globe ever vary in shape?

When the earth's shadow is cast on the moon it is always circular. This is called an **eclipse** of the moon.

Stick a pin in your globe so that it stands upright. Turn it slowly away from you.
Which part of the pin disappears first?
Which part do you see the longest?
Would this happen on a flat earth?

Give a definition of a sphere. Name some objects that are spheres.
Is the earth a sphere?
What shape has the earth?
Draw a picture of a spheroid.

Give some absolute proofs that the earth is a spheroid.

4 — The Size of the Earth

Purpose — To study the measurements of the earth.

Materials — An apple, knitting needle, small globe, compass, ruler, pencil.

Thrust the knitting needle through the center of the apple.

What is a diameter?

With a ruler measure the diameter of the apple as shown by the needle.

Measure the diameter through the apple from side to side.

Is this diameter greater or less than the one represented by the needle?

Turn the apple about the needle.

What is an axis?

Turn the globe about its axis.

What is the length of this diameter?

What is the length of the diameter from side to side?

The earth is so much larger than your globe that there is a marked difference between its two diameters (about 27 miles).

Which diameter of the earth is the larger?

What is a circumference?

With a piece of string, measure the circumference of your apple and of your globe.

What is the circumference of your desk?

Draw a picture of your apple with the knitting needle through it and indicate its axis and greatest circumference.

Turn your globe slowly upon its axis.

What names do we give to the ends of this axis?
Where is the greatest circumference of this globe located?
What do we call this circumference?
Where is it located relative to the poles?

With a radius of two inches, draw a circle and indicate its two diameters.

Name the line which represents the axis in your drawing.
How many times greater is its circumference than its diameter?
Mark the equator upon your apple.
Find the equatorial circumference upon your globe.

Examples.

If the greatest diameter of the earth is 7,926.6 miles what is its greatest circumference?
The mean diameter of the earth is 7,917 miles: what is its surface area?
Find the volume of the earth.
The mean density of the earth is 5.6: find its mass.

5 — Directions

Purpose — To determine directions and to establish a meridian.

Materials — Small globe, small post, piece of cardboard, ruler, pencil.

Rotate the globe counter-clockwise.

Does the axis change its position?
In what direction does the earth's axis always point?
How can you locate the north star?
What name do we give to the upper end of the earth's axis?
To the lower end?
What other directions does the equatorial diameter give us?
If you leave the north pole, in what direction must you travel?
What lines upon the globe give you the north and south directions?
How many of these lines are there?
How far are they apart at the equator? At the poles?

With your pencil trace one of these lines from pole to pole.

What part of a circle have you covered?
How many degrees have you covered?
From what line do we reckon distances north and south?
How many degrees can you go north? South?

Find the meridian marked 0. This is called the **Prime Meridian.**

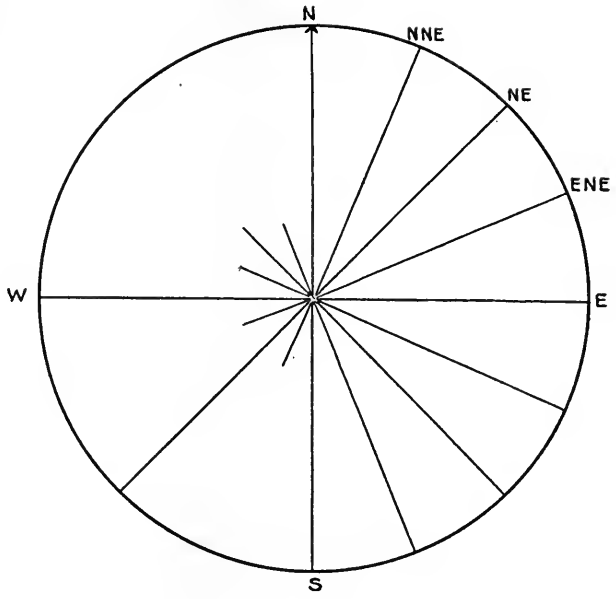
What large city is located on this meridian?
From where the 0 meridian crosses the equator pass to the east:
What is the fartherest point you may reach?
What is the name of this meridian?
How many degrees have you traveled?
Suppose you go 10 degrees farther east: will you be nearer or farther from your starting point?

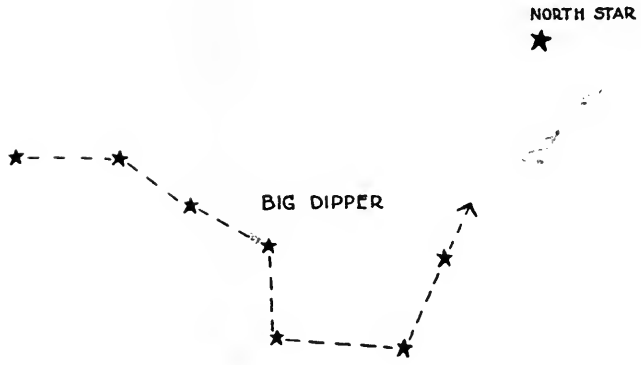
Place the meridian of your home toward you.

How far can you see to the east? The west?
What are the lines called that extend east and west of your home?
If you should travel along the parallel of your home, would you go as many miles as you would if you went along the equator?
Would you go as many degrees?

These lines, called meridians and parallels, help us to determine directions upon the earth's surface. The directions that they give us are called the cardinal points and are established by the rotation of the earth.

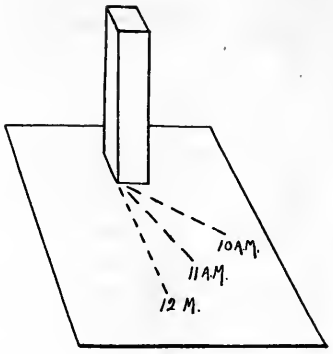
Fill in the blank quadrants in the figure below.





Method of locating the **North Star.**

To establish a meridian:



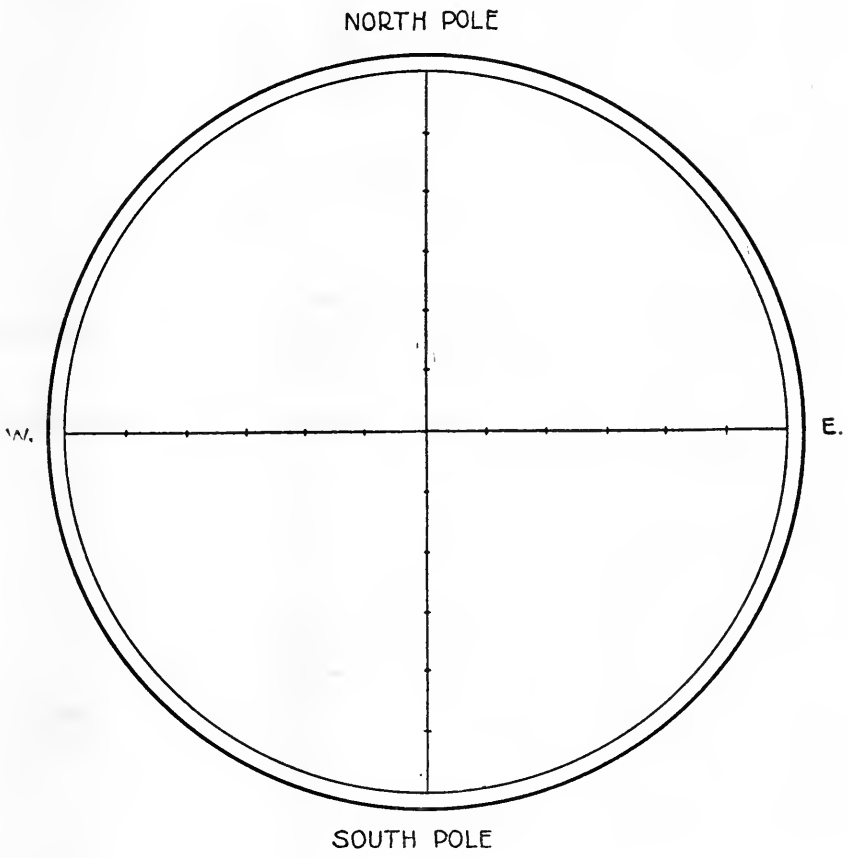
Fasten the small post to the piece of cardboard so that it will stand exactly perpendicular. Place this cardboard in a south window being careful to see that it is absolutely level. Note the shadows cast by the post upon the board. Make a mark upon the cardboard where the shadow is shortest. Do this for several days so that an accurate measurement may be made. Connect the base of the post and the mark obtained with a heavy line: this is the north and south line or meridian of the place. Check this line at different times of the year and compare the time the sun's shadow reaches it with noon time as shown by your clock.

Upon a smooth piece of ground erect a six-foot post being careful to get it perpendicular. (This may be done with the help of a plumb line.) Note the shortest shadow cast by this post. Drive a small stake into the ground at the end of this shadow. With these two points for guides, stake off a north and south line about a rod long. Set a permanent stake midway in this line. Establish the east and west directions from this middle point.

6 — Latitude and Longitude

Purpose — To study latitude and longitude.

Materials — Small globe, compass, ruler, pencil.



Draw lines parallel to the equator through the points indicated upon the meridian. Draw the meridians from pole to pole. For the tropical circles (latitude 23½) and the polar circles (latitude 66½) draw dotted lines parallel to the equator.

Number the parallels by indicating their degrees from the equator. Do the same with the meridians, numbering the center one 0. Write the names of the circles and of the equator in their proper places.

How many meridians have you upon your diagram?
How far apart are these meridians?
Which is the most eastern meridian? The most western?
How many degrees of longitude are there?
What is longitude?

How many miles of longitude are shown upon the equator?
Do the degrees of longitude vary in length?
What are the limits of this variation?
About what is the length of a degree of longitude at your home?

How many parallels are there in your diagram?
How far apart are these parallels?
How many are north of the equator? How many south?
How many degrees can you go north of the equator? How many south?
What is latitude?

Is there any variation in the length of the degrees of latitude?
On which parallel is a degree of longitude equal to half the length of a degree on the equator?
What kind of angles do the meridians make with the equator?

Study the meridians and parallels on your globe. Note the differences between the ones on your globe and those in your drawing.

How many meridians are there on your globe?
How many could there be?
How far apart are these meridians?
Which one is marked 0? Which one 180?
What kind of angles do these meridians make with the parallels?
Why do not the meridians in your drawing make the same kind of angles?

How many parallels are there on your globe?
How do they vary in size?
Do the meridians vary in size?
Find the circles on your globe: how are they marked?

What is the latitude of the north pole?
What is its longitude? Why?
What is the latitude of the equator?
Does the equator have a longitude?
What is the latitude of your home town?
What is its longitude?
Find the latitude and longitude of the capital of your state.

To determine the latitude of your home.

Upon the post that was erected to establish a north and south line, fasten a four-foot stick, pivoted in the center, so that it will move up and down. Point this stick to the north star and with a protractor measure the angle it makes with the upright post. This angle subtracted from 90 degrees will give the latitude of your place
Why? Prove this.

(As the axis of the earth does not point directly to the north star, there will be a slight error approximating 1¼ degrees according to the time of year the observation is taken.)

To determine the longitude of your home.

The longitude of a place is found by getting the difference in time in hours between that place and Greenwich and multiplying it by 15. The earth turns 360 degrees in 24 hours, therefore moving 15 degrees every hour. From an almanac, get the difference in time between your home (or that of the nearest recorded city) and Greenwich. Multiply this by 15 to get the required degrees of longitude.

7 — Rotation

Purpose — To study the rotation of the earth.

Materials — A small globe.

Place the globe in the sunlight so that both poles are lighted.

How much of the globe is illuminated?
What is the shape of this illuminated part?
How much of the globe is dark?
What do we call the lighted part? The darkened part?
Locate the "twilight zone."
What time of day is it to places in this zone?

Turn the globe slowly from west to east.

Does the circle of illumination change?
Which side of the globe is entering darkness?
What time is it at these places?
When is it noon at any place?
How do the sun's rays strike the earth at noon?
At evening?
How many degrees of longitude pass the sun in one rotation?
What is the speed of the earth's rotation?
Which places upon the earth's surface will see the morning sun first?
Which part of the earth moves the fastest?

Place the globe with the north pole pointing toward the sunlight.

How much of the globe is illuminated?
How far beyond the north pole does the circle of illumination extend?
Does the south pole receive any sunlight?
Rotate the globe: does any part of the earth fail to receive light?
Locate these places.

What causes day and night?

Are days and nights of equal length all over the earth?
Where are the nights the longer?
Where are the days and nights of equal length?

Repeat these experiments by placing the south pole toward the sunlight and note any differences you may discover.

From a study of your globe, give the approximate differences in time between

Greenwich	and	Buenos Aires
Philadelphia	"	New Orleans
Cape Town	"	Pekin
Washington	"	your home.

Fill in the following table:

Lengths of days

Places	Latitude	March 21	June 21	December 21
Entebbe	0			
Mazatlan	23½			
Christiania	60			
Ness	66½			
Your own home				

Give proofs that the earth rotates upon its axis.

Illustrate by a drawing that falling bodies tend to deviate toward the east.

Explain Foucault's Pendulum.

8 — Time Belts

Purpose — To study the time belts.

Materials — Small globe, colored pencils.

Rotate the globe from west to east.

In what direction does each day travel?

When it is noon on the 0 meridian, what time is it on the 90th west? On the 90th east?

When Tuesday is beginning in Greenwich, what time is it in San Francisco? Pekin?
(A day is reckoned from midnight to the following midnight.)

When it is noon Saturday at Greenwich, what time is it at the 179th meridian west? At the 179th east?

What change in time takes place at the 180th meridian?

If you sail east across this meridian do you gain or lose a day?

If you sail west?

Upon the map of the world ink heavily the 0 and the 180th meridians.

Draw the International Date Line on this map.

Why does not the International Date Line coincide with the 180th meridian?

Color with yellow pencil an area of the map which will represent 12 hours of sunlight.

Is this the same as the circle of illumination upon your globe?

Over which meridian is the noon sun shining?

Turn your globe toward you to coincide with your map: do the boundary meridians of your globe correspond to those on your map?

With a band of yellow mark an hour of time on the map. Mark four minutes of time.

Draw the meridian of your home.

How far is it from the Greenwich meridian?

East or west?

How will the time of your meridian vary from that of the 0 meridian? From that of the 140th?

Upon the map of the United States, ink the meridians that are used as the bases for the Standard Time Belts.

How far apart are these meridians?

How much difference in time between any two of them?

Why were these meridians chosen?

What large cities are near each meridian?

Sketch in the time belts with colored pencils using a different color for each belt. (Maps of these belts to help establish their boundaries may be found in any physical geography.)

Name the belts.

Why are the boundaries of these belts so irregular?

When is it noon in each belt?

Is the time slow or fast at a place east of the belt meridian?

West of it?

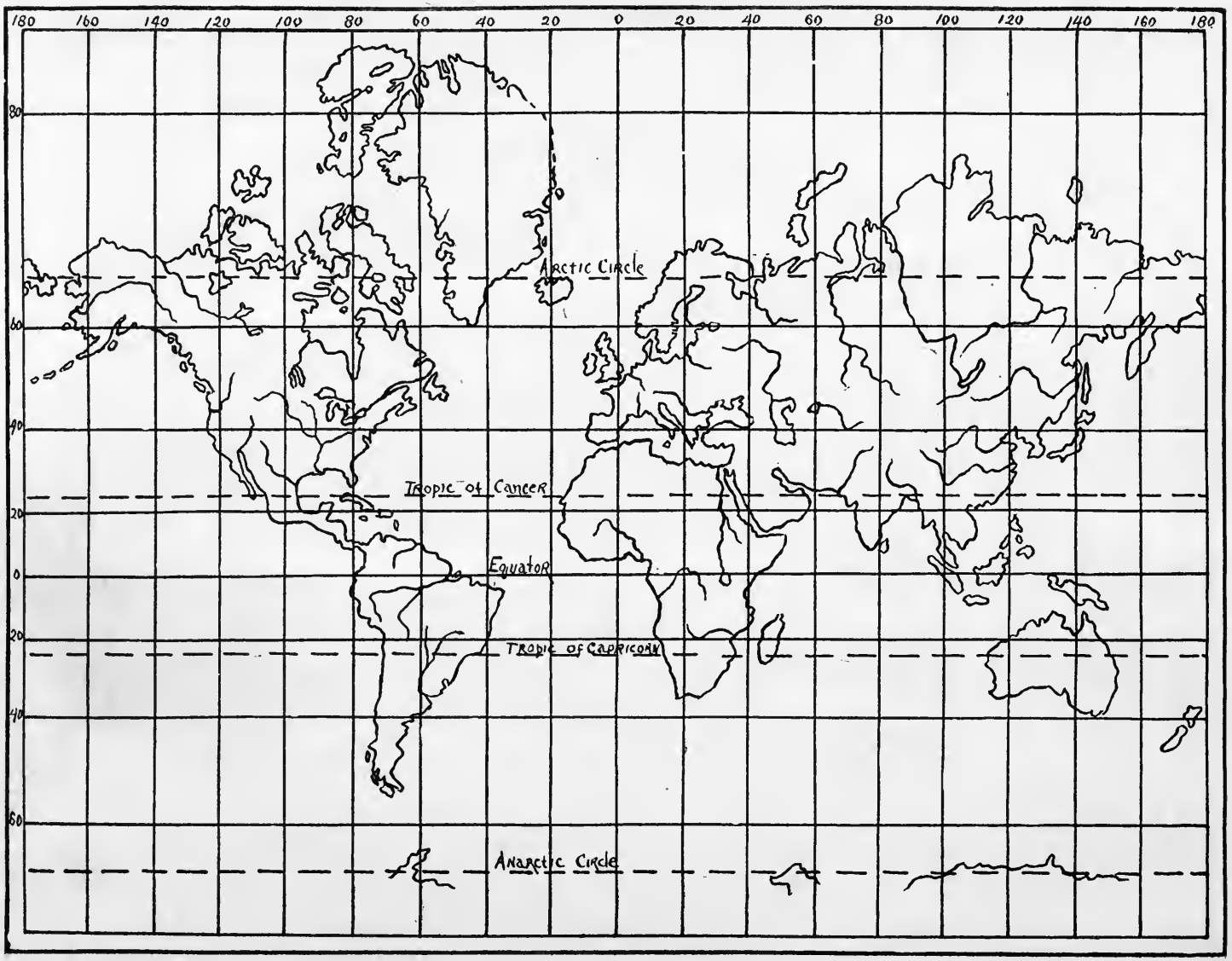
Which places would be likely to use two kinds of time?

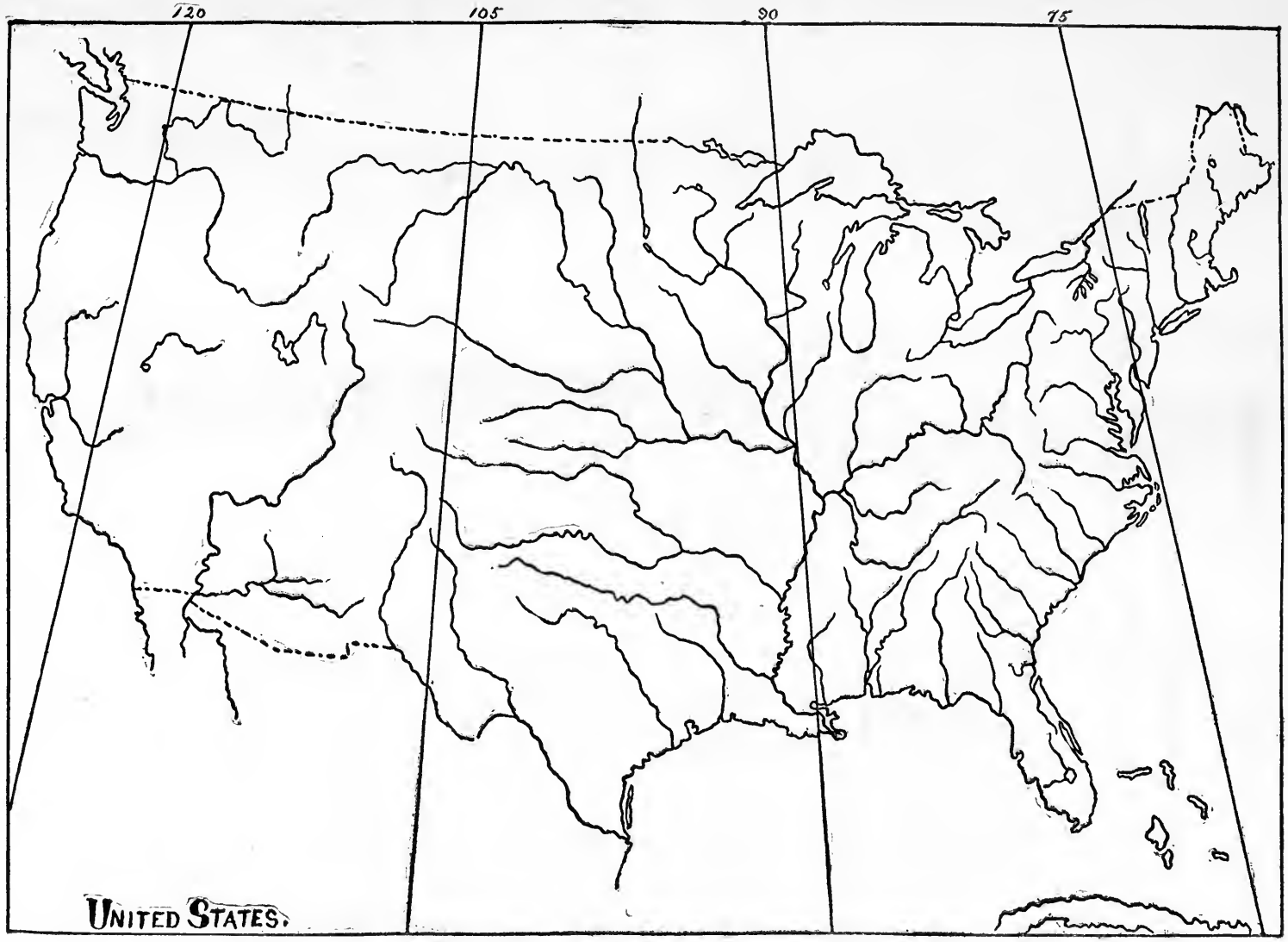
Is the time of your own home slow or fast of your belt time?

How much?

Which section of the United States passes from Central to Pacific time? Why is this?

Explain any other marked irregularities that you find on your map.


180 160 140 120 100 80 60 40 20 0 20 40 60 80 100 120 140 160 180
80
60
40
20
0
20
40
60
Arctic Circle
Tropic of Cancer
Equator
Tropic of Capricorn
Antarctic Circle


120
105
90
75
UNITED STATES.

9 — The Seasons

Purpose — To study the seasonal changes.

Materials — Small globe, a hoop of pasteboard just large enough to slip over the globe, compass, ruler, pencil.

Study the apparent path of the sun through the heavens.

At what season of the year is the sun highest at noon where you live?
At what season is it lowest?
Where does the sun rise?
Does it always rise at just the same place?
When are the days longest? About how long?
When are the nights longest? About how long?
Is the sun high at noon when the days are short?
At what times in the year does the sun rise directly in the east and set directly in the west?

Hold the globe up even with your eyes with the axis inclined 23½ degrees to the right hand. Place the pasteboard hoop over the globe level with the eyes.

What part of the globe is directly in front of your eyes?
Can you see both the north and the south poles?

Pass the globe to the left, keeping it at the same level and having its axis point in the same direction. Move it one-fourth way around your head.

Which part of the globe is opposite your eyes?
Can you see beyond the north pole?
Can you see the south pole?

Pass the globe one-half way around your head keeping the axis in the same direction.

Which part of the globe is opposite your eyes now?
Can you see each pole?

Pass the globe three-quarters way around your head letting the axis point in the same direction.

Describe its position relative to your eyes.

What is revolution?

What is inclination?

What is parallelism?

The hoop about your globe represents the plane of the earth's orbit. (It is also the plane along which the vertical rays of the sun pass to the earth.)

Trace the line printed upon your globe to represent this plane.
What is this line called?
How much is the axis of the earth inclined to this plane?
What is the measurement of the angle between this plane and the equator?
How far beyond the poles does the circle of illumination ever pass?
What determines the distance of the tropical circles from the equator?
What determines the distance of the polar circles from the poles?

With the north pole of the globe pointed toward you and the Tropic of Cancer at the level of your eyes, rotate it slowly.

Describe the day and night of the north pole.
Of the south pole. Of the 60th parallel of latitude.
What season is it in the northern hemisphere?
In the southern hemisphere?

Briefly describe the seasonal changes due to the change in the sun's position.

With a radius of 1¼ inches describe a circle to represent the path of the earth about the sun. At the four quarters of this circle represent the earth by smaller circles. Indicate the north pole in each of these smaller circles as it would be located for each of the seasons. Color that part of the earth dark which does not receive any sunlight. Name each of the four positions.

10 — Magnetism

Purpose — To study the magnetism of the earth.

Materials — Bar magnet, compass needle, some pins, pencil.

Place several pins upon your desk: hold the end of the bar magnet close to the pins. What occurs?

Use the other end of your magnet and describe what happens.

Place the north end of your magnet next to the north end of your compass needle. Describe the movement that takes place.

Reverse your bar magnet. What occurs?

Place the south end of your bar magnet below the north end of your needle. How does the compass needle move?

Swing the compass needle. Where does it stop?

Why does this show that the earth is probably a magnet?

Which end of the compass needle points toward the north?

Which end of the earth's magnet must be at the north?

Locate the north magnetic pole.

Is this a point or an area?

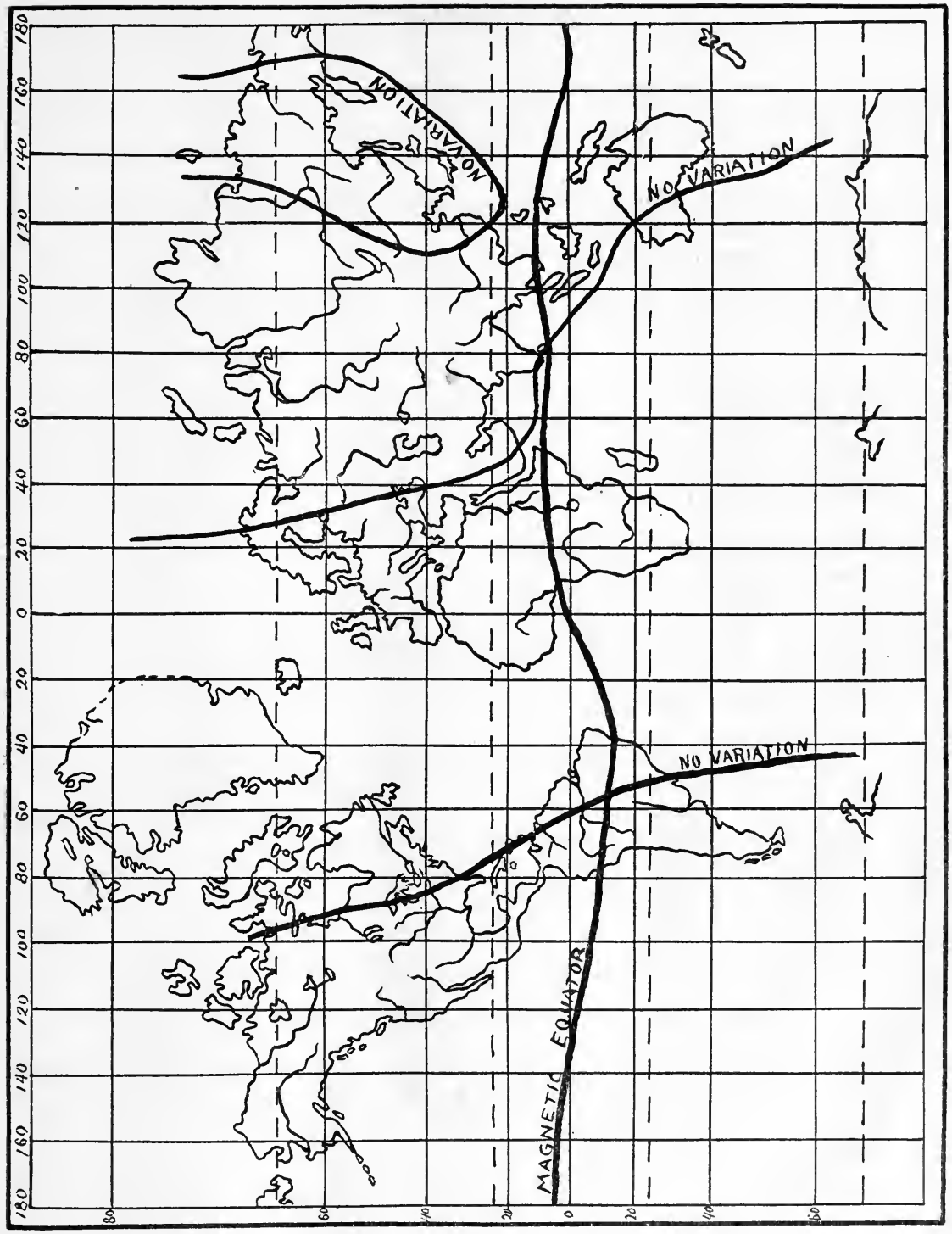
What happens to the compass needle as it approaches the north magnetic pole?

Does the compass needle ever point to the true north?

What are agonic lines?
Trace the agonic lines on the accompanying map.

What is magnetic declination?
What are isogonic lines?
In what general direction do they extend?
Draw the 10, 30, and 60 isogonic lines.

What are isoclinic lines?
In what general direction do they extend?
Draw the 20, 50, and 70 isoclinic lines.


NO VARIATION
NO VARIATION
NO VARIATION
MAGNETIC EQUATOR

11 — Globular Maps

Purpose — To represent the curved surface of a hemisphere.

Materials — Small globe, compass, pencil, ruler.

Place your globe in the sunlight and allow its shadow to fall against a white upright surface.

What is the shape of the globe?
What is the shape of the shadow?
How many dimensions has the globe? The shadow?
Sketch a picture of this shadow.

What is projection?
What kind of a figure is the projection of a sphere?
How is it foreshortened?
Is its outline true to shape?
Where will its dimensions be correct?

Move the globe farther from the upright surface.

How does its shadow vary in size?
Does the shadow vary any in shape?

Move the globe until the shadow's diameter is one half that of the globe.

What is scale?
Why is scale necessary in map-making?

Draw the meridians and parallels upon the accompanying map. Number them by their proper degrees. Place the circles in their right location and name them.

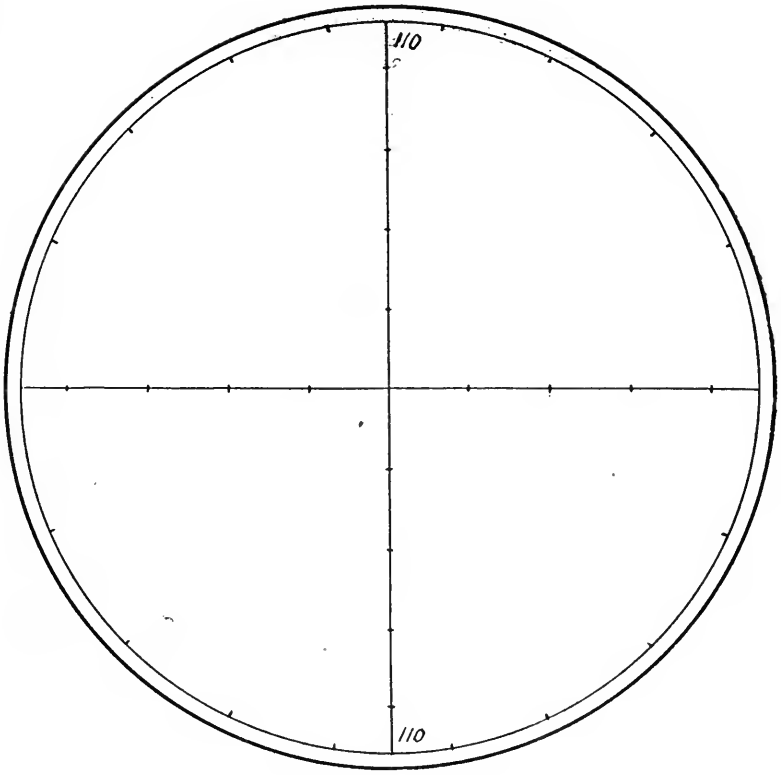
How do these lines compare with the lines on your globe?
Is this drawing a fair projection of your globe?
Are all the degrees of latitude the same length?
Account for this difference.

How does the 110th meridian differ from that of your globe?

Locate by latitude and longitude the following places: (Make a dot where they are to be placed on your map.)
Cape Barrow, St. Johns, Cape Hatteras, Cape Sable, Yucatan, Panama, San Francisco, Alaskan peninsular. Sketch in the outline of North America.
How does this sketch vary from the North America of your globe?
What inaccuracies do you find?

Compare the width of North America at the 60th parallel with its width on your globe.

Globular Projection



12 — Mercator's Map

Purpose — To draw a world projection in which the points of the compass do not shift.

Materials — Small globe, dividers, ruler, pencil.

What kind of angles do the meridians and parallels make upon your globe?
With your dividers measure the distance between meridians at the equator. The 60th parallel. The 90th parallel.
What kind of lines are the north and south lines on your globe?

On your globular map?

What kind of lines are the east and west lines on your globe?

On your globular map?

What kind of a line is the equator?

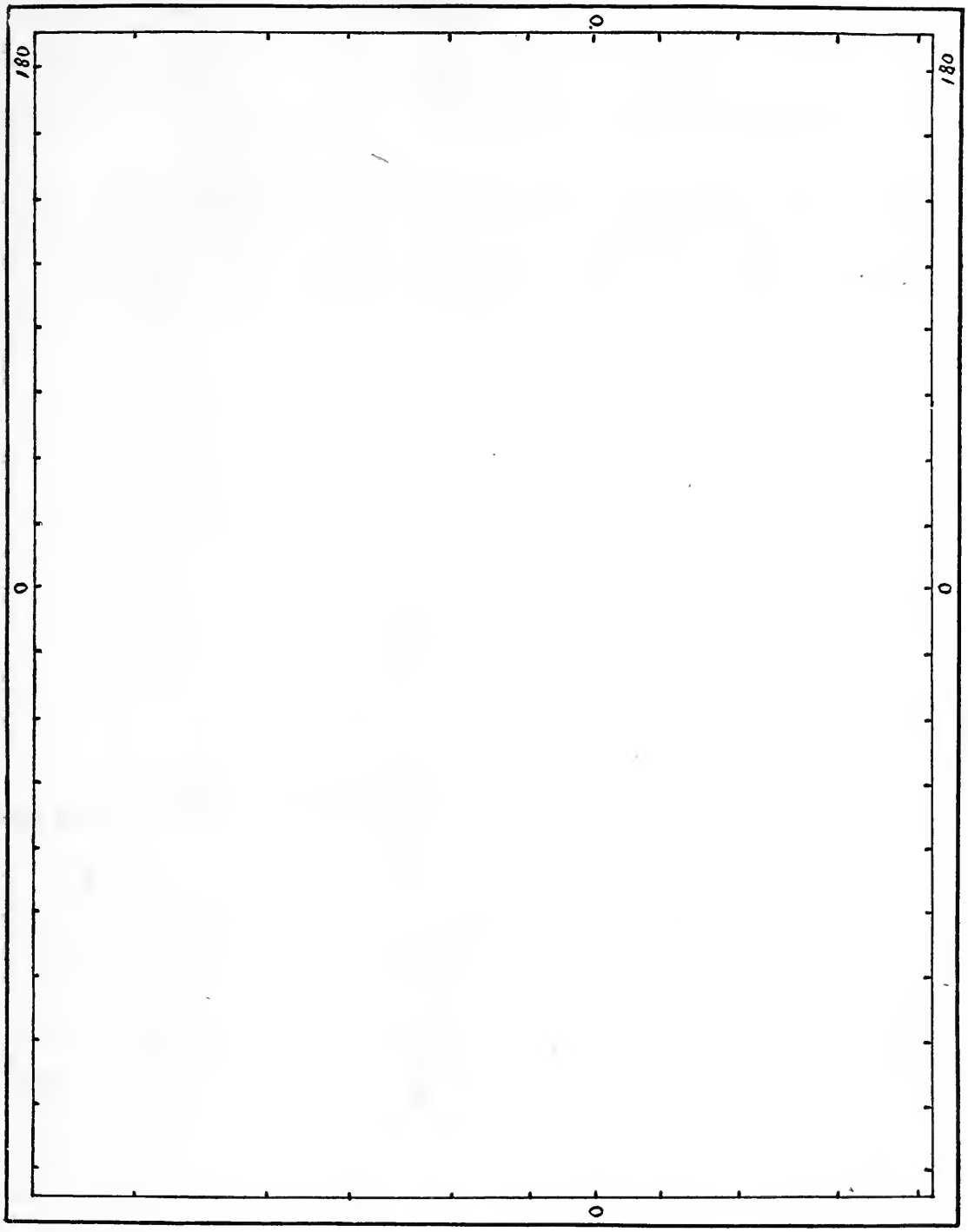
If the meridians are drawn at right angle to the equator on your globular map, will they be at right angle to the other parallels?
Does the length of a degree of longitude vary as we go north?
In what ratio?

Upon the diagram on the next page, draw the parallels and equator as straight lines. (Use the marks on the margins for a guide.)
Do the east and west points of the compass change on this map?
Which side of the map is east? Which is west?

Draw the meridians indicated by the marks on the other margins.
Are these meridians perpendicular to the parallels?
Do the north and south points of the compass change?
Can you get direction by a straight line?
Are the degrees of longitude of the same length?
Do the meridians meet at the poles?
What represented the poles in your globular map?
What is the shape of the north pole in this map?
What distortion has taken place?

Why cannot a scale be given for a Mercator map?

Number the meridians as designated and sketch in North America. Compare this with the North America of your globe.
How **long** have you made your north pole?
Which part of North America is distorted the most?
Is there any north and south distortion?
Of what advantage is a Mercator map?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13 — Contour Maps

Purpose — To express relief features by contour lines.

Materials — Modeling sand, sand board, ruler, pencil.

Fashion the moist sand into hill forms with their attendant valleys. Do not try for irregular formations but make the relief simple.

Draw a flat outline map of your model, indicating the position of the hills and valleys by inserting names. Select your own scale and indicate this on your drawing.

Study your model carefully.

How high is your highest hill?

Note the heights of all the hills in inches.

Dot all points on your map that have an elevation of 1 inch, 2 inches, 3 inches, etc.

Connect with an irregular line all points that have the same height. These are **contour** lines.

What general shape do your hill contours have?

Do contour lines extend up or down a valley?

Where do the contour lines come closest together?

With a scale for elevation of 50 feet to an inch, number the contour lines on your map.

Study some simple formations about your home. Reproduce upon your sand board some simple valley formation found near your home. (A washed-out gully after a shower will do very well.)

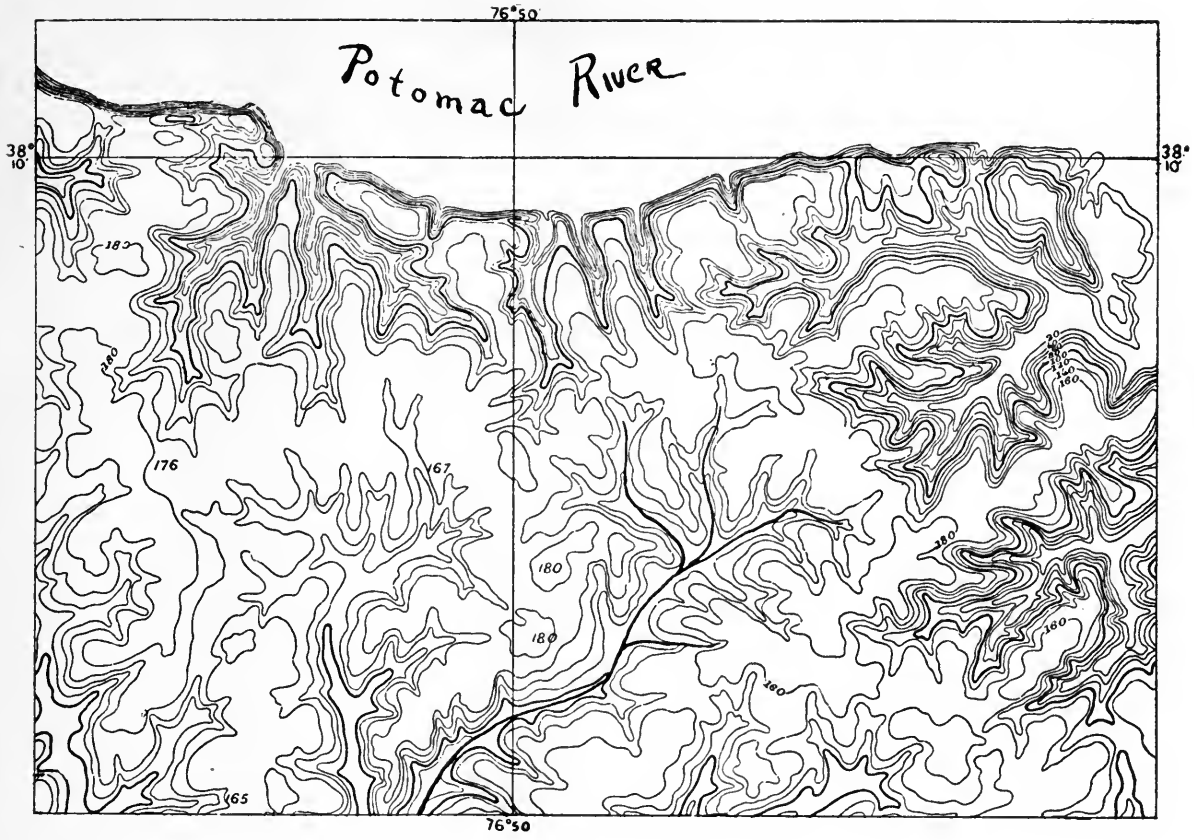
Where is its highest part?

In which direction does the land slope?

Is the slope gradual or sudden?

Find all the points of equal elevation.

Compare altitudes and depressions.



Study the contour lines in the accompanying map.

Which section represents the lowest part of the map?
Why?

Trace out the principal river valleys.
Where are the highest sections?

Where are the level sections?

How high are they?
How far apart are the contour lines?
Is the river in the valley correctly drawn?
What changes would you suggest?

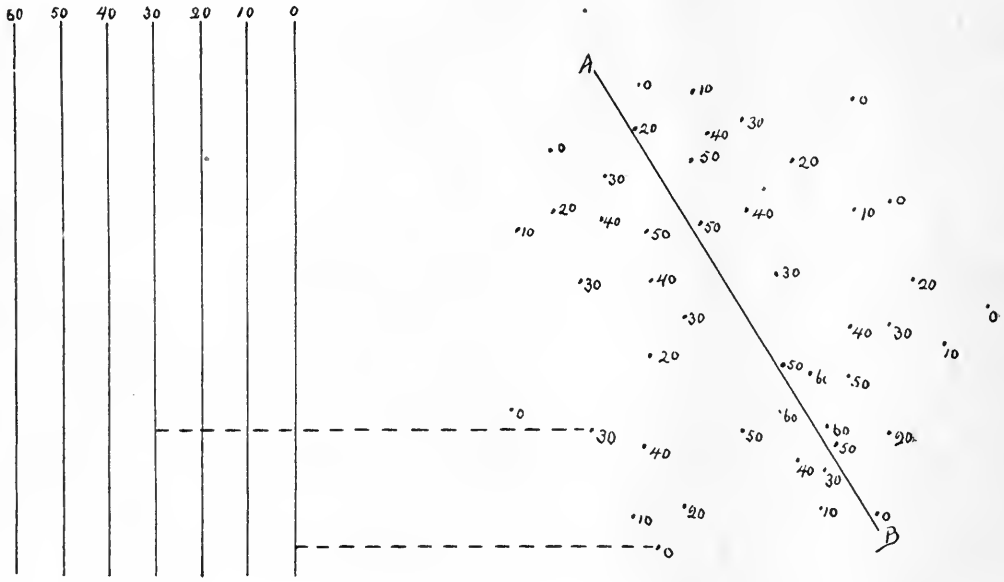
Draw a river in the valley to the west.
What formation do you find in the northeast corner of the map?

Shade lightly with your pencil all sections of the map that represent the Potomac river or its tributaries.

14 — Contour Maps

Purpose — To construct a contour map from given data and to draw a given profile.

Materials — Ruler, pencil.



Scale: 1 mile to 1 inch.

Connect with irregular lines all points having the same altitude.

What is the general shape of the island?
Where are the highest points located?
Draw the river.
Indicate the swamp land.
What is the contour scale?

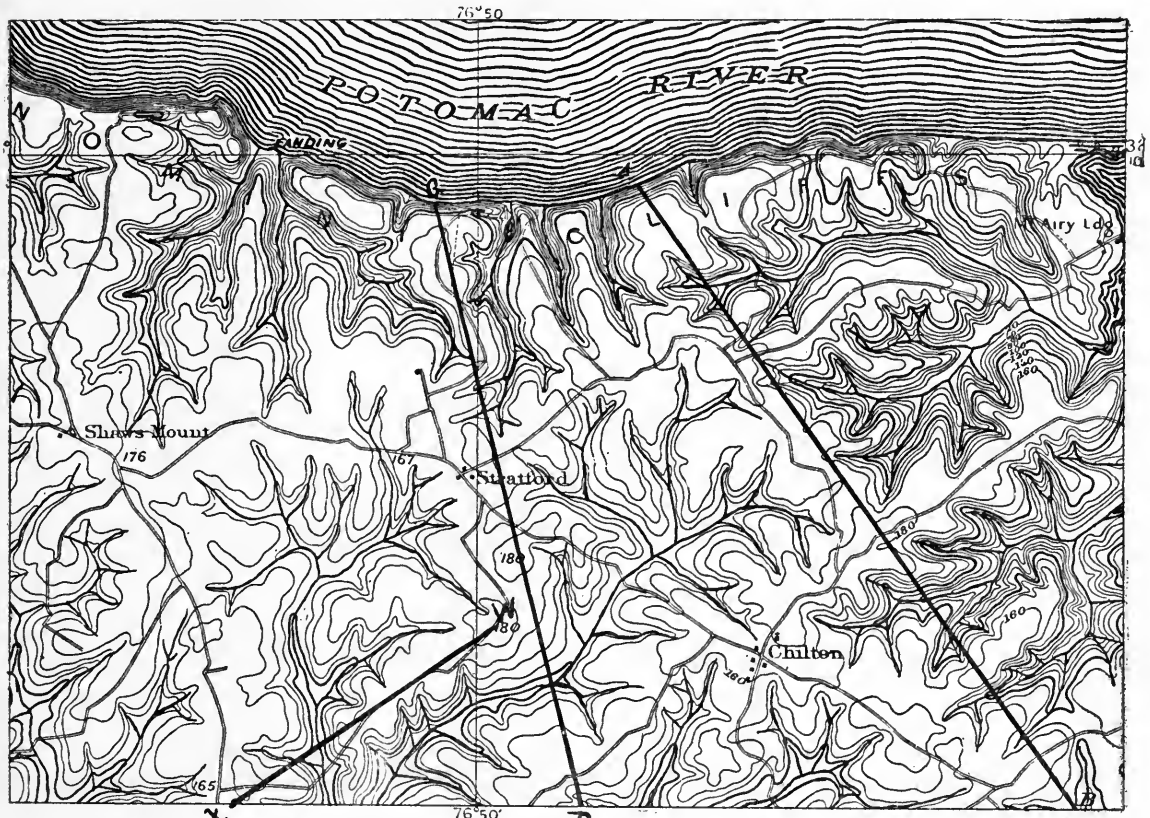
How long is the island?
How far apart are the hills?
How many feet above sea level?

How high is the source of the river?
How much is its fall?

Describe the general features of the island.

To draw a profile along the line AB.

Wherever contour lines cross the line AB draw dotted lines (two of them are shown in the diagram) to the corresponding elevation lines at the left. Connect the ends of the dotted lines where they meet the elevation lines. This will give the required profile.



B. CONTOURS, DRAINAGE, AND CULTURE: PART OF MONTROSS (VA.-MD.) SHEET

Study the profiles along the lines AB and CD. Compare their irregularities and note their differences. Construct a profile along the line WX.

15 — Groundwater

Purpose — To study the solvent effect of groundwater.

Materials — Lime water, some fragments of limestone or marble, granite, hydrochloric acid (HCl), test tube, straw, Bristol (Va.) topographic sheet.

Place some small pieces of the limestone or marble in the test tube and cover them with water. Add a little dilute HCl. Describe what takes place.

Add more acid.

Does the HCl entirely dissolve the limestone?
What will the residue be (if there is any)?
What color is the liquid?

Place some small pieces of the granite in the test tube, and repeat the above experiment. Describe the results.

Place some limewater in the test tube. With a straw, blow through the limewater. What takes place?

Continue to blow into the limewater. Describe what happens when an excess of CO_2 from the breath is introduced.

Will pure water dissolve limestone?
Will HCl dissolve limestone?
Will an excess of CO_2 dissolve limestone?

How are caves formed?

In what kind of soil will caves be found?

What chemical compounds does the groundwater contain?

Bristol (Va.) topographic sheet.

Locate the two sink belts in the contour map. Study their location in regard to other topographic features.

In what direction do these belts run?
Describe their general formation.

About how many sinks are there in each belt?
Where is this area located in your United States map?

Are there other sink areas near this?

Why should these sink holes be located at this place?

Where are the out-cropping hard layers?
Why have these layers resisted erosion?

Mark with an X the highest elevations and trace with a pencil the principal drainage areas.

Describe briefly the topography of this section.

16 — Springs and Wells

Purpose — To study spring and well formation.

Materials — Pencil and note book.

Field work — Visit some spring near your home. Study its location, topography of the surrounding land, kind of soil, and the quality of its water. Is the spring intermittant? Is the water cool or warm? Does the water come from some nearby source? Write a good account of your trip, embodying answers to these questions.

Watch the digging of a well.

How is a well constructed?

How deep are the wells about your home?

How high does the water rise in the well you are studying?

What does this prove?

When is the water in the well low?

What is the source of this well-water?

Explain an artesian well.

17 — Water Erosion

Purpose — To study water erosion.

Materials — Pencil, note book, Gallatin and Canyon (Wyo.) topographic sheets.

Study the effects of running water upon the soil. (The school yard after a heavy rain storm furnishes an effective area for study.) Measure the depths of the gullies made by the running water and compute their areas. Study the erosive effects of some nearby stream or river. Map a given area, showing the main channels and their tributaries.

Write a short account of the effects of water erosion.

Topographic sheets.

Outline the various drainage areas.
Describe evidences you find of erosion.

Where has erosion occurred the most?
Note the altitude of the Yellowstone river's bank.
What is the fall of Broad creek as shown by your map?
Locate the marshes and give their altitude.
Describe the Carnelian creek drainage basin.

18 — River Profiles

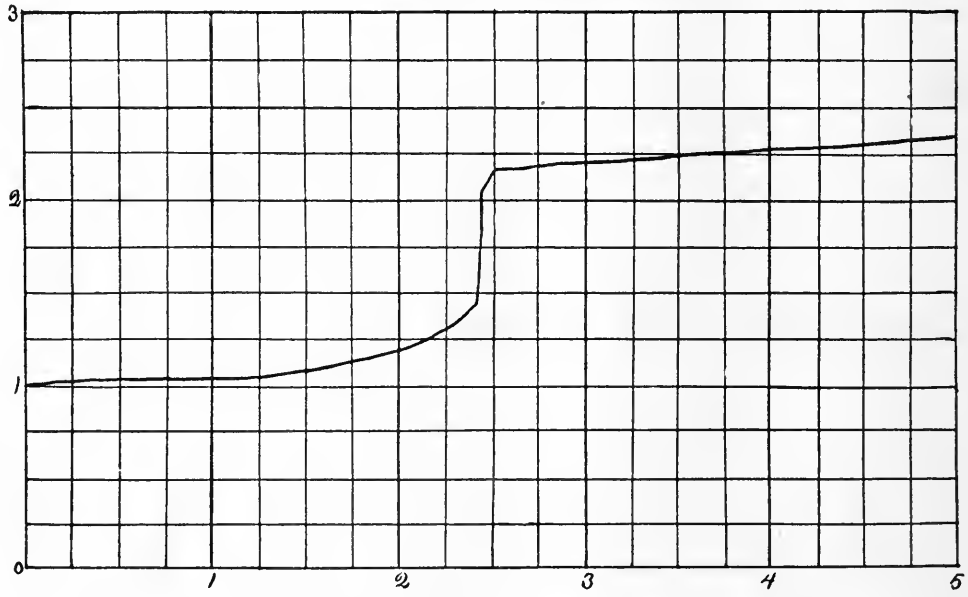
Purpose — To map the profiles of rivers.

Materials — Cross-section paper, pencil.

Example.

Niagara river.	Miles from mouth.	Feet above sea.
Mouth	0	250
Escarpment	7	270
Whirlpool	11	300
Below falls	14	360
Above falls	14	520
Head of rapids	15	550
Lake Erie	30	570

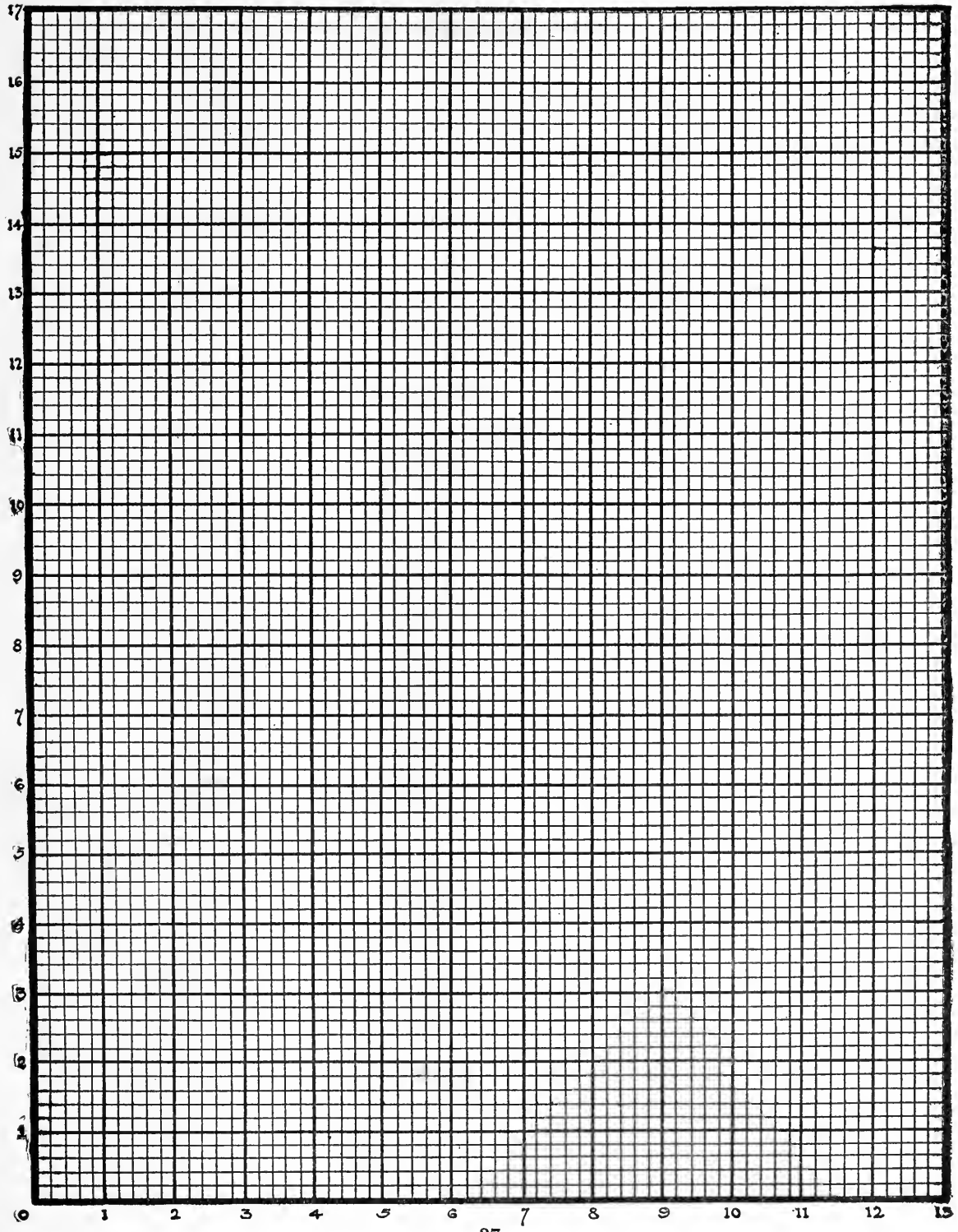
Vertical scale—250 feet to 1 in. Horizontal scale—6 miles to 1 in.



Upon cross-section paper construct profiles of the following rivers:

Mississippi river.	Miles from mouth.	Feet above sea level.
Mouth	0	0
Vicksburg	487	48
Mouth of Ohio river	1,090	275
" " Missouri	1,290	395
LaCrosse	1,790	630
St. Paul	1,937	685
Lake Itasca	2,295	1,460
Arkansas river.		
Mouth	690	115
Wichita	1,380	1,225
Pueblo	1,885	4,700
Source	1,980	6,500

Vertical scale—500 ft. to each numbered square. Horizontal scale—200 miles to each numbered square.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19 — Transportation

Purpose — To study transportation processes.

Materials — Note book, pencil.

Field work — Visit a small stream near your home where the process of erosion is active. Examine the stream carefully.

Is it carrying any sediment?
Where did the stream get this sediment?
Describe the kind of sediment the stream is carrying.

How large are the largest soil particles that are being carried?
Would larger streams carry larger particles?
Is there any material held in solution in the stream?
What color is the stream?

Is the stream deepening its course?
What is "headwater erosion"?

Is the main stream straight?
What is a meandering stream?

What causes the stream to meander?

How does the shape of a stream's bed vary with its age?

What are tributary streams?

Do they carry sediment?
What becomes of the sediment carried by a stream?

Can you find any of it left along the banks?
What does sediment left at these places form?
Are these bars permanent?

Is the direction of the stream's course changed by these bars?

Will a shallow stream carry much sediment?

What kinds of streams will carry larger rocks and stones?

20 — Alluvial Fans

Purpose — To study alluvial fans.

Materials — Cucamonga (Cal.) topographic sheet.

In a few brief words describe the topography of this section.

Locate this region upon a United States map.

What are its genèral climatic conditions?

About what is its rainfall?

What mountains are represented at the northern part of the map?

Have these mountains been more or less eroded?
What shows this?
In what direction does the plain slope?
How much is the fall of the plain as shown on your map?

Trace out the principal streams and describe their drainage basins.

In what direction do these streams run?
Where do they rise?

Trace the boundaries of the San Antonio fan.

How many other fans do you find.
How do the contour lines bend around these fans?
Explain why they should do this.

What form do the rivers take after they reach the highest point of the fans?

What name would you give to this form?

From what places did the material for these cones come?

What is the average slope of the San Antonio fan for the first five miles of its course?

What is the area of this fan (approximately)?

What kind of sediment composes these fans?

What conditions will arise when the mountain streams become swollen with the spring floods?

Where are the roadways?

In what direction does the railroad extend?

Are there any human habitations on the fans?

Where are the cities and towns located?

Field work — Study the alluvial fan formations found in the school yard after a hard rain. Compare with the map formations.

Sketch a map of the yard formation.

21 — Flood Plains

Purpose — To study the construction of a flood plain.

Materials — Donaldsonville (La.) topographic sheet.

Locate this area upon the United States map.

What is the scale of the contour map? Of the United States map?

What is the contour interval?

Which part of the Mississippi river does this contour map represent?

Make a cross section from Bayou Verrette to the swamp on the other side of the river. Indicate the scale used.

Where are the highest points of the plain?

Are these natural or artificial?

Describe a levee.

Trace the drainage areas tributary to the Mississippi.

How do they vary in size?

In which directions do they extend?

Are these areas level or uneven?

Why are there so many swamps?

Where are the roadways?

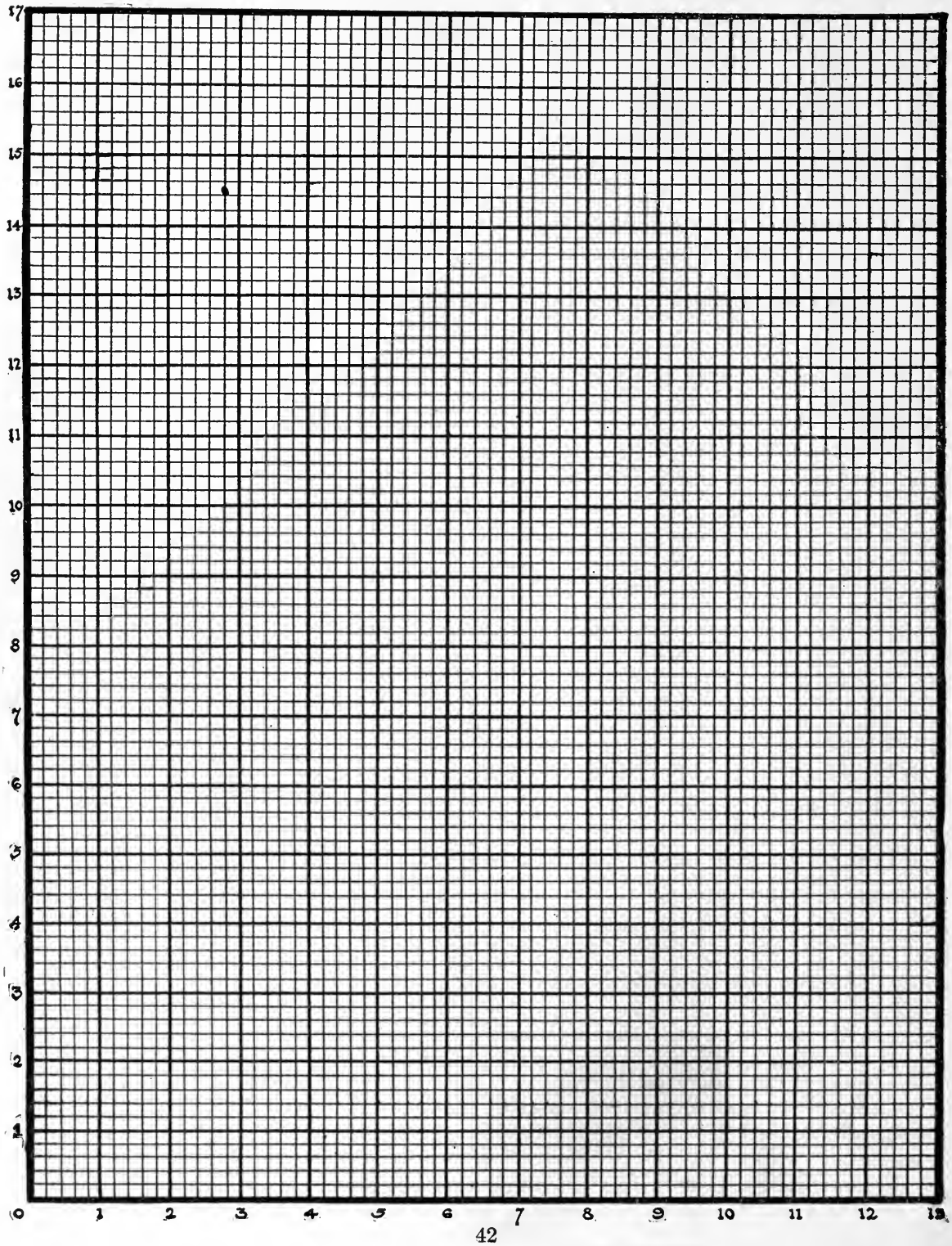
Explain the causes that led to their location.

Of what use are flood plains to man?

Where are the human habitations located?

Is this a healthful region?

Describe the bed of the Mississippi river.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22 — Deltas

Purpose — To study delta formation.

Materials — Mississippi river delta, Coast survey chart, Tacoma (Wash.) folio.

Mississippi river delta.

Locate this section upon the United States map.
How does this delta map vary from the contour charts?

What do the numbers signify?

What is the scale of this map?
Trace the course of the Mississippi river.
Compare this part of the Mississippi with other parts of the river as shown in the United States map and explain any differences you may see.

How many main distributaries has the Mississippi river?
What form do they take?
Why does a river need distributaries?

Show this need from your United States map.

Trace all the smaller streams running from the Mississippi to the Gulf.

Where is new land being formed?

Describe the formation of the Chandeleur islands.

How have these islands influenced the shape of the land?

What is the depth of the water inside these islands?
Why is it difficult for ships to enter the Mississippi?

Why is New Orleans the only large city in this section?

What will be the nature of the land about this river?

Compare the delta of the Mississippi with that of the Amazon, the Nile and the Ganges.

Tacoma (Wash.) folio.

What is the contour interval of this map?
Trace the two smaller valleys and study their general formation.
How much wider are they than their rivers?
In what direction do they extend?
How long is the main valley? How wide?
Where is the present delta?

Describe its shape?

What kind of land forms this delta?

Where do you find other evidences of swamps?

Are there any distributaries?
Describe them.

Where are the alluvial plains?

What kind of a river is the main stream?

Where are the cities located?

Why?

Describe the location of the railroads.

What kind of a harbor has Tacoma?

How much difference in elevation is there between the valley and the cliff opposite McMillan?

23 — Youthful Area

Purpose — To study the erosive action of a young stream.

Materials — Oak Orchard (N. Y.) topographic sheet.

Locate this area on your United States map.

What lake is at the north?
In what general direction does the land slope?
Is this slope regular or irregular?
What is the difference in elevation between East Gaines and Point Breeze?
Are the rivers large?
Are they swift or slow flowing? Why?
How deep is the bed of Oak Orchard creek?
What future changes are likely to occur in its banks?

Where do you find swamp areas?

Why are there no lakes or ponds?

How far apart are the heavy contour lines?
Where is the greatest fall in Oak Orchard creek?

In what directions do the roadways run?
Why are they not more irregular?

What would be the industries of the inhabitants of this area?

24 — Mature Area

Purpose — To study the erosive action of a mature stream.

Materials — Charleston (W. Va.) topographic sheet.

Compare this sheet with the one studied above.

What differences do you note in the drainage areas?
What evidences do you find of extensive erosive action?

Was this area once like the area in the former sheet?
What evidences do you find to prove this?

What kind of a plain has the Kanawha?

Where is this river eroding its bluffs?

Why do we term the rivers of this section mature rivers?

Where are the cities and roadways located?

Compare these roads with those on the previous map.
Where are the railroads located? Why?

Would the industries of the inhabitants of this area be such as those of the people living in the section represented by the Oak Orchard sheet?

What would be the industries of this section?

25 — An Old Age Area

Purpose — To study the erosive action of an old stream.

Materials — Princeton (Ind. - Ill.) topographic sheet.

Compare this sheet with the two just studied.
How does this differ in topography?

How do the rivers differ from those shown in the other areas?

Where do you find the greatest elevations?
Explain the presence of the Claypole and Gordon hills.

What evidences do you find that this plain once contained much swamp land?

Explain the origin of the "cut offs."

What evidences do you find of irrigation?
What is the prevailing industry in this area?
Why are there no large cities in this section?

Compare the roadways with those of the two maps just studied.

26 — Water Gaps

Purpose — To study the formation of water gaps.

Materials — Harrisburg (Penn.) topographic sheet.

What is the scale of this contour map?
What is the contour interval?
Locate this area upon the United States map.

What mountain system crosses this section?
How do the mountain ranges run?
Is this arrangement characteristic of the whole system?
Find the three elevation areas and give their altitudes.

Trace the boundaries of the flat river valley.
Upon which side of the river is this valley the broader?
Where does this valley plain entirely disappear?

How many water and wind gaps do you find in this section?
Where is the first water gap of the Susquehanna river?

How wide is it?
Where is the second gap?
How wide is it?
Where are the largest tributaries to be found? Why?

Why is the Conodoguinet creek so meandering in its course?

Is this section composed of hard or soft rock?

Has the Susquehanna river carried much sediment?
What formations show this?

Account for the presence and formation of the islands.

Where are the towns located?

Upon which bank will you find the larger towns? Why?

Explain the presence of the railroad bridge opposite Fort Hunter.

Would this be a good agricultural section?
Give reasons for your answer.

27 — Streams in Arid Climates

Purpose — To study stream formation in an arid climate.

Materials — Sevier Desert (Utah), Camp Mohave topographic sheets.

Sevier Desert sheet.

What is the scale of this map?
What is the contour interval?
Why is this so large?

Locate this area upon your United States map.
What is the average annual rainfall of this section?
Why does it receive so little rain?

What mountains surround this area?
What and where is the greatest elevation?

What is the average altitude of the Sevier desert?
Where is the canyon of the Sevier river?

Are the drainage areas well developed?

How many lakes do you find in this section?
What are their sizes?
Where do they get their water?

Describe Spring lake and its outlet.

Why are there no inlets?

Where does Spring lake get its water?
What becomes of the outlets of Spring lake?

In which direction does Oak creek run?
What is the height of its source?
What supplies it with water?
At what elevation does it disappear?
In which direction does Cherry creek run?
Which part of Cataract creek is dry part of the year?

Describe the Round valley drainage system.

Camp Mohave sheet.

Compare the contour irregularities of this sheet with those of the Sevier desert sheet.
Which has the more irregular contour? Why?
Which has the higher elevations?
Which has the greater plains?

What is the annual rainfall for this section?
What mountains are in this area?
Are they regular or irregular in contour?

In which direction does the Colorado river flow?
What is the nature of its channel?

Are there any tributary drainage systems?
Why?

Account for the presence of so many wells and springs in this section.

Why are there no rivers or creeks of any size?

Trace the course of the short stream from the springs on the side of Mt. Perkins.
What becomes of this stream?
How long is it?
How much is its fall?

Why are there no tributary streams in the defiles just west of the Colorado river?

Account for the hot spring near Mt. Wilson.

In what direction does Meadow creek flow?
Describe the trail from Kingman to Camp Mohave.

28 — A Delta Lake

Purpose — To study the formation of a delta lake.

Materials — Reconnaissance map, Salton Sea, California.

Locate this area upon your United States map and study its topographic conditions.

What do the minus signs mean on this map?

Was this section ever a part of the Gulf of California?

What river formed a delta to cut off the Salton Sea?
How was this done?

Trace the outline of the old Gulf of California.
How much below the level of the Gulf of California is the Salton Sea?
How much higher is the old delta than the Salton Sea?
Where is the mouth of the Colorado river?

What conditions must arise for this river to drain into the Salton Sea?

Did this ever occur?

Is the Salton Sea fresh or salt? Why?

What kind of land forms the barrier between the Gulf of California and the Salton Sea?

Is this land fertile? Why?

Why does the water of the Salton Sea keep at approximately the same level?

What supplies this sea with water?

Study the drainage areas about this sea.

29 — Crater Lake

Purpose — To study the formation of a crater lake.

Materials — Geologic map of Mt. Mazama and Crater lake (Ore.).

What is the scale of this map?
What is the contour interval?
What is the greatest elevation you find in this area?
Where is it?

Where do you find a plain formation?

How wide is this lake?
What is its shape?
What is the altitude of its shore line?
How deep is the lake?
Where is the deepest part?

What supplies this lake with water?

Explain the presence of Wizard island.

What keeps the lake from overflowing?

Draw a cross-section of the lake from Fleetwood cove to Eagle cove.

What evidences do you find of erosion?

Is this a region of hard or soft rock? Why?

What sort of drainage areas are found in this section?

30 — Glacial Lakes

Purpose — To study the formation of glacial lakes.

Materials — Lake Geneva (Wis.) topographic sheet.

Locate this area upon your United States map and compare with the surrounding country.

What is the location of the terminal moraine belt?

In what direction does it extend?
Describe its formation.

How high is the moraine southeast of the White river?
Are the drainage areas in this section well developed?

What shows this?

Are the rivers old or young? Why?

Where are the largest swamp areas?

Trace the moraines that make the northern and northeastern shores of Lake Geneva.
Describe the formation and location of Lake Como.

Explain the location of the city at the head of Lake Geneva.

Why are there no lakes along Como creek?

Will Lake Como grow smaller or larger? Why?

What would be the boundaries of Ryan lake if it filled its valley?

31 — Niagara Falls

Purpose — To study the topography of the Niagara Falls.

Materials.— Niagara river and vicinity topographic sheet (1901).

Locate the Niagara river upon your United States map.

How long is this river?

What is its vertical descent?

Between what points is the river navigable?

Between what countries does its main channel form a boundary?

Locate the two plains that the Niagara crosses and study their general formation.

What is the average height of the upper plain?

In what direction does it slope?

What is the average height of the lower plain?

In what direction does it slope?

Locate the Niagara escarpment.

What is its elevation?

Where does the escarpment divide into sections?

What is the height of each section?

Describe the river from Buffalo to Goat island.

Describe the river from the escarpment to Lake Ontario.

Locate the falls of the Niagara.

What is the shape of the Canadian falls?

What is the shape of the American falls?

Which is the larger?
Over which is the river the more actively eroding its bed?

Why?

Where were the falls originally?

How far is it from the escarpment to the present falls?
If the falls recede five feet a year, how long has it taken Niagara to reach its present position?

What part of this river forms the gorge?
Describe it.

Where is the whirlpool?
Describe its shape and formation.

What change happens to the river below Lewiston?

What is its fall from there to Lake Ontario?
Compare this fall to the fall in the gorge. (See profile diagram, lesson 18.)

In what direction do the rivers flow in the lower plain?
In the upper plain?
Are there any evidences of former glacial activities to be found in this section?

Trace the ridge road from Lewiston to Dickersonville.
Along what elevation does this road travel?

Trace the road from Lewiston to Pekin.
Where is it the steepest?
What is the difference in elevation between Lewiston and Pekin?

Tell something of the new industry that is being developed at the Niagara Falls.

32 — Glaciers

Purpose — To study glacial structure.

Materials — Shasta (Cal.) special topographic sheet.

Locate this section upon your United States map.
In what part of California is Mt. Shasta?
How does it compare in size with the other mountains surrounding it?

How high is this mountain?
How many glaciers are there upon the mountain?
Where are they located?

Trace the boundaries of each glacial valley.
Describe the general shape of each glacier.

Why are there no glaciers upon the mountain top? Explain fully.

How far down the mountain side do these ice sheets extend?
What is the elevation of the foot of the southern glacier?
Is this elevation the same for all the glaciers?
Why do not the glaciers extend farther down the valleys?

Describe the terminal moraines.

How are the lateral moraines indicated upon the map?

Are there any other glaciers upon this map beside those on Shasta? Why not?

Trace the drainage areas about Shasta.
Where do the rivers get their water?
Do they rise above or below the moraines? Why?

Do you find evidences of former ice sheets?

33 — Glacial Effects

Purpose — To study the local effects of ice sheets.

Materials — Glacial pebbles and rocks, some soil from a till bank.

Field work — Glacial features should be studied in the field if possible. Photographs and pictures of glaciated areas may be obtained easily for class-room work and should be used wherever outdoor work is impossible.

Illustrate by means of a diagram the method used in determining the movement of a glacier. Explain how glaciers " flow."

Compare the glacial pebbles with those found in a river bed. With those found embedded in the soil.

What are the striæ upon the glaciated rocks?

In what direction does the striæ extend? Why?

Describe a drumlin. A kame. An esker.

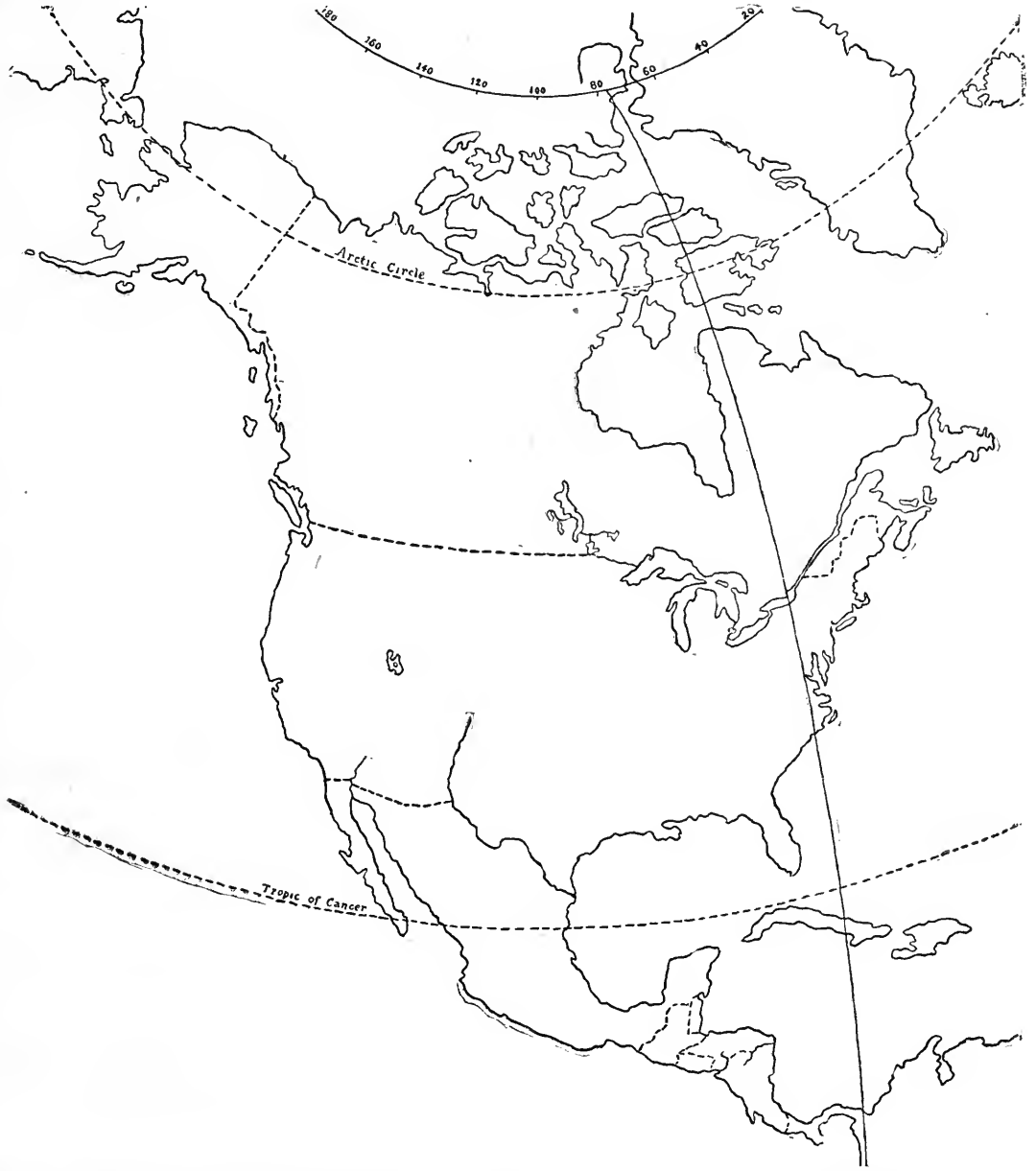
Of what kind of clay is till composed?
Where are till formations found?
Are such formations stratified?
Would water form till? Would wind? Why?

Describe any other glaciated formations found about your home.

34 — Ice Sheets

Purpose — To locate the ice sheet of North America.

Materials — Colored pencils.



Sketch lightly the outline of the ice sheet of North America. Color the sheet green with the colored pencil. Indicate the moraines with a brown pencil.

35 — The Ocean

Purpose — To study the ocean.

Materials — Small globe, colored pencils, ruler, pencil.

Which of the hemispheres of the globe may be called the water hemisphere? Which the land hemisphere?
What proportion of the earth's surface is water?
What proportion is land?
If the water covers 143,259,000 square miles of the earth's surface, how much does the land cover?

On the cross-section paper represent the water area by letting each large square represent 20,000,000 square miles. Color this area blue. With the same scale represent the land area. Color this area brown.

Compare these areas with the land and water areas as shown on your globe.

Upon what parallel of latitude could the earth be circumnavigated by a sailing vessel?
Could the earth be circumnavigated along any meridian?

Upon what meridian could you sail from Iceland to the Antarctic continent.
What kind of a line would represent the shortest distance on your globe between Valparaiso (Chile) and Yokohama (Japan)?

Between Queenstown and New York?

What kind of lines would these be upon the Mercator map?
Draw these lines upon the Mercator map and name the different divisions of the ocean crossed. Place the names of the other parts of the ocean upon this map.
Which of these ocean divisions is the largest?
Which is the smallest?
Which is the most regular in shape?
Which takes the form of the letter S?

With a scale of 1 inch to represent 10,000,000 square miles, draw lines to show the comparative areas of the oceans.

Table of comparative areas. (These figures are approximate areas.)

Pacific ocean	71,000,000	square miles.
Atlantic ocean	34,000,000	" "
Indian ocean	27,000,000	" "
Arctic ocean	7,259,000	" "
Antarctic ocean	4,000,000	" "

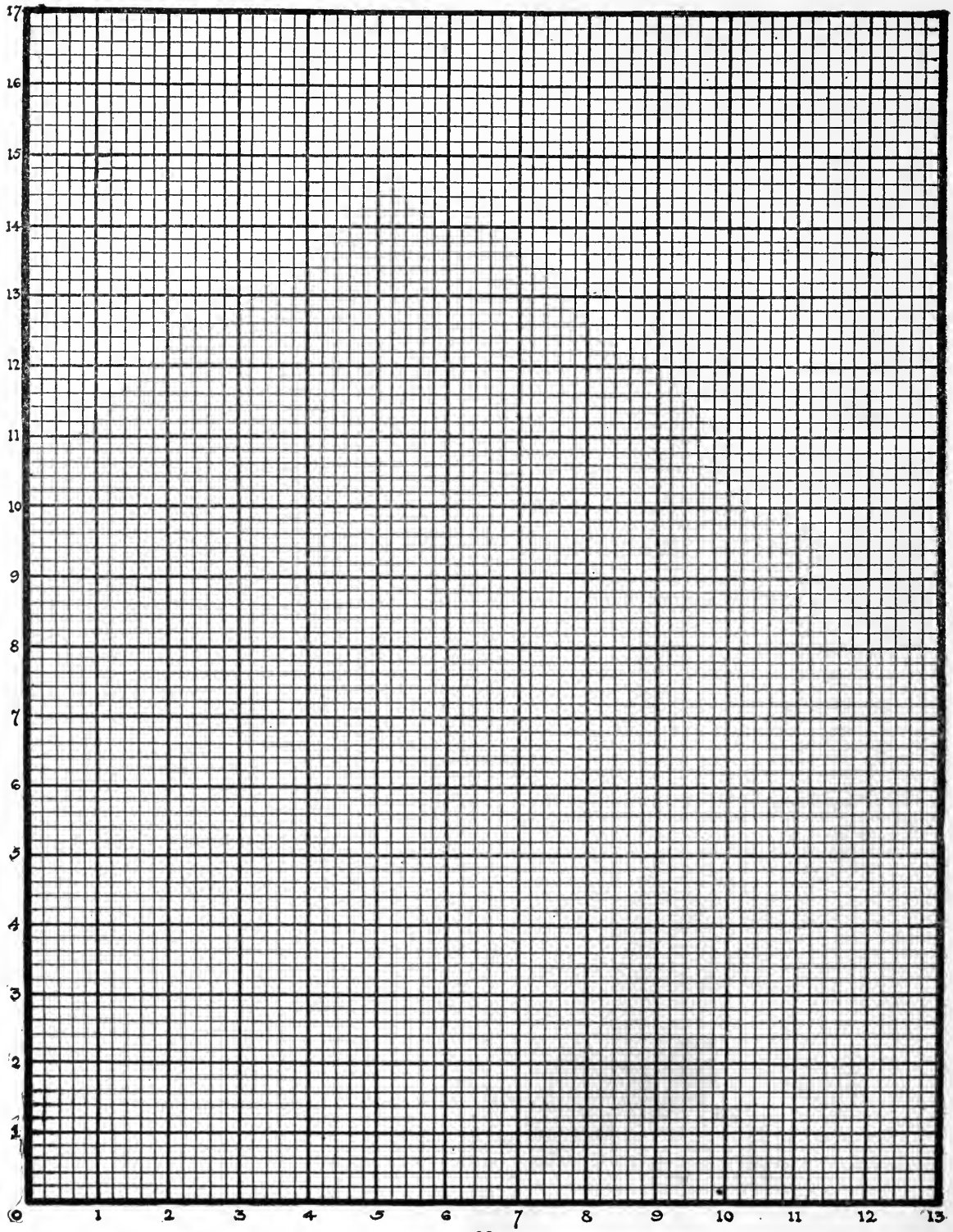
On the cross-section paper construct a profile of the North Atlantic ocean from the following table. (Taken along the 40th parallel.)

Distance from American shore. Miles.	Depth of water. Feet.
0	0
200	650
350	6,500
900	20,000
1,100	21,000
2,125	13,000
2,500	6,500
3,000	15,000
3,350	6,500
3,425	660
3,500	0

Indicate upon this profile the two continental shelves and the mid-Atlantic ridge.

Construct a profile of the continental shelf east from Atlantic City, New Jersey.

Distance from the American shore. Miles.	Depth of water. Feet.
0	0
20	15
30	25
40	20
60	40
75	100
85	500
90	1,000
100	1,300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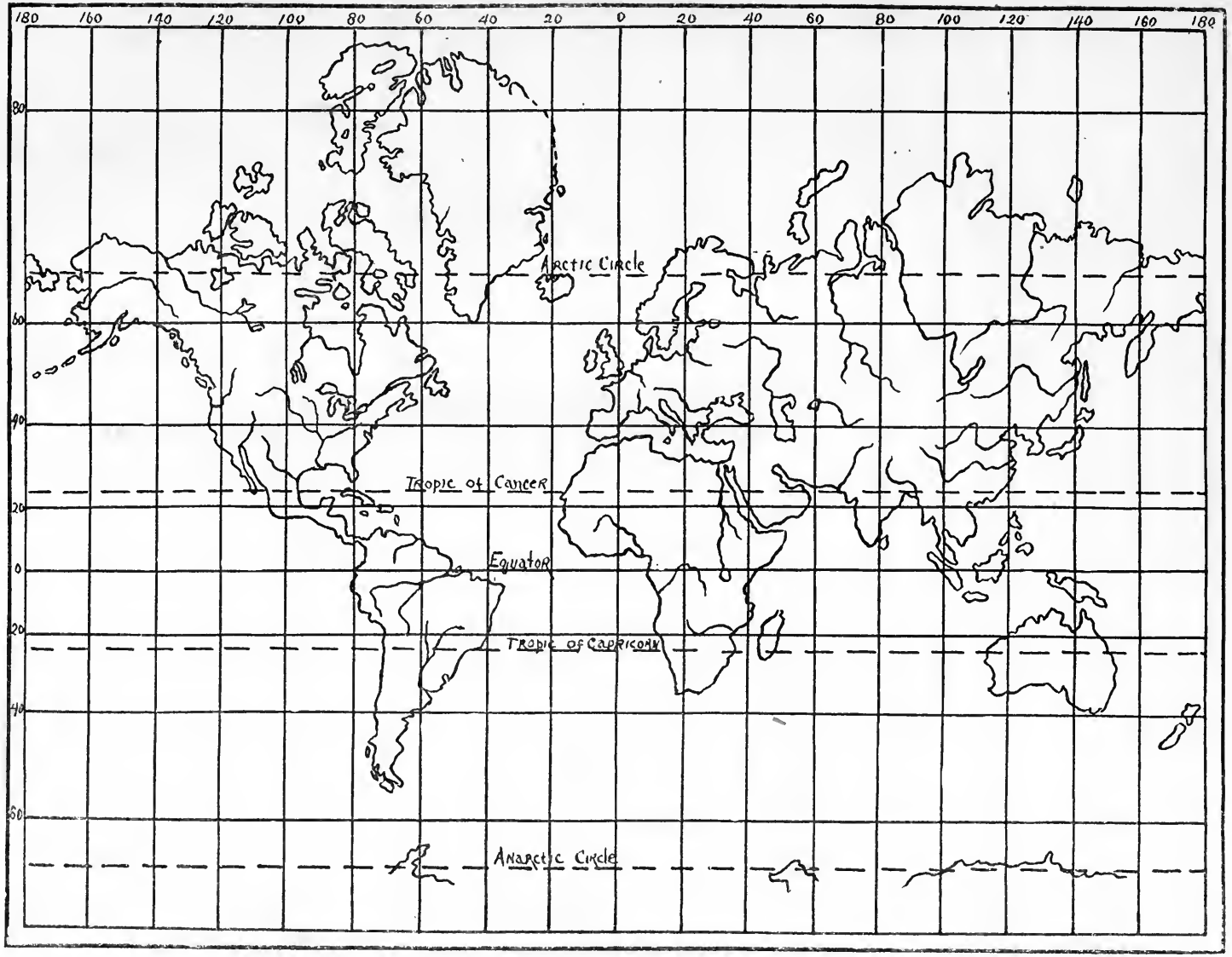
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Arctic Circle
Tropic of Cancer
Equator
Tropic of Capricorn
Antarctic Circle

36— Composition of Sea Water

Purpose — To study the composition of sea water.

Materials — Fresh water, some sea water, scales, compass, ruler, pencil.

Note — If sea water cannot be obtained, a fairly good substitute may be made by dissolving 1¾ lbs. of salt in 50 lbs. of water. But sea water should be obtained if possible.

What difference do you notice in taste between the two waters?

Is the sea water bitter to the taste as well as salty? (If sea water is not obtainable this question cannot be answered.)

What difference is there in unit weight?
What then is the density of salt water?
Which is the more buoyant, salt or fresh water?
Why?

What effect upon the color of the water has the mineral matter in it?

Draw a circle and divide it into segments to represent the proportion of fresh water and of mineral matter in sea water.

From the following table construct a circle and divide it into segments to represent the proportions of the various mineral substances found in sea water.

Sodium chloride	77.758%
Magnesium chloride	10.878%
Magnesium sulfate	4.737%
Calcium sulfate	3.600%
Potassium sulfate	2.465%
Calcium carbonate	.345%
Magnesium bromide	.217%
	100.000

Where does the mineral matter come from that is in sea water?

Where do the rivers get these mineral substances?

Is the water of rivers fresh or salt?
Why do we not taste this salt?

Describe a way whereby we can get salt from sea water.

Where are some of the large deposits of salt found in the United States?

Account in a brief way for the location of these deposits.

37 — Ocean Temperatures

Purpose — To study ocean temperatures.

Materials — Chart to show mean annual surface temperatures of the ocean, ruler, pencil.

What is the mean annual temperature of the equatorial region?

Compare the width of this belt in the Atlantic ocean with that in the Indian ocean. Account for any differences you find.

What causes the Red Sea to be so warm?

Where are the inequalities in the ocean heat belts the greatest, in the northern or southern hemisphere?

Where do you find the lowest annual temperatures recorded?

Compare the annual ranges of temperature between the land and the water. (Select the 40th parallel for this comparison.)

Where would you expect to find the greater extremes? Why?

On the cross-section paper construct a curve showing the decrease of ocean temperature with the increase of depth.

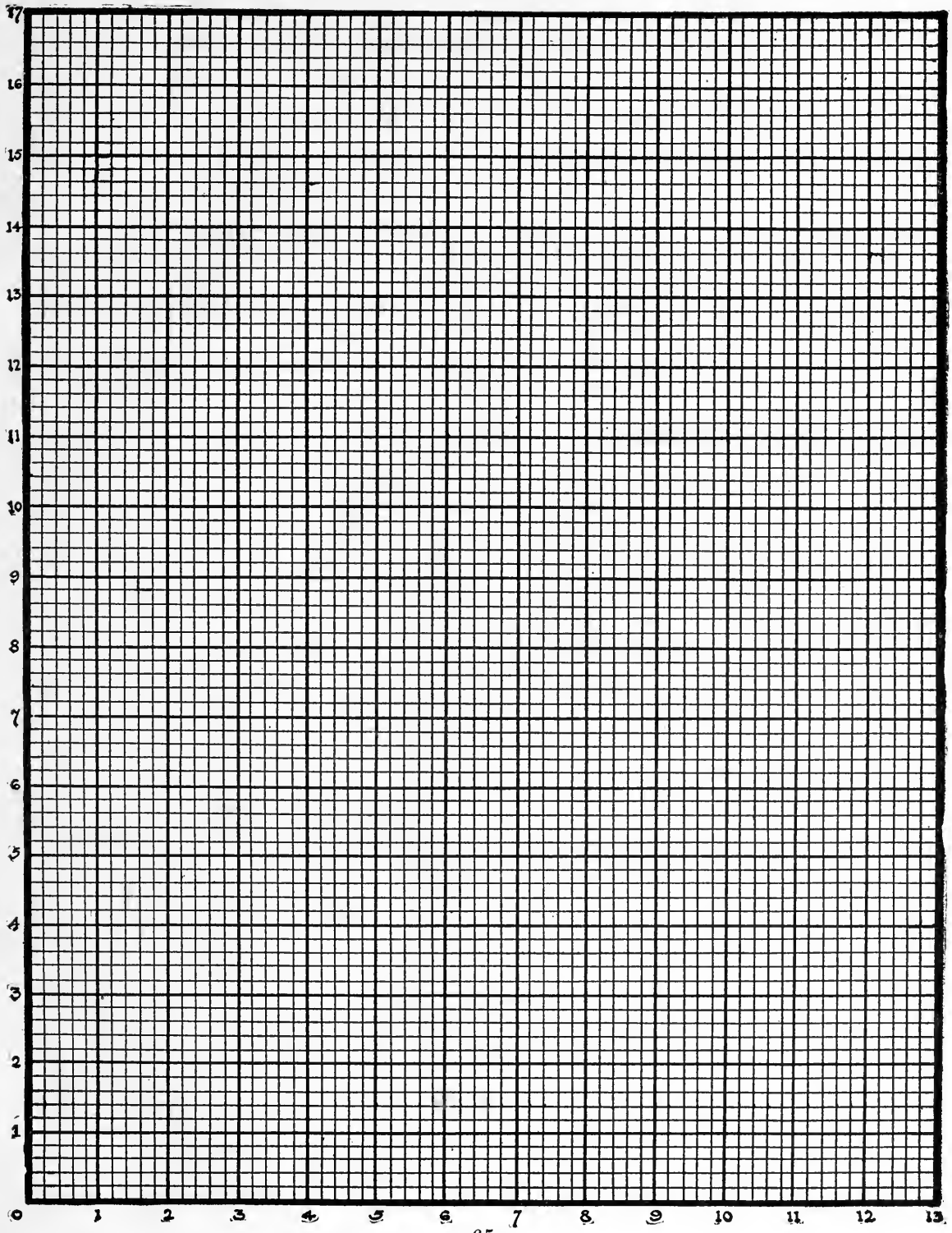
Report of Challenger, 3½ degrees south of the equator:

Surface	78.0	Degrees, F.
270 feet deep	68.0	"
960 " "	50.0	"
1,920 " "	41.0	"
9,000 " "	36.5	"
15,200 " "	33.0	"

Report of Challenger, latitude 42 – 32 S., longitude 56 – 27 W.:

The temperature curve where the ocean water is affected by the Antarctic current. (Locate temperature area.)

Surface	57.0	Degrees, F.
600 feet deep	36.5	"
3,000 " "	35.6	"
6,000 " "	35.0	"
9,000 " "	34.7	"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38 — Ocean Currents

Purpose — To study the location and direction of the ocean currents.

Materials — Colored pencils, wind zone map.

On the Mercator map indicate the equatorial currents with small green colored arrows. (The arrows to point in the direction in which the current flows.) Indicate the Gulf Stream with red arrows and the Canary current with blue arrows.

In the Pacific, indicate the Kuroshiwo with brown arrows and the California current with purple arrows. Write the names of these currents in their proper places.

Do the same with the southern hemisphere currents.

Indicate all Arctic and Antarctic currents in black.

In what general direction do the currents flow along the equator?

What causes the flow of sea water?
Give two factors that influence the direction of flow?

Compare the map you have made with the wind zone map.
What relations do you find between them?

Have coast irregularities the same effect upon wind currents that they have upon the water currents?

Describe the Gulf Stream drift.

What irregularities do you note in the Monsoon drift?

Account for these irregularities.

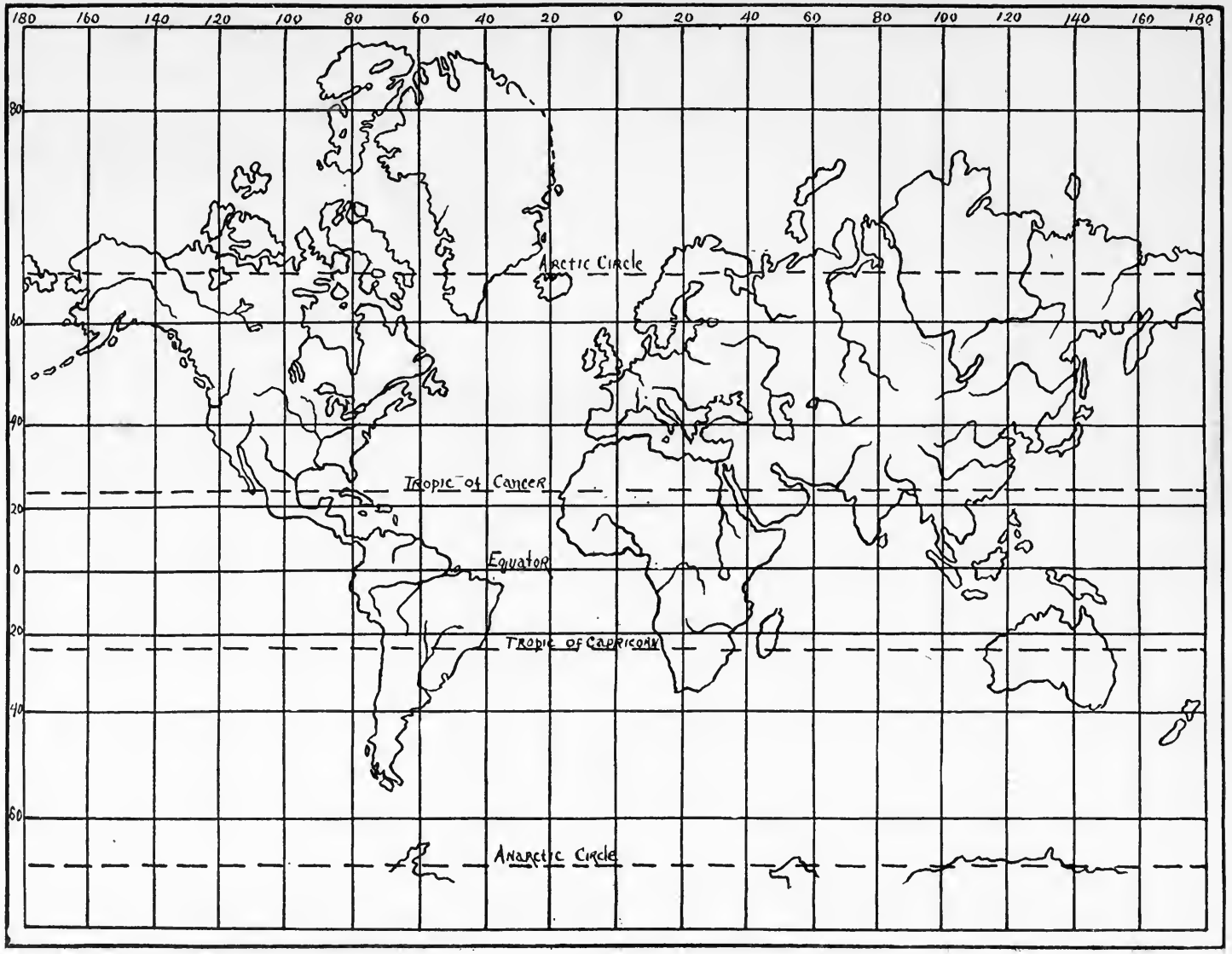
What seasonal changes are there in this current?

Locate five ocean areas that have no current.

Give the latitude and longitude of their centers.

Which currents or drifts will have a warming influence upon climate?

Which a cooling influence?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Arctic Circle
Tropic of Cancer
Equator
Tropic of Capricorn
Antarctic Circle

39 — Sargasso Seas

Purpose — To study the sargasso seas.

Materials — Map of the world showing the sargasso seas.

Upon the world map in exercise 38, mark the areas that have the sargasso formation.

Write a short account of the formation of the sargasso seas.

Describe the experience that Columbus had in crossing one of these sargasso seas.

40 — The Tides

Purpose — To study the formation of tides.

Materials — Compass, ruler, pencil.

Give in a few concise words the causes of tides.

Represent diagrammatically the relative positions of the sun, moon and earth for Spring tides and for Neap tides.

When is there the highest tide?

When is there the lowest tide?

What is the average time between tides?
Explain this by use of a diagram.

Represent diagrammatically the formation of the tide upon the opposite side of the earth from the moon.

During which day in March, 1908, was the tide highest in Boston?
On which day was it lowest?
How much difference in elevation was there?
What was the average tide in Boston for this month?

Compare the high and low tides with the phases of the moon as given in the table.

At what time was it high tide March 8th?
At what time was it low tide March 27th?
How many flood and ebb tides were there on March 18th?
Explain this.

Construct a graph of the Boston tides from the following table:

Use the following measurements on your cross-section paper.

Horizontal scale, 1 large square to every 12 hrs. time.

Vertical scale, 1 small square to every foot.

TIDES AT BOSTON, MASS., MARCH, 1908

Moon	Day of– W.	Day of– Mo.	Time and Height of High and Low Water				Moon	Day of– W.	Day of– Mo.	Time and Height of High and Low Water			
P	**S**	1	3.50	10.00	16.25	22.34		M	16	4.15	10.24	16.42	22.48
			—0. 2	10. 8	—1. 3	10. 0				0. 9	9. 4	0. 0	8. 9
●	M	2	4.42	10.55	17.16	23.25	⊙	Tu	17	4.56	11.05	17.18	23.25
			—0. 7	11. 2	—1. 6	10. 4				0. 5	9. 6	—0. 2	9. 3
	Tu	3	5.34	11.48	18.08.....			W	18	5.35	11.43	17.55.....	
			—1. 1	11. 3	—1. 7.....					0. 2	9. 8	—0. 2.....	
E	W	4	0.14	6.24	12.38	18.50	E	Th	19	0.05	6.14	12.20	18.35
			10. 7	—1. 3	11. 2	—1. 6				9. 5	0. 0	9. 8	—0. 2
	Th	5	1.00	7.16	13.28	19.42		F	20	0.40	6.55	13.00	19.15
			10. 8	—1. 3	10. 9	—1. 3				9. 7	—0. 2	9. 7	—0. 1
	F	6	1.50	8.05	14.16	20.30		S	21	1.20	7.36	13.45	19.54
			10. 7	—1. 1	10. 4	—0. 9				9. 8	—0. 2	9. 5	0. 2
	S	7	2.40	8.56	15.08	21.16		**S**	22	2.00	8.20	14.28	20.38
			10. 4	—0. 7	9. 8	—0. 3				9. 7	—0. 2	9. 3	0. 5
	S	8	3.30	9.50	16.00	22.10		M	23	2.48	9.10	15.17	21.25
			10. 0	—0. 3	9. 2	0. 4				9. 6	0. 0	9. 0	0. 9
☽	M	9	4.22	10.45	16.55	23.05		Tu	24	3.36	10.05	16.10	22.20
			9. 6	0. 2	8. 6	0. 9				9. 4	0. 1	8. 7	1. 1
	Tu	10	5.15	11.42	17.55	23.58	☾	W	25	4.35	11.05	17.10	23.20
			9. 2	0. 5	8. 1	1. 3	S			9. 3	0. 3	8. 4	1. 3
N	W	11	6.15	12.35	18.54.....			Th	26	5.40	12.08	18.15.....	
			8. 9	0. 9	7. 9.....					9. 3	0. 3	8. 4.....	
	Th	12	1.00	7.10	13.38	19.52		F	27	0.25	6.45	13.10	19.20
			1. 5	8. 8	0. 9	7. 8				1. 2	9. 4	0. 1	8. 6
A	F	13	1.56	8.07	14.30	20.45		S	28	1.35	7.46	14.10	20.20
			1. 6	8. 8	0. 8	7. 9				0. 8	9. 6	—0. 2	9. 0
	S	14	2.46	8.56	15.19	21.32	P	**S**	29	2.35	3.48	15.10	21.20
			1. 4	9. 0	0. 5	8. 2				0. 3	10. 1	—0. 6	9. 5
	S	15	3.32	9.44	16.00	22.10		M	30	3.30	9.47	16.05	22.15
			1. 2	9. 1	0. 3	8. 5				—0. 3	10. 5	—1. 0	10. 1
								Tu	31	4.28	10.40	16.55	23.05
										—0. 9	10. 8	—1. 2	10. 6

Compare the Boston tides with the tidal heights given in the following table. (These figures are for March 1st, 1908.):

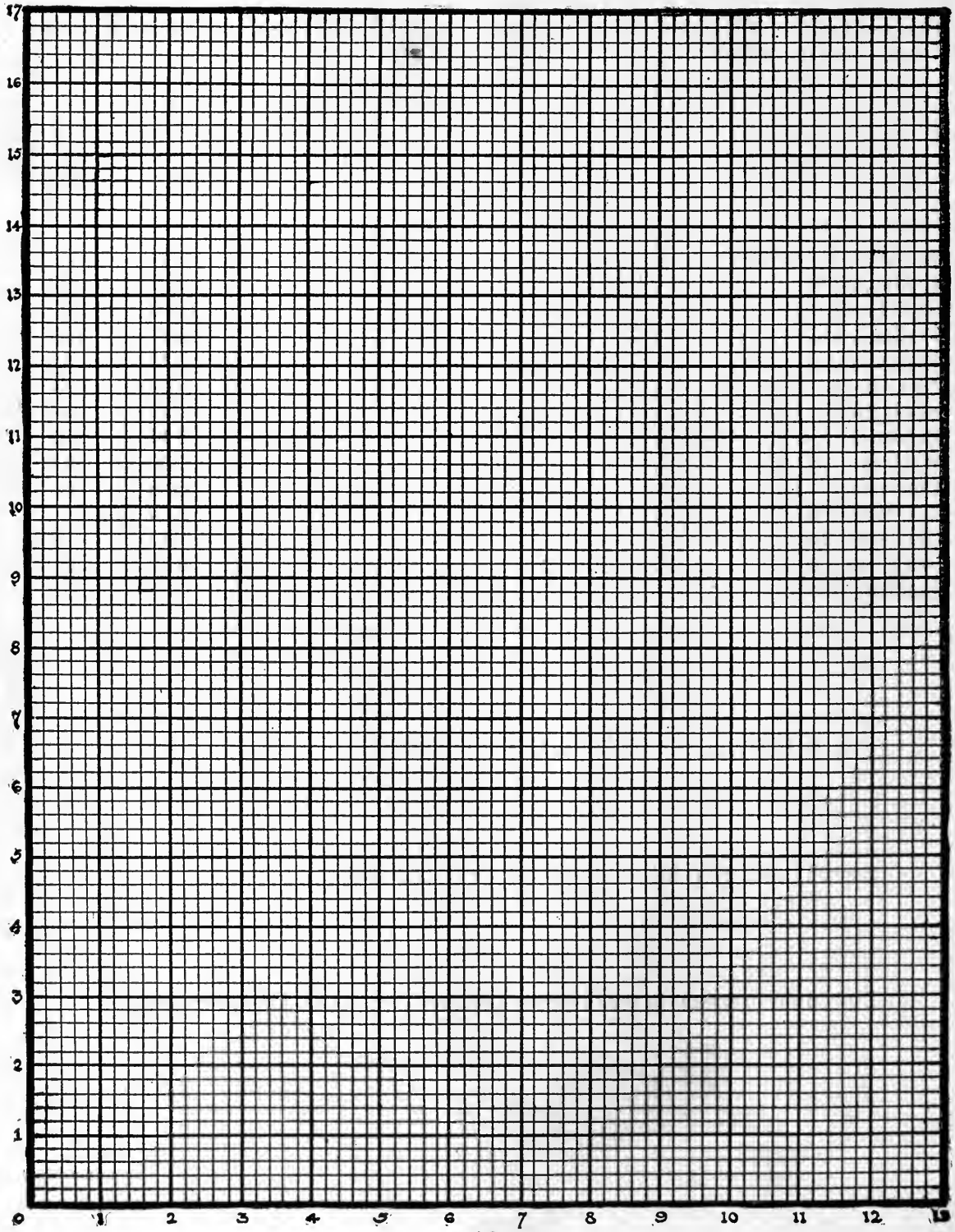
TIME AND HEIGHT OF TIDE AT ATLANTIC PORTS

	Time	Height
St. Johns, Newfoundland	5.54	3.6
Halifax, N. S.	6.38	5.3
St. John, N. B.	10.20	24.
Portland, Me.	9.27	10.1
Newport, R. I.	6.18	4.3
New London, Conn.	8.00	2.9
Sandy Hook, N. J.	6.20	5.4
Baltimore, Md.	5.14	1.2
Washington, D. C.	6.50	2.7
Charleston, S. C.	6.38	6.
Key West, Fla.	7.55	1.
Galveston, Tex.	1.10	1.1
San Diego, Cal.	8.01	6.5
San Francisco, Cal.	9.55	5.8

Why do Key West and Galveston have such low tides?

Explain the extreme height of the St. John (N. B.) tide.

Explain the difference in time between the Key West and the Galveston tides.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41 — Tidal Formations

Purpose — To study tidal formations.

Materials — Any good encyclopedia or text on physiography.

Write a short account of the effects of tidal waves. (Special reference may be given to the tidal waves at Galveston.)

Write concisely about tidal bores.

42 — Ocean Trade Routes

Purpose — To study the principal trade routes of the world.

Materials — Large map of trade routes, colored pencil, ruler. (To designate routes use different colored pencils.)

Atlantic Ocean

On the Mercator map represent the northern and southern routes between New York and Queenstown.

Why should there be two routes?

What atmospheric conditions do vessels encounter off Newfoundland?

Why do so many routes pass close to the island of Newfoundland?

Draw the sailing route from Liverpool to Rio Janeiro. Describe this route carefully, noting all climatic changes and the ocean currents crossed.

Draw the shortest route from Southampton to Bombay.

Why is this called the inside route?

Draw the corresponding outside route.

Trace the probable route of the Norsemen.

What geographic agents made this route difficult to travel?

Mark the southern limit of the icebergs.

When are storms most abundant in the north Atlantic?

Why did Columbus sail to the Canary islands and then westward?

What would be the shortest route from Philadelphia to Lisbon?

What sort of a line would you sail along?

Trace a few main routes that will be benefited by the new Panama canal.

What effect will the opening of this canal have upon the trade of the Southern states?

Pacific Ocean

Why is the largest ocean called the Pacific?

Give reasons for your answer.

Upon your map of the trade routes place your ruler from San Francisco and Yokohama.
Does this represent the sailing route?
Draw this line.
What kind of a line is this upon the earth's surface?
How much longer is this distance than that between New York and Queenstown?

Draw the sailing route between San Francisco and Manila by way of Honolulu, Midway and Guam.
What current proves helpful in this trip?

Draw the sailing route from Seattle to Auckland.
What currents would you cross?
What different temperatures would be experienced?

Trace and describe the sea route from San Francisco to New York by way of Cape Horn.

Where is the southern limit of the northern ice drift in this ocean?
How does it compare with that of the Atlantic ocean?

Mark the northern limit of the southern ice drift.
Where does it approach the continents?
Is it as regular in outline as the limit of the northern drift?
Does it interfere as much with the commercial routes?

Why?

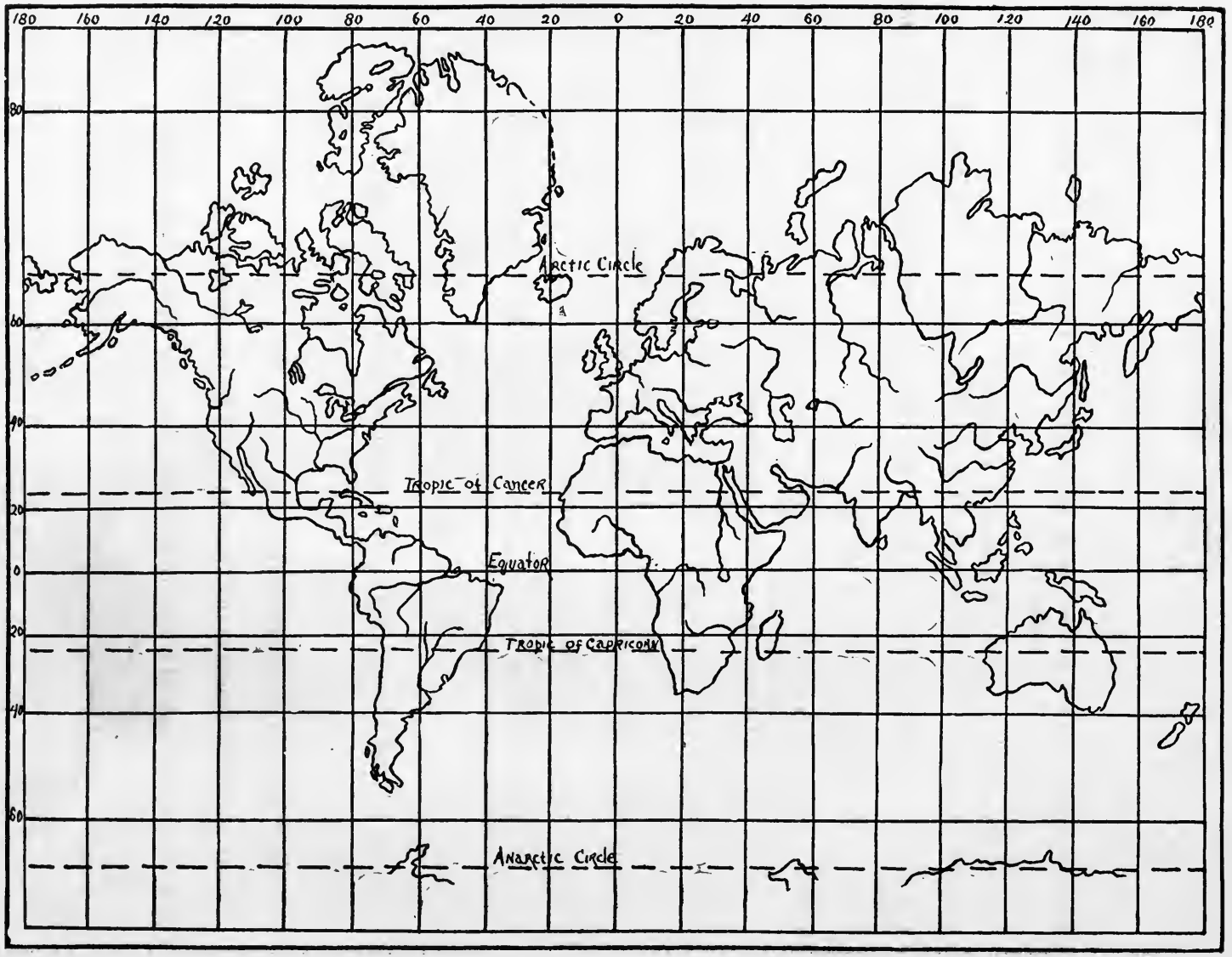
Is the presence of islands in the Pacific a hindrance or a help to navigation?

Why?

Where are these islands situated?

Are there many islands in the Atlantic valuable for trading purposes?

Sketch the probable route of a coast trading vessel from New York to Montevideo.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Tropic of Cancer
Equator
Tropic of Capricorn
Antarctic Circle

III. THE LITHOSPHERE

43 — Irregular Coast Lines

Purpose — To study the formation of irregular coast lines.

Materials — Boothbay (Me.), Boston Bay (Mass.), Tolchester (Md.) topographic sheets.

Boothbay (Me.) sheet.

Locate this area upon your United States map and compare it with the other sections of the Maine coast.

What mountain system extends across the state of Maine?
In what general direction do the separate ranges extend in this area?

Why is this coast so irregular?

Trace the principal hill ranges by means of the contour lines.

In what direction do they run?
Are they continuous or isolated hills?
What is the contour interval?

What is the highest elevation upon the island of Westport?
How many of these hills are there?
What is the height of Mt. Pisgah?
Is it any higher than Big Hill?
Why is this called the " Piedmont Section?"

Account for the swamp formation west of Griffith Head.

Explain the formation of " The Gut " just north of Rutherford island.

Why is the anchorage in Boothbay Harbor better than that at East Boothbay?

Explain how the locations of the lighthouses help vessels to enter Boothbay Harbor.

In what general direction do the bays extend?
What is the age of the topography of this section?
Give reasons for your answer.

Are the shores steep or low?
Are they rocky or sandy?
Will the water off-shore be deep or shallow?

Why is this called a " drowned coast?"

Why are there no large cities along this coast?

What are the occupations of the people who live in this area?

On cross-section paper, draw a profile along the line from Burnt island light to Hendrick Head light.

Boston Bay (Mass.) sheet.

Locate this section upon a map of the state of Massachusetts.

Is this coast similar to that studied in the Boothbay sheet?

What are Nahant and Little Nahant?

Describe how they have become tied to the mainland.

What kind of land formation is Lynn Beach?

What evidences do you find that Nahant is of rock formation?

What is the elevation of the highest point in Nahant?
How does this compare with the elevation northwest of Lynn?

What kind of shore formation is west of Point of Pines?

What geographic agent has helped to make the strip of beaches from Crescent Beach to Point of Pines?

Why is not the city of Lynn a large shipping center?

Which body of water is more likely to be affected by ocean storms, Nahant bay or Lynn harbor?
Why?

Compare this area with a map of Boston harbor.

Tolchester (Md.) sheet.

Locate this section upon your United States map and carefully study the other sections of Chesapeake bay.
What evidences do you find that this bay is a large drowned valley?

Trace the main stream and its tributaries through this bay.
Describe briefly the general form of this drowned river valley.

What protection does it have from the action of ocean storms and waves?

Trace the lower valley of the Gunpowder river.
How long is it?
How wide is it?
In what direction does it extend?

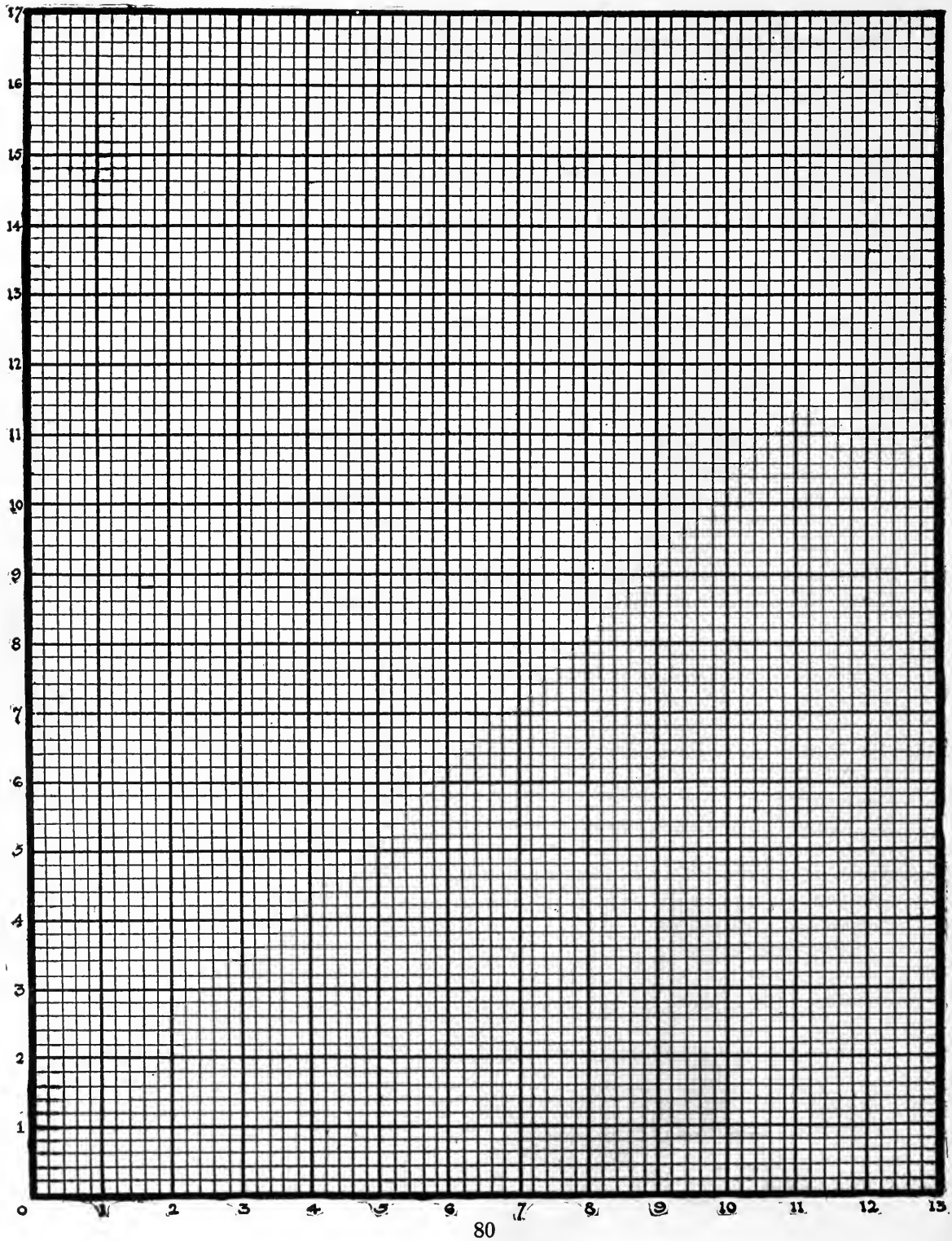
Trace the coast plain that lies west of this arm of the Chesapeake.
How wide is it at its widest part?
What is its average elevation?
Is this a rocky coast? Why?

Why are there so many marsh formations?

Describe the topography west of the Philadelphia, Wilmington and Delaware railroad.

Explain the formation of Spesutie island.

On the cross-section paper draw a profile from Robins Point to Edgewood.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44 — Regular Coast Lines

Purpose — To study the formation of regular coast lines.

Materials — Sea Isle (N. J.), Provincetown (Mass.), Wellfleet (Mass.), Talmalpais (Cal.), Oceanside (Cal.) topographic sheets.

Sea Isle (N. J.) sheet.

In which physiographic division of the United States is this area located?

Is this a submerged or an elevated section?
Why?

Describe the drainage areas.

What geographic agent caused the formation of the beaches?

Is this coast line old or young?
What will be the history of the swamp land back of these beaches?

Is Ludlam bay salt or fresh?
How will the tides affect this section?

How many life-saving stations are there?
Where are they located?

Of what use are they?

Why are there no lighthouses along this coast?

Will the sea water be deep or shallow off this coast line?
What will be the nature of the continental shelf in this region?

Describe the old coast line before the beaches were formed.

Provincetown (Mass.) and Wellfleet (Mass.) sheets.

What form has the land in this area?
What name is given to this form?
What has caused this form?

How was Long Point built?

Is this formation a protection to Provincetown harbor?
What is the nature of the soil of Cape Cod?

What kind of vegetation will grow there?
What and where is its greatest elevation?
Describe its drainage areas.

Are these old or young?
Are there many tributary streams?

What will be the geographic history of Race Run?

Of what use is Long Point light?

Locate Highland light.
Why is this so far inland?
Is this of any use to ocean steamers?
Explain the presence of the ponds at the western end of Cape Cod.

What evidences does Salt Meadow show of recent land formation?

Which side of Cape Cod will experience the more severe storms?
Why?

Tamalpais (Cal.) and Oceanside (Cal.) sheets.

Locate these two areas and compare their topographic structure.
Which has a rugged shore?
Which has a coastal plain?
In which are the drainage systems the larger?
Which area has the greater elevation?

Tamalpais (Cal.) sheet.

In what direction does the Polinas ridge extend?
Is it parallel to the coast?
Why are there no large rivers draining into the Pacific ocean?

What evidences do you find of coastal erosion?

Where is the coast being built up?
Will this action make the coast more or less regular?
What effect upon a coast line has deposition? (Compare with the deposition going on in the Sea Isle sheet.)

Describe the coastal terraces west of Bolinas bay.

Oceanside (Cal.) sheet.

In what direction do the drainage systems extend?

What influence have they had upon the coast line?

What influence has the coast had upon the rivers?

What becomes of the water in the rivers?

How does the salt get in the marshes?

Where has deposition shut in marshes and lagoons?

Where is a lake being formed?

Describe the coastal terraces.

What evidences do you find of erosion?

Where?

What will be the history of this coast?

45 — Lake Shores

Purpose — To study the structure of a lake shore.

Materials — Milwaukee (Wis.) quadrangle topographic sheet.

Which shore of Lake Michigan is represented in this area?
What kind of a shore line has this lake?

How high is the shore cliff above sea level?
How high is it above Lake Michigan?
Are there any beaches along this shore line?
Describe this shore line carefully.

What is the greatest elevation shown in this area?
Where is it located?
What evidences do you find that ice sheets once covered this section?

Account for the direction in which the Milwaukee river flows.

Is this an old or a young river? Why?

Trace the divide between the Menominee and the Milwaukee rivers.

What geographic advantages has the city of Milwaukee?

How has man built an artificial harbor?

Why doesn't the Milwaukee river build a delta at its mouth?

Of what advantage are the artificial inlets about the mouth of the river?

Compare the coast line in this area with those found along the shores of the other Great Lakes and those shore lines in the sections already studied.

46 — Quartz

Purpose — To learn the characteristics of quartz.
Materials — Some quartz specimens, dilute HCl, stirring rod, piece of glass, knife. (Type specimens should be kept for class comparison.)

Note — The common minerals of the earth's surface are classified as follows: 1. quartz group; 2. feldspar group; 3. calcite group; 4. mica group; 5. amphibole group; 6. pyroxene group; 7. iron group; 8. gypsum group; 9. salt group; 10. ice group.

Quartz (silica, SiO_2).

Carefully compare the individual specimen with the type specimen.
What is the color? (May vary from transparency to jet black.)
What is its luster?
Has the mineral formed into crystals?
How many sides has the quartz crystal?
Describe its general shape.

What is meant by amorphous?

Name some varieties of quartz.

Is quartz light or heavy?
Is it hard or soft?
Will it scratch glass?
Will a knife scratch it?
Will it withstand erosion?

Is it brittle?
In what shape will quartz break?
Has it any cleavage?

Test it with HCl. Is it chemically strong?

Is quartz soluble in any substance?

In what substance? Do we find this substance in nature?

How do plants use quartz?

Where is quartz found?

How important is it in earth structure?

47 — Feldspar

Purpose — To study the characteristics of feldspar.

Materials — Some feldspar specimens, dilute HCl, stirring rod, knife. (Type specimens should be kept for class comparison.)

Feldspar (silicate of alumina, SiO_2 and Al_2O_3 with potash, soda or lime).

What is the color of the feldspar specimen you have?
Does feldspar vary in color?
What is its weight?
How does it compare with quartz in this respect?

Is it as hard as quartz?
Will it scratch glass?
Will a knife scratch it?
In what shape does it break?

What are cleavage planes?

Is feldspar crystalline in structure?

What is kaolin?

Where is feldspar found?

For what is it used?

48 — Calcite

Purpose — To learn the characteristics of calcite.

Materials — Specimens of calcite, dilute HCl, stirring rod, knife. (Type specimens should be kept for class comparison.)

Calcite (carbonate of lime, $CaCO_3$).

What is the color of the calcite specimen you have?
Does calcite vary in color?
What is its weight?
Will a knife scratch it?
Will it crumble?
In what form does calcite crystallize?

Is it ever amorphous?
In what shape does it break?
Compare the broken calcite with quartz and explain the difference.

Does it respond to the acid test?
Describe the action fully.

Is calcite soluble in water?
Will it withstand erosion?
Of what use is it to animals?

Where is calcite found?

Name several different varieties found in the calcite group.

Name a number of uses of calcite. (It is one of the most important and useful minerals in the earth.)

49 — Mica

Purpose — To study the characteristics of mica.

Materials — Mica specimens, HCl, stirring rod, knife. (Type specimens should be kept for class comparison.)

Mica (complex silicates of alumina).

What variations in color do you find?
What causes these variations?

What is the luster of mica?
How does mica split? Describe carefully.

Is this a characteristic of mica?
Are these plates elastic? (Bend them carefully to see.)

Is mica easily scratched with a knife?
Can you scratch it with your thumb nail?
Do micas decay easily?
Are there any insoluble forms? (Test your various specimens with the HCl.)

Do we find mica particles in any of our soils?

In what condition are these particles?

Why do these particles glisten?

In what rocks may mica be found?

Describe some commercial uses of mica,

50 — Amphibole and Pyroxene Groups

Purpose — To study the characteristics of these groups.

Materials—Specimens of hornblende and augite.

Note — The members of these groups, complex silicates with iron, are very similar in characteristics and cannot be told apart when occurring in small bits of rock without the aid of a microscope. Specimens from a labeled collection may be easily distinguished.

What is the color of these specimens?
Do they appear hard or soft?
How do they compare to quartz?

Do you find any evidences of the presence of iron?

Where do these minerals occur in the earth's surface?

How do they show the presence of iron when decaying in bogs and clays?

51 — Iron Group

Purpose — To study the characteristics of the iron group.

Materials — Specimens of magnetite (Fe_3O_4), hematite (Fe_2O_3), limonite ($2Fe_2O_33H_2O$), and pyrite (FeS_2).

Distinguish between these minerals.

Why are they called oxides and sulphides of iron?
What is the color of magnetite?

What is the color of hematite?

What is the color of limonite?

What is the color of pyrite?

What evidences do you find that magnetite is crystalline in structure?

Hematite is the most valuable of our iron ores in the United States: it gives the red color to our soils and rocks.

Is hematite hard?
Is it heavier than magnetite?
Will it scratch quartz?

To distinguish these ores, scratch them upon a piece of quartz or rough porcelain.

What is the color of the streak of each of the ores?

Iron pyrite is one of the commonest forms of iron in the bed rock.

Is it hard?
Will it scratch quartz?
Does it glisten?
What name is sometimes given to it?

Locate about your home such soil areas as seem rich in iron deposits.

Are there any springs about your home that show the presence of iron?

Where are they? (Give their topographic location.)

How can you tell when iron is present in a spring?
How can you tell when iron is present in the soil?
Does it make the soil more productive?

52 — Gypsum Group

Purpose — To learn the characteristics of this group.

Materials — Specimens of gypsum, dilute HCl, stirring rod.

Gypsum (sulphate of lime, $CaSO_4 + 2H_2O$).

What is the color of gypsum?
Is it soluble in water?
What effect has water upon it?

Is gypsum as hard as calcite?
Does it resemble calcite in any way?

Does it respond to the acid test?

What is its cleavage?

Does the specimen you have resemble mica in its cleavage?
Do all the varieties of gypsum resemble mica in this respect?
Are the thin plates of the gypsum flexible?

What is Plaster of Paris?

For what is it used?

Where is gypsum found?

Is it abundant in the earth's surface?

Name some of the uses of the different varieties of gypsum.

53 — The Salt Group

Purpose — To study the characteristics of salt.

Materials — Specimens of common salt, dilute HCl, stirring rod, knife.

Salt (sodium chloride, NaCl).

What is the color of salt?
What would change its natural color?

What impurities does it sometimes contain?

Describe its structure.

Is it crystalline?
How does it crystallize?

Is it hard or soft?
Will it crumble?
Is it easily scratched?
What happens when you scratch it with a knife?

What is its taste?
Does it respond to the acid test?

Is it soluble in water?
How soluble?
What effect does it have on the water?

Of what use is it to animals?

Where is salt found?

Does it appear as a part of rock formation?
Where do we get salt for commercial purposes?

How may we get it from the sea water?

Describe the different varieties of salt that come in this group.

54 — The Ice Group

Purpose — To study the characteristics of ice.

Materials — Ice specimens, dilute HCl, stirring rod, knife.

Ice (solid form of H_2O).

What is its color?
What impurities would change this color?

Is ice crystalline in structure? (Notice the frost upon the window in winter.)

Is it easily scratched?
What are its cleavage planes?

Is it brittle?
Will ice bend?
What is the viscous quality of ice?

What effect does a change of temperature have on ice?

Does it respond to the acid test?
Is it soluble in cold water (below 32 F.)?

Is it soluble in warm water?

What three forms may H_2O have?
When will it have each of these forms? (Give the temperature ranges.)

Where does solid H_2O exist?
Where does liquid H_2O exist?
Where does gaseous H_2O exist?

Do we find ice in the earth's crust?

Is it ever found in rocks?

What part does H_2O play in the changes going on in the earth's crust?

55 — The Properties of Minerals

Purpose — To study the properties of minerals.

Materials — Some mineral specimens, dilute HCl, stirring rod, needle, steel rod. (A knife will do for this latter.)

Collect several specimens of minerals such as quartz, feldspar, calcite, common salt, gypsum, mica, etc.

Number your specimens and name those that you know.

By means of the following tests, catalogue your specimens in the table given on the following page.

Color — give the general color of your specimen.
Structure — (a) fine; (b) coarse; (c) porous; (d) compact; (e) uniform; (f) stratified.
Luster — bright or dull.
Weight — light, medium, heavy.
Hardness — (a) very soft, may be scratched by the thumb nail; (b) soft, may be scratched with a needle; (c) hard, difficult to scratch with a needle or steel rod; (d) very hard, cannot be scratched with steel.
Cleavage and fracture — When minerals break into smooth surfaces or faces, the planes of breakage are called cleavage planes. When the breakage is irregular, it is called a fracture.
Transparency — (a) transparent; (b) translucent; (c) opaque.
Acid test — with stirring rod, place a drop of HCl on the specimen.

Record results. (Gas may be formed as shown by the presence of bubbles; the rock may be so porous that the acid sinks into it or it may be so hard that the acid has no effect.)

Minerals — The constituents that form the rock should be noted whenever possible. (The elements of granite are easily distinguished and may be used as a type for study.)

A test for porosity.

Mineral.	Weight dry.	Weight wet.	Per cent. of increase.

Specimen number.	Color.	Structure.	Luster.	Weight.	Hardness.	Transparency.	Acid test.	Cleavage.	Name.

56 — The Study of Rocks

Purpose — To study the kinds of rocks.

Materials — Specimens of granite, gneiss, shale, clay, trap, sandstone, limestone, iron ore, salt, coal, slate, marble, one or two volcanic rocks, dilute HCl, stirring rod, knife.

Separate these specimens according to general distinguishing features and study the color, structure, hardness, etc., of each specimen.

Opposite the following list write the principal characteristics of each rock.

granite —
gneiss —
shale —
clay —
trap —
sandstone —
limestone —
iron ore —
salt —
coal —
slate —
marble —
volcanic rocks —

Which of these are igneous rocks?

Which of these are sedimentary rocks?

Which of these are metamorphic rocks?

Granite.

Of how many mineral elements is granite composed?
Tell their distinguishing differences in regard to color and luster.

Does granite respond to the acid test?
Will a knife scratch it?
How are the grains arranged in the specimen you have? (Compare with the piece of gneiss.)

Could these grains have been collected and arranged by water?

Will granite withstand erosion?

Limestone.

Describe the structure of limestone.

Describe the action of HCl on limestone.

Will a knife scratch this specimen?
How are the grains arranged?

Could water have aided in arranging these grains?

Do you find any fragments of rocks or shells in your specimen?

Marble.

Describe the structure of this rock.

Does it respond to the acid test.
Describe the action of the HCl.

Is the marble as hard as the limestone?
Will a knife scratch it?
Do you find any evidences that marble was once limestone?

Did water aid in forming this rock?

What other agent was needed to make marble?

In the following tables classify your specimens.

Classification of igneous rocks.

Eruptive or volcanic.			
Acid rocks.		Intermediate rocks.	Basic rocks.
with quartz.	without quartz.		
		Abyssal or intrusive.	

Write the name of your specimen in its proper place.

Classification of sedimentary rocks.

	Fragmental.	Chemically precipitated.	Organic.
Coarse grained.			
Intermediate grained.			
Fine grained.			

Write the name of your specimen in its proper place.

Classification of metamorphic rocks.

Name of rock.	Nature of metamorphism.	Kind of rock.	Source.

Write the name of your specimen in its proper column and fill out the others as designated.

57 — The Soil

Purpose — To study the formation of soil.

Materials — Samples from loam, clay, gravel, sand, dilute HCl, stirring rod, piece of glass, hand magnifier, scales, four lamp chimneys, four pans.

Field work — A careful study of soil formation should be made in the field. An exposed cliff where the underlying rock shows will form a good type for study. Notice the gradual breaking-up of the rock to form the top soil. Distinguish between top soil, subsoil, and solid rock. Trace the zone of plant growth and notice how the roots of plants and grasses penetrate the soil. Collect samples of each kind of soil for class-room work. As much work as possible should be done in the field.

Place some samples of the different soils collected upon the piece of glass and study them with the hand magnifier.

What is the general color of each of these samples?

What gives each its color?

Which of these samples contains the largest particles?
What is the shape of these particles?
Describe them carefully.

What are they?

Do you find any coarse grains in the loamy soil?
Do you find any evidences of root or leaf particles?
Why should they be there?

Do you find these in the sandy soil?
Why not?

Which of these specimens is the more gritty?
Which will scratch glass?
Of what are these particles composed?

Test each of these specimens with HCl and record the results.

Weigh each of the four specimens carefully and record the results in the table below.

	Weight.	Weight dry.	Weight wet.
loam			
clay			
sand			
gravel			

Dry each sample over a lamp and weigh again. Record results.

Place each sample in a pan and cover with water: allow them to stand a few hours. Drain off the water and weigh the samples. Record the results.

Which soil is heaviest in its natural condition?
Which soil is heaviest when dried?
Which soil absorbs the most moisture?

To determine the porosity of soils.

Cover the narrow ends of four lamp chimneys with thin cheese cloth. Fill the chimneys two-thirds full of each of the four specimens you have collected. Place these chimneys in a stand so that they may be supported above drip-pans, the cloth end downward. Fill the remaining part of the chimneys with water.

Which of the four soils allows the water to pass through it?
Which retains the most water?
What percentage of water is retained by each?

Which would be called heavy soil?
Which would be called light soil?
Which would be the best soil for plant growth?
Why?

Which soil would move the easiest? Why?

Has the water changed the color of the soil any?

Which specimen would allow air to enter readily?
Why? (Explain this fully.)

Mix several of these specimens and repeat the experiment.

Record the several results below adding such explanations as you think best.

Name all the different kinds of soil you know and tell their principal characteristics.

What name do we give to soil that occurs in the place of the original rocks?
Locate such soil about your home.

What name do we give to soils that have been moved from their original home?
Locate such soils about your home.

Name and describe the three kinds of soil that have been moved from their place of formation.

58 — The Geologic Cycle

Write a short account of the geologic cycle.

Explain the life growth of some physiographic formation near your home.

59 — Volcanic Formations

Purpose — To study volcanic formations.

Materials — Marysville (Cal.) folio, Lassen Park (Cal.), Shasta special (Cal.) topographic sheets.

Marysville (Cal.) folio.

What is the average elevation of the plain upon which the Marysville buttes are built?
What is the highest elevation in this area?
Do you find any volcanic cones?
What evidences do you find that these buttes were formed by lava intrusion?

Explain the formation of the igneous rock.

Account for the sedimentary rock area west of the 121–50 meridian.

Where has erosion taken place the most extensively?

Describe the streams that descend from these buttes.

Which part of the profile section represents the volcanic necks?

Which part shows surface lava that has been intruded?

Lassen Park (Cal.) sheet.

What evidences do you find that this is a volcanic area?

What is the height of Crater peak?
Does this peak show evidences of erosion?
Describe the topography of the southwest section of this area.

Why are there so many lakes in this area?

Are these lakes salt or fresh?
Describe the outlet to Lake Bidwell.

Are the river systems young or old? Why?

Which part of this area is comparatively level?
Is this a lava plain?
Describe the elevation at the eastern border of this area. (Compare with Crater lake topographic sheet.)

Has this elevation been eroded?
What evidences does this elevation show of volcanic origin?

On cross-section paper draw a profile of this elevation.

Locate Lassen peak. How high is it?
Is this of volcanic origin?
Is it snow covered? Why?
Was this ever an active volcano? Why?

Shasta special (Cal.) sheet.

What is the elevation of Shasta above sea level?
Above the town of Sissons?
Is Shasta snow covered?
What evidences do you find that this was once an active volcano?

Locate the lava flows.
How was Shasta built?

Where was the main cone of Shasta?
Locate the secondary cones.
Were any of these cones ever active? Why?

How was Shastina built?

Is this a steep or low cone?
Upon which side of Shasta has erosion taken place the most rapidly?
Where do the rivers on the east side obtain their water?
What is the elevation of their source?

Describe fully the drainage system known as Inconstance creek.

Why do so many creeks about Shasta disappear?

Where are the roadways located?
Describe the trails.

What products will man obtain from this mountain?

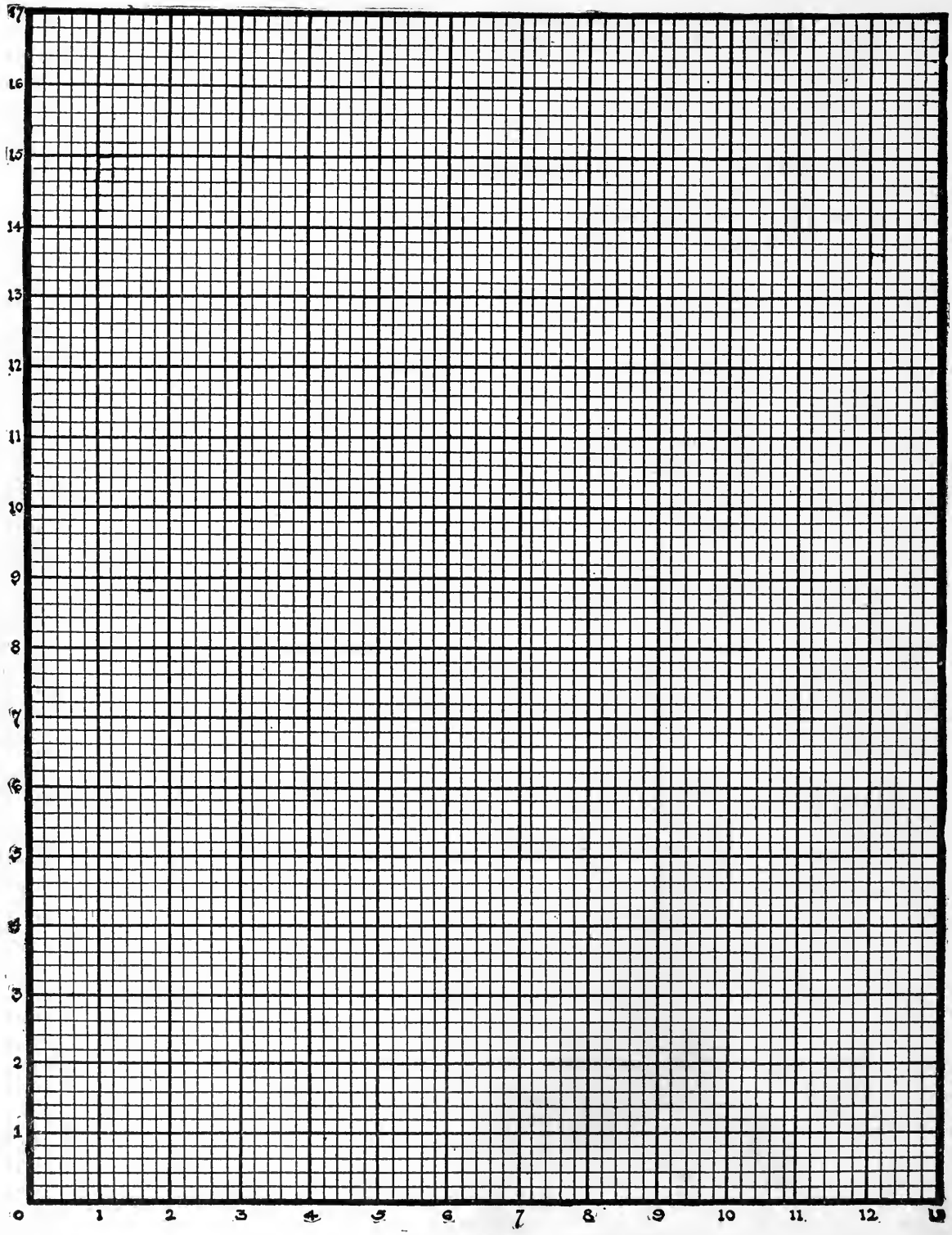
Is Shasta an old mountain? (Give your reasons for this answer.)

Where will you be likely to find igneous rock?

Which part of this area will be composed of sedimentary rock?

Using the heavier contour lines for guides, draw a profile of Mud creek upon the cross-section paper.

Draw a profile from Shasta to Shastina.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60 — Laccolites

Purpose — To study the structure of laccolites.

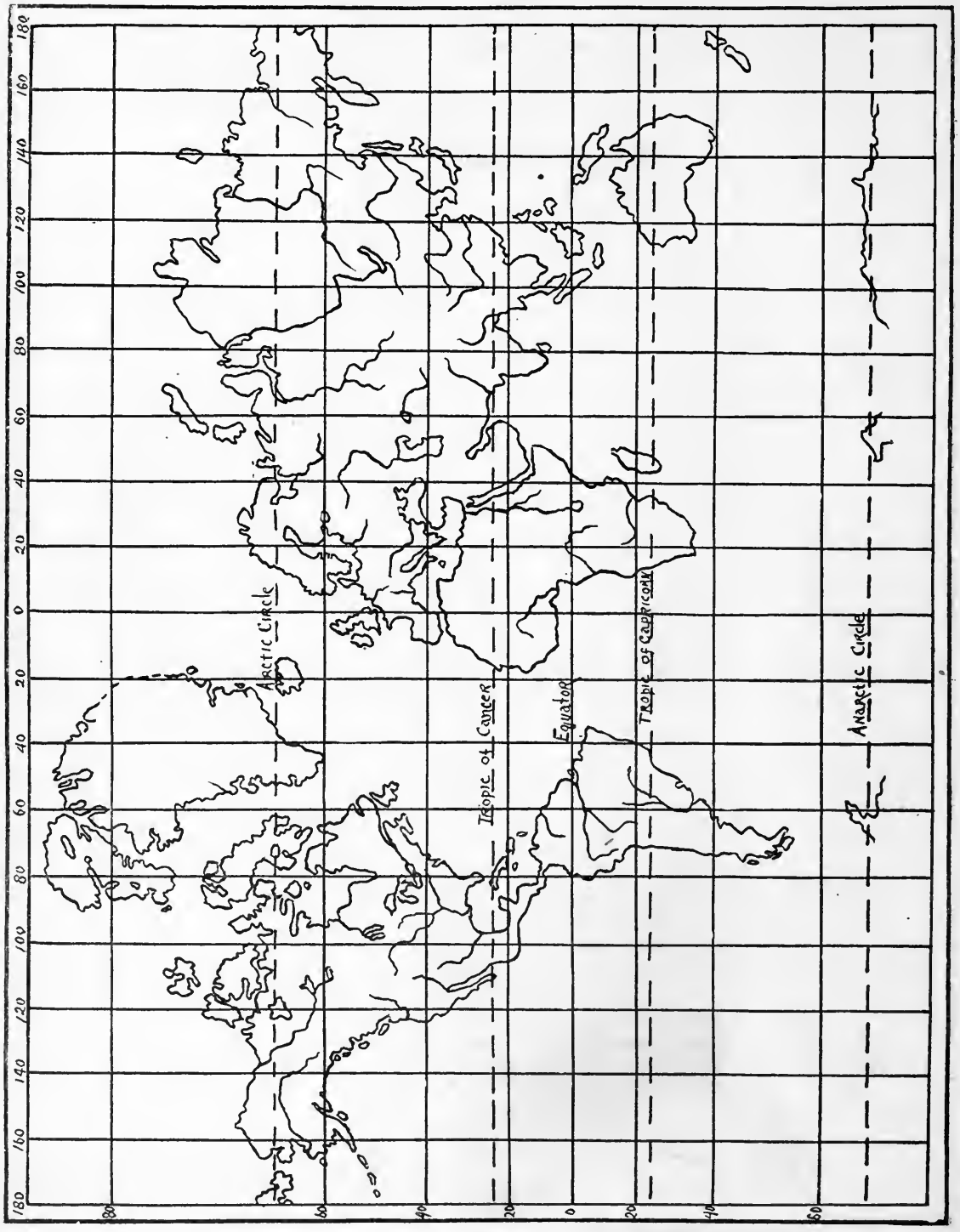
Materials — Pencil, ruler.

Draw a sectional view of a laccolite as first formed.

Draw a sectional view of the above laccolite after erosion has taken place.

61 — Distribution of Volcanoes

Locate the Pacific volcanic area in red, the Atlantic area in blue, and the Mediterranean area in green. Interior volcanoes may be located in brown.



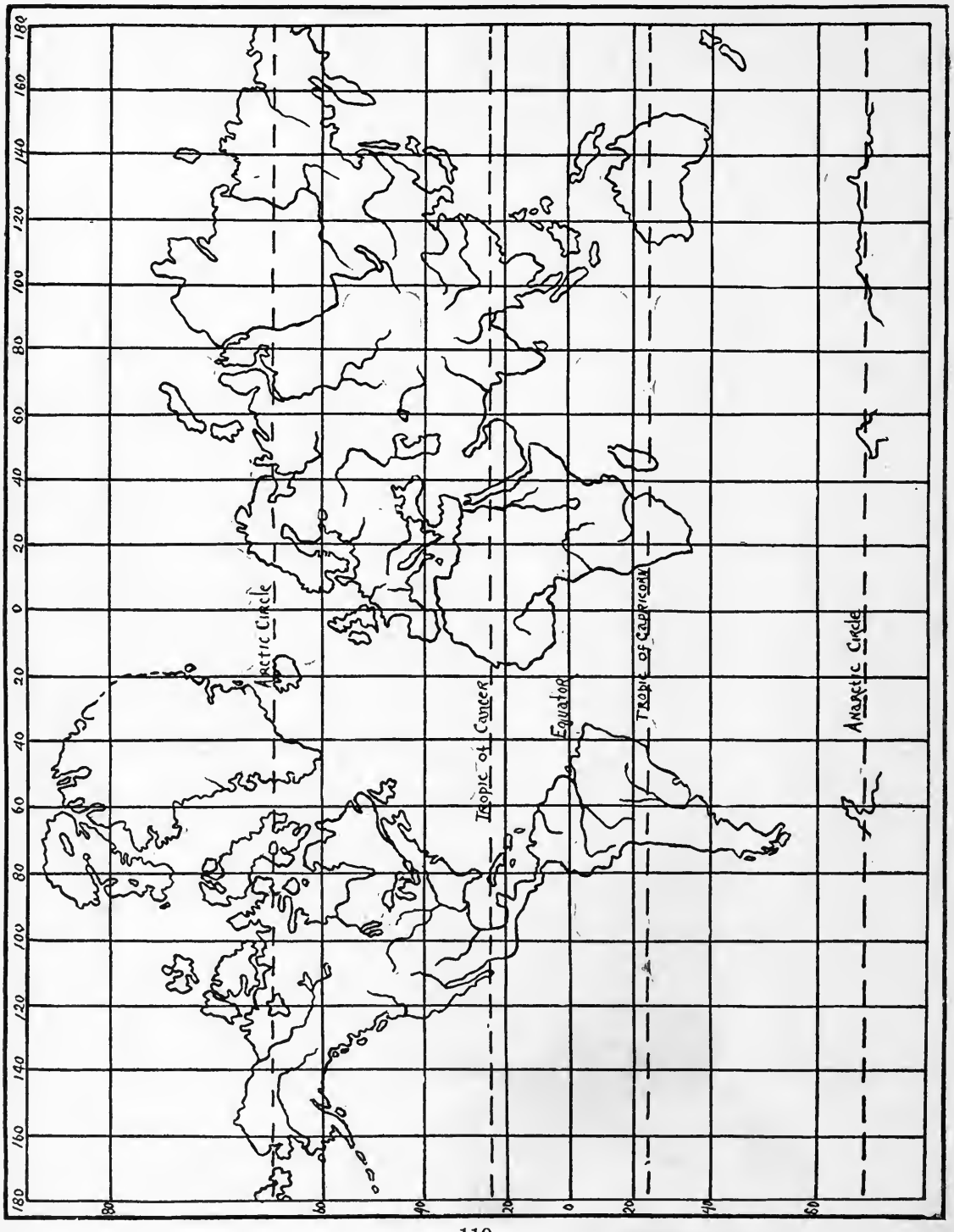
62 — Earthquakes

Describe the causes and movements of earthquakes.

Write a short description of the Charleston earthquake.

63 — Distribution of Earthquakes

Locate the areas most susceptible to earthquake actions.



64 — Plains

Purpose — To study the structure of interior plains.

Materials — White Bear (Minn.) quadrangle, Evansville (Wis.) quadrangle, Caldwell (Kan.) topographic sheets.

White Bear (Minn.) quadrangle sheet.

Locate this area upon your United States map.
Is this section included in the glaciated area of North America?
What evidences do you find of glacial action?

What is the highest elevation of this plain?
What is the lowest elevation?
Explain the presence of lakes.

Are there any large rivers? Why not?

Where is the great marsh section?
Of what use are the ditches?

For what will this land be used in the future?
Account for the marsh formation between Wilkinson and Pleasant lakes.

Is this the remains of an older lake?
Find other evidences that some of the lakes in this area have decreased in size.
To what drainage system will this section belong?
What is the direction of its drainage outlet?
Describe Rice creek.

Where does the city of Minneapolis get its drinking water?

What supplies this reservoir with water?
What will be the future history of this area?

Evansville (Wis.) quadrangle sheet.

Locate this area.
Which represents the older developed area, this or the former sheet?

In which do you find the greater number of lakes?
In which are the marshes larger?
Which has the better developed rivers?
What evidences of erosion do you find in this sheet?

Trace the outline of the former marshes about Sugar river.
What contour line represents their borders?
What kind of a stream is Sugar river?
What work is it doing?

What is the average altitude of this area?
Is it a rugged or a rolling country?
Is it well adapted to agriculture? Why?

What is the nature of its soil?

Are the roadways well developed?
In what general direction do they extend?
Why are they able to do this?
Why are there no trails in this section?

Caldwell (Kan.) sheet.

Compare this area with those of the preceding two sheets.
What is the greatest elevation?
What is the least elevation?
Have the rivers eroded this plain?
Compare the rivers found in this sheet with those of the other two sheets.

Does this sheet show greater age than the other two?
Explain this fully.

Why are there no lakes or marshes present?

Is this rough or rolling land?
Are there any high mountains?
Are there any deep valleys?
Describe the roadbed of the Missouri Pacific railroad.

How do the roadways run?

Is this regularity unusual?
In what kind of country would such roads be found?
What will be the industries of this section?
Are there good shipping points here?
Explain the growth of Caldwell.

Compare these areas with other plains found in the United States.

65 — Low Coastal Plains

Purpose — To study the formation of a low coastal plain.

Materials — Atlantic City (N. J.), Sandy Hook (N. J. – N. Y.) topographic sheets.

Atlantic City (N. J.) sheet.

Locate this area upon your United States map.
What part of the United States coast is this?

In what physiographic area of the United States is this?

What is the scale of this map?
What is the contour interval?
Where is the highest part of this area?
What is the average elevation?
Trace the old coast line.
Where are the sand bars?

What agent helped to build these bars?

Are they being enlarged or destroyed? Why?

How far is it from the northern life-saving station on Brigantine beach to Somersville point?
What is the nature of the land inside the bars?

Will this land ever become a part of the coastal plain?
When?

What kind of marshes are these?
Are they affected by the tides?
Are the inland bays navigable?
Where do you find evidences that the marsh land is drying up?

Will this marsh land ever assume the topography of the section around Conoverville?
What will drain the inland bays?
How do the railroads get from the mainland to the outer bars?

Why is Atlantic City so large a place?

What natural advantages has it?

What is its elevation?
Is it in danger from high tides?
Of what use is Absecon light?

Sandy Hook (N. J. – N. Y.) sheet.

Locate this area in reference to the one just studied.
Why is the coast line so much more regular than that in the Boothbay sheet?

How is the ocean making the coast line regular?

Where on this coast do you find sea-cliffs?

Are the Navesink and Shrewsbury, estuaries or rivers?
What was the probable cause of this formation?

What evidences do you find of new land being formed about the Shrewsbury river?

How is this being formed?

Are the drainage systems young or old?
Explain the formation of Sandy Hook.

Why does this hook turn westward?
What effect has the wind had on the formation of the hook?

In what shape are the dunes? Why?

Of what use are the lights and the beacons?
What vessels will make use of these?

What are the Highlands of Navesink?

What is their greatest altitude?
Where do they approach the sea in cliff formation?
Where has the ocean built a beach about their base?
Describe this formation.

How have these highlands been a protection to the mainland?

What evidences of erosion do you find on the mainland?

66 — Narrow Coastal Plains

Purpose — To study the formation of a narrow coastal plain.

Materials — Haywards (Cal.), Port Orford (Ore.) folio topographic sheets.

Haywards (Cal.) sheet.

How much of this area represents a coastal plain?
What is the gradient of this plain?
In what two ways might this plain have been made? (Mark the absence of drowned valleys.)

Where is the old coast line?
Describe the topography east of this line?

In what direction do the hills extend?
Are there evidences of erosion?
Find the course of the former river that emptied where Haywards is now located.
Describe the shape of the contour lines between this place and the sea.

What does this shape show?

Describe the drainage systems of this coastal plain.

Account for the presence of the Coyote hills.

Do they form a part of the ranges of the mainland?
Where would they most likely connect with these ranges?

Is the land west of the Coyote hills rising or sinking?
Why?

What do the lakes in the marsh formation signify?

How do you account for the presence of so much salt?

What shape has the coast line of this area?
Why are there no good harbors?

Why do the railroads extend along this plain instead of along the mainland?

Explain the location of the city of Haywards.

Why should this place be larger than Decoto?

Why are there no large cities along the coast?

Port Orford (Ore.) folio sheet.

Trace the elevated shore cliff.
How far is it from the present coast line?
How high is this cliff?
Is it abrupt or gradual in its slope?
Is this highland an old sea-line?
Describe the topography east of this cliff.

What difference is there in age between the eastern highlands and the western lowlands?
How has this narrow coastal plain been made?

Describe the work of the Elk river.

What part has the ocean played in the formation of this coastal plain?

Of what significance are the lagoons?

Trace and explain the outlet of Floras lake.

What kind of a coast line is that north of Blacklock point?
South of Cape Blanco?
Account for the unevenness of the coast between these two points.

Is the Sixes river aiding in the straightening of the coast between these two points?
How is it doing this?

Where are most of the roadways?
Is this a thickly settled coast?
Why are there no good harbors on a narrow coastal plain that is largely alluvial in its formation?

Compare these plains to other narrow coastal plains found in the United States.

67 — A Dissected Plain

Purpose — To study the formation of a dissected plain.

Materials — Wicomico (Md.– Va.) topographic sheet.

Wicomico (Md. – Va.) sheet.

Locate this area upon your United States map.
To what physiographic section does it belong?

What is the scale of this map?
What is the contour interval?
What large river is in this area?
Describe its course.

Where is the land highest in this area?
Describe the coast line.

How do the rivers cross this plain?

Where are the swamp areas?

Are they being drained?

Locate the principal crest found in this section.
How high is the divide between Zekiah and Gilbert swamps?
In what directions do its sides slope?
What evidences do you find of erosion?

What is the grade of the Wicomico river?
Why is this river so wide?

Describe the roadways.

Why do they not extend more regularly?

Where are the railroads located?
Why?

68 — Alluvial Plains

Purpose — To study the formation of alluvial plains.

Materials — St. Louis (Ill. – Mo.), Sierraville (Cal.) topographic sheets.

St. Louis (Ill. – Mo.) sheet.

How was this alluvial plain built?

What evidences do you find that the Mississippi river ever occupied any other than its present bed?

Explain the formation of Pittsburg lake.

Near which cliff is the Mississippi river now flowing?
What large city is situated upon this cliff?
What is the elevation of the river at this point?
In which direction does Cahokia creek flow?
Explain the formation called Dead creek.

What is the average elevation of this alluvial plain?
What evidences do you find that the river ever flowed against the eastern cliff?

How has the migration of the river changed its valley?

Where did the Mississippi river get the soil that is deposited on this plain?

Sierraville (Cal.) sheet.

Locate this area upon your United States map.
What evidences do you find that this is an arid region?

In what general direction do the rivers flow?
Why are there so many channels in the river system at the north?

How are the mountains located?
What will be the climate of this area?
Are the rivers making or draining the marsh in the western part?

Which contour line marks the limit of this alluvial plain?
What is the approxmate area of this valley?

69 — Lacustrine Plain

Purpose — To study the formation of a lacustrine plain.

Materials — Fargo (N. D. – Minn.) topographic sheet.

Fargo (N. D. – Minn.) sheet.

What large river drains this area?
What evidences do you find of glacial formation?

What lake once covered this section?
Is there much or little relief shown in this map?
Why?

Where is the greatest elevation?
What is the average slope?
In what direction does the land slope?
Describe the river systems?

Locate and describe the principal divides.

Is this a young or an old section?
Has erosion been active?
How are the roadways arranged?

What great industry is found in this section?
Why are these lands well adapted to it?

What is the rainfall of this area?

70 — Glacial Plains

Purpose — To study a glacial region.

Materials — Whitewater (Wis.) topographic sheet.

Whitewater (Wis.) sheet.

Locate this region upon your United States map.
Is it within the area of the ice sheet of North America?
Where is the terminal moraine in this area?

In what direction does it extend?
Describe its topography.

Where is the most important drainage system located?
Describe this system.

Why are there no rivers in the moraine?
Account for the lakes?

Where is the drumlin area?
What is the shape of these drumlins?
In what general direction do their long axes extend?
How high are they?

What is the altitude of the swamp in the north?
Is this swamp being drained by the Scuppernong river?

Is this a young or an old area?
Why?

Will the farm lands become more or less valuable with age?
Of what kind of soil are they composed?
Where are the centers of population?

Give reasons for their location.

71 — A Lava Plain

Purpose — To study the formation of a lava plain.

Materials — Modoc (Cal.) lava-bed topographic sheet.

Modoc (Cal.) sheet.

Locate the lava beds in this sheet.
Which is the largest bed?
What is its greatest width?
What is its greatest length?
What high elevation is found in this bed?
What is the average altitude of this bed?
Describe the topography about Mount Hoffman.

Why has it no drainage systems?

Where does Medicine lake get its water?

Locate any lava flows you find in this section.
How do these compare in size with the lava beds found in the other sections?

What is the height of the lava ridge between Tule and Lower Klamath lakes?
Describe Tule lake.

In what part of this map do you find the larger drainage systems?

Describe the course of Pitt river.

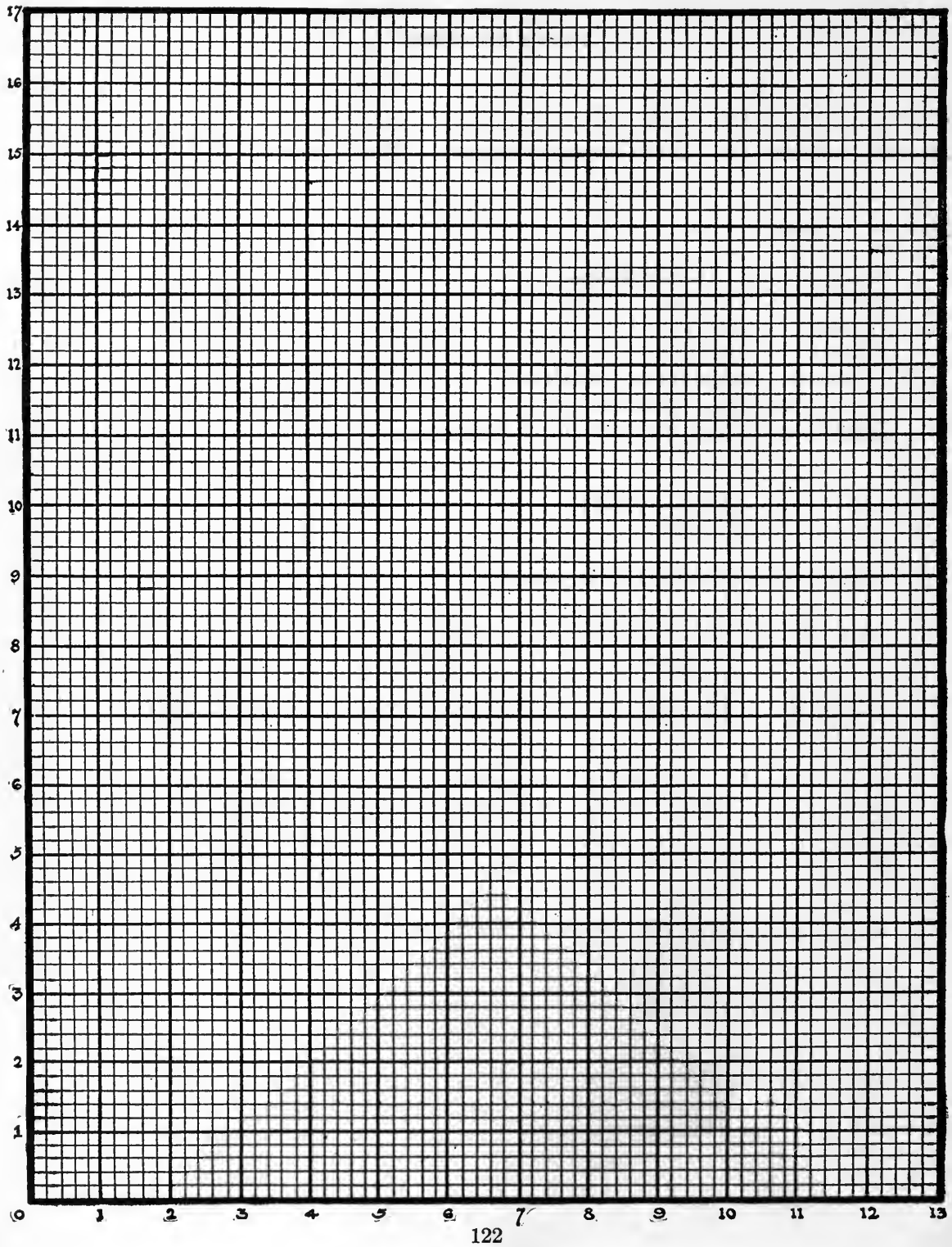
Explain the presence of the hot springs in Big valley.

Where are the centers of population?
Why are there so few settlements in the north?

Is this a young or an old area?
What will be the history of this area?

On cross-section paper draw profiles from

Dry lake	to Bieber.
Cornell	to Fairchild.
Burgettville	to Happy Camp.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72 — Peneplains

Purpose — To study the characteristics of peneplains.

Materials — Belchertown (Mass.), Webster (Mass.), Blackstone (Mass.) topographic sheets.

Locate these areas upon a map of Massachusetts and study their general structure. Compare their elevations and depressions, their drainage areas, and other physical features. Compare the areas represented in these sheets with other sections of Massachusetts.

Write a short description of the formation of a peneplain.

Draw a profile of a peneplain, dotting its former profile before being eroded.

73 — Plateaus

Purpose — To study plateau formation.

Materials — Centerpoint (W. Va.), Kaibab (Ariz.) topographic sheets.

Centerpoint (W. Va.) sheet.

Locate this area upon your United States map.
In which physiographic section of the United States is it?

In which part of the Appalachian plateau is it?

What is the climate of this section?
What is its rainfall?
What is the highest elevation of this area?
What is the lowest elevation of this area?
How does the elevation of this plateau compare with the elevation of the plateaus in the western part of the United States?

Is there a general slope to this plateau?
What is a good evidence of slope?

Locate the ten hills shown in this area.
What are the different heights of these hills?

What has caused the surface of this section to become uneven?

What general shape do the cross-sections of the valleys have?

Do some of the valleys show greater age than others?
Why?

Describe the shape of the divides.

Are there any small plateaus in this area?

At what stage of erosion is this section?

Is this a thickly settled section?
Are there any forests in this region?
What would be the industries of the inhabitants?

Are the roadways well developed?

Compare this area to other plateau sections of the United States.

Kaibab sheet.

Locate this area in reference to the above section.
Does the Kaibab sheet show more or less erosion than the Centerpoint sheet?
Which area is the older?
What is the greatest elevation in this section?
In what general direction does the land slope?
Describe the Kaibab plateau.

How much higher is this than the Kanab plateau?
Which shows the greater erosion?
In which are the valleys deeper?
In which part of this map are the river systems largest?
Which part of Kanab creek is intermittent?
What becomes of the creek running out of Big Spring?

What is the rainfall of this section?
Compare with that of the Centerpoint (W.Va.) area.
Why are there so few settlements?

What are the industries of this area?

What will be the history of this section?

74 — Valleys

Purpose — To study the formation of valleys.

Materials — La Salle (Ill.), Lykens (Penn.), Shamokin (Penn.) topographic sheets.

La Salle (Ill.) sheet.

What is the scale of this map?
How many square miles are represented in this section?
What is the contour interval?
Why is this contour interval made so small?

To what drainage system does this area belong?
In which direction does the Illinois river flow?
Of what river is it a tributary?
Locate the gorge about four miles west of Vermilion river.
Is this a deep or a shallow gorge?
How deep is it?
Where is it steepest?

What is the gradient of this stream?
Where are the tributaries of this stream located?

In what other parts of this area do you find similar gorges?

Are these young or old gorges? Why?

What is the average altitude of the land at the heads of these gorges?
What is the average altitude at their mouths?
Describe the course of the little Vermilion river north of the Illinois.

What is the depth of its bed?
Has it any tributary streams?
Describe the Tomahawk.

Is its gorge as narrow as those previously studied?
What is the width of the gorge of the Vermilion two miles north of La Salle?

Describe the Vermilion river found south of the Illinois.

What differences do you find between its gorge and those already studied?

Is this as young a gorge as the other two?
What is the width of the gorge where the road from Oglesby crosses it?
How deep is it there?
Is this a swift flowing river? Why?
What contour lines form the boundaries of the Illinois valley?
Are the valley sides steep or gentle in slope?
Give reasons for your answer.

Where are they the steepest?
Is the base of the Illinois valley wide or narrow?
What kind of a plain has this river made?
Where is it eroding its bank?
Where has deposition taken place?
What is the average altitude of the flood plain?
What geographic agent formed the valleys in this sheet?
Is this latter valley an older formation than the others?
Give your reasons for this answer.

Of what use is the Illinois-Michigan canal?

Explain the value of the location of La Salle.

Explain the regularity of the Illinois Central railroad north of La Salle.

Describe and locate the principal roadways.

Lykens (Penn.) sheet.

How does this area differ from the preceding one?

How many valleys do you find in this section?
Which is the largest one?
Which is the smallest one?

Were these valleys made by the rivers?
Locate and describe a valley made by a river.

What and where is the greatest altitude on this map?
How many ranges of mountains are there?
In what general direction do these mountains extend?
Describe the formation called Peters mountain.

Where is its elevation steepest?
Where does it spread out fan-shape?
How far is it across the valley at Williamstown?
What is the greatest distance from Mahantango mountain to Line mountain?
Which of these two valleys shows the greater erosion?
Is the region between Berry mountain and Peters mountain a plateau?
Is it a regular or irregular plateau?
Does it show evidences of erosion?
Locate and describe some of the principal water gaps.

How do the roadways cross these mountains?

Do the main roads generally follow the valleys?
Why?

Explain the peculiar turnings of the Kalmia Branch, Philadelphia & Reading railroad.

Of what use is the tunnel through the Big Lick mountain?

Where does this Summit Branch railroad end?
Why does it not go farther up the mountain?
How would you reach the top of the mountain from the end of the railroad?
Why are there no railroads in the valley at the north?

Describe the roadways in this valley.

Where are the centers of population?

What are the industries of these towns?
What are some of the industries of this section?

Shamokin (Penn.) sheet.

Describe the valley of Shamokin creek from Shamokin to Reed Crowl.

Describe the valley of Shamokin creek from Reed Crowl to Arters.

Describe the valley of the Susquehanna river.

How do the valleys of this area differ from those of the two sections just studied?

75 — Canyons

Purpose — To study a river canyon.

Materials — Kaibab (Ariz.) topographic sheet.

Kaibab (Ariz.) sheet.

Locate the area of this river upon your United States map.
To what drainage system does it belong?
Where does it empty?
Where does it rise?
What is the climate of this section?
What is its rainfall?
What evidences do you find that this is an arid country?

Describe the course of the Colorado river.

How much of the Grand Canyon shows in this sheet?
Where is its widest part?
How wide is it?
What is the greatest depth of this canyon?
Which of its sides shows greater erosion?
Measure the width of the top of the canyon along the parallel 36–15 from 112–15 to the greatest height just west of 112–30.
Draw the profile on the cross-section paper at this place. (Use only the heavier contour lines for guides.)

From the intersection of 36–15 and 112–15 measure the distance across the canyon to the corresponding contour line.
How deep is the canyon at this place?
How are the contour lines arranged?

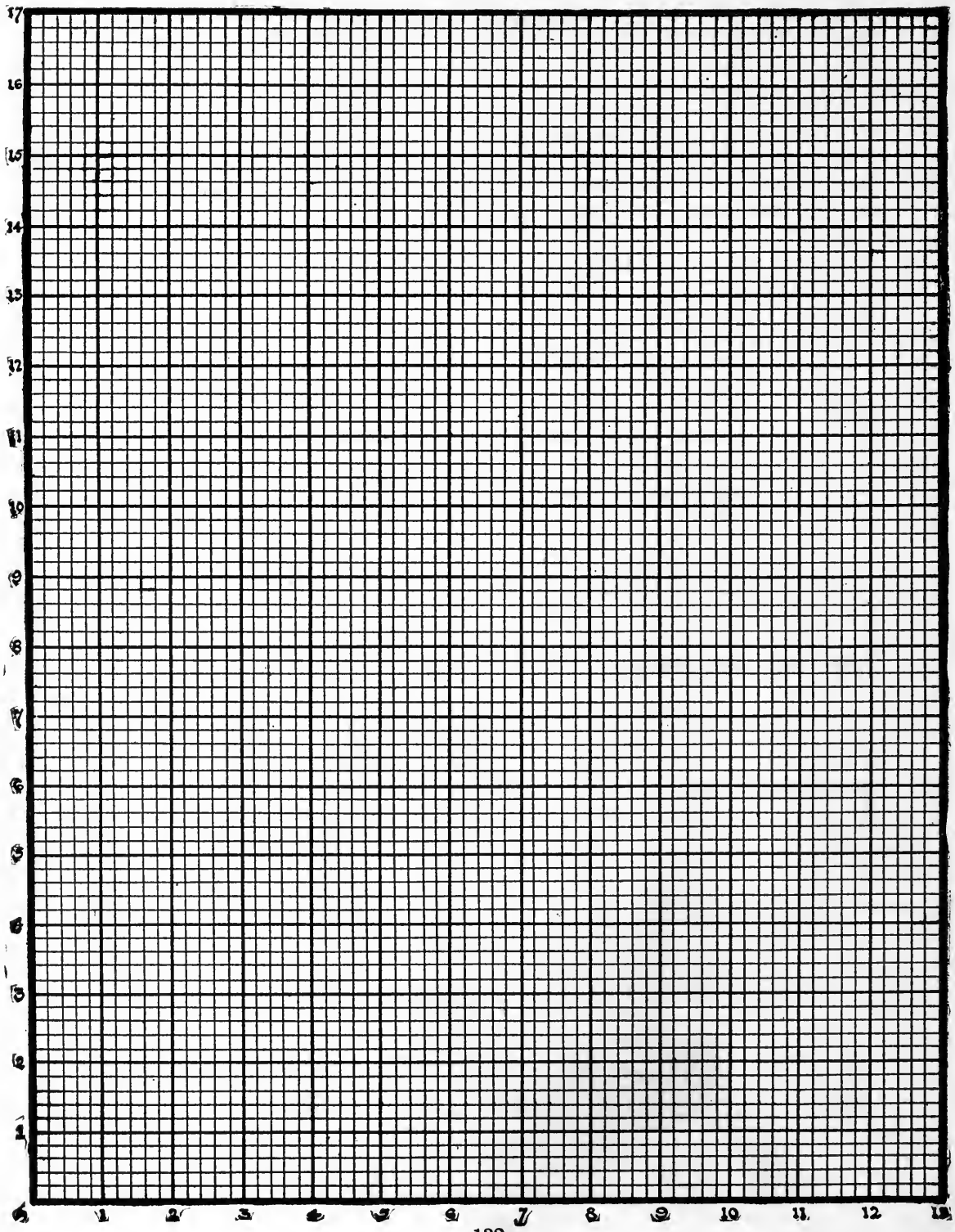
Describe Powells plateau.

Why are there so few tributary streams in this section?

Compare this section of the Grand Canyon with that west of the 112–30 meridian.
Which is the wider?
Which is the deeper?
Which section shows the more erosion?
Which has the larger tributary canyons?
What is the distance across the canyon where the Kanab creek enters the Colorado river?
Are the sides of this canyon as steep as those of the canyon farther east?
What is the difference in height of the Colorado river at Bright Angel creek and at Cataract creek?
What is the gradient of this river?
Is the river broad?
Is it still eroding its bed?
Is this a young or an old area?
What will be the history of this river?

Draw a profile on the cross-section paper of the Colorado river where the Kanab enters it.

Write a short account of a trip through the Colorado canyon.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76 — Desert Formation

Purpose — To study the structure of a desert.

Materials — Sevier desert (Utah) topographic sheet.

Sevier desert (Utah) sheet.

Locate this area upon your United States map.
To what physiographic section does it belong?
What is the climate of this country?
What is its rainfall?
What is the altitude of the Sevier desert?
Describe the surface of this desert.

Is this topography characteristic of all desert formation?
What mountains are in the eastern part of this area?

To what system do they belong?
What is their greatest altitude?
What evidences of erosion do they show?

Will erosion take place rapidly in this area?
Why?

How does the Sevier river cross these mountains?
Has this river many tributaries? Why?
What elevations are found to the south?
Describe Cherry creek.

Is there much alluvial soil in this area?
What is the nature of the soil?

Why are there so few roadways?

Are the centers of population large or small?
What will be the principal industry of the cities in the northern part?
Will this area ever be valuable to man?

Compare this desert area with other desert areas to be found in the world.

77 — Folded Mountains

Purpose — To study the structure of folded mountains.

Materials — Hummelstown (Penn.), Harrisburg (Penn.) quadrangle topographic sheets.

Hummelstown (Penn.) sheet.

Locate this section upon your United States map.
To which physiographic region does it belong?

What system of mountains extends across this area?
What are the names of the ranges?

How do they extend?
What is the average height of these mountains?
How deep is the first valley?
How wide is it?
How deep is the valley of Stony creek?
How wide is it?
Describe the topography between Sharp and Stony mountains.

Which side of these mountains is the more deeply eroded?
Which valley has the more irregular surface?
Where will you be likely to find anticlines?
Where will you find synclines?
How are folded mountains made? (Explain fully.)

What evidences do you find in this area that these mountains might have been made in this way?

Draw a profile of the first valley from the summit of Blue mountain to the summit of Sharp mountain.

Harrisburg (Penn.) quadrangle sheet.

Compare this area with that of Hummelstown.
Note briefly the similarities and the differences.

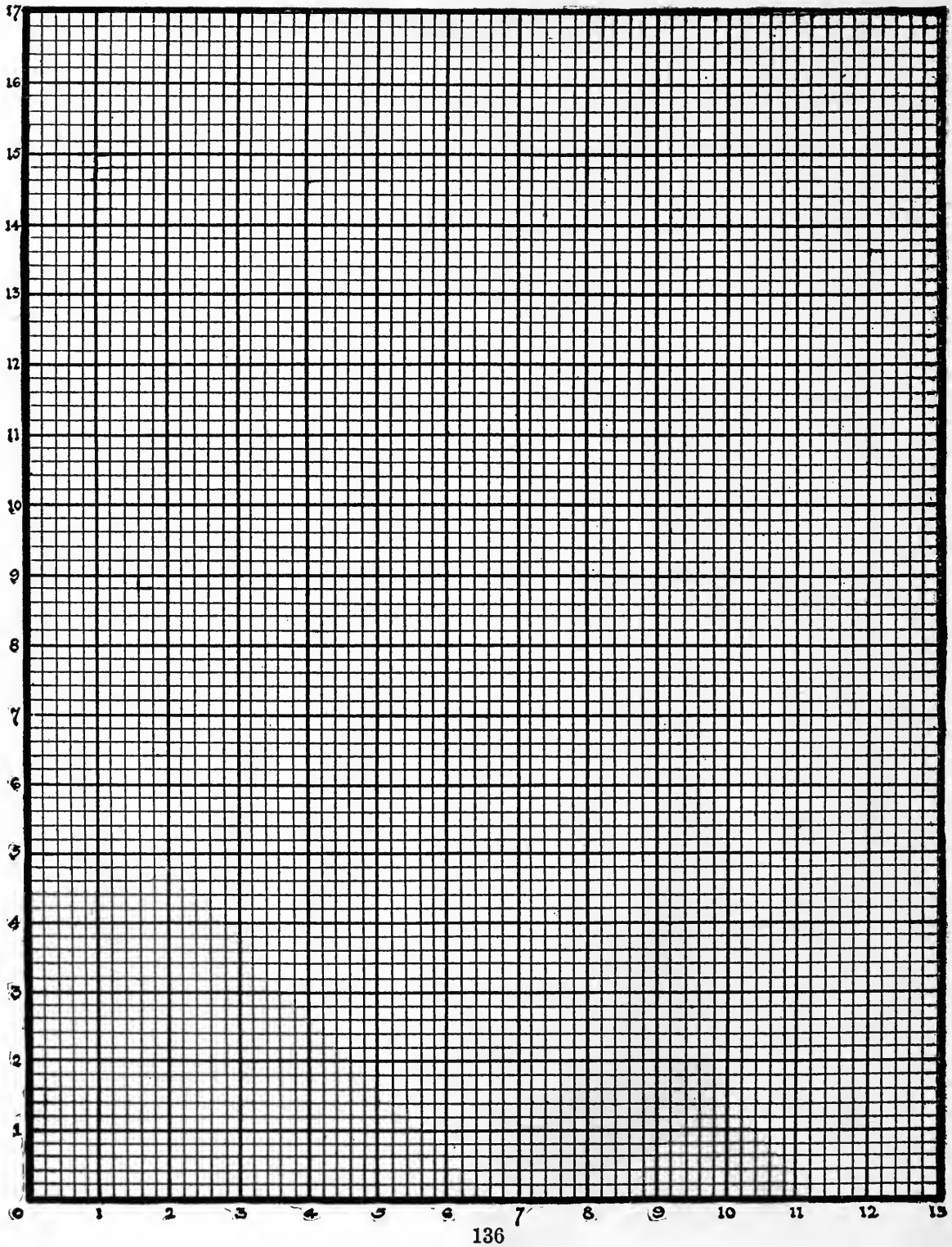
How many parallel valleys do you find?

What is the width of the valley of Fishing creek?
How deep is it?
Is it an eroded valley?
Compare this valley to that of the Colorado river.

What is the gradient of Fishing creek?
Describe the valley through which the Philadelphia & Reading railroad passes.

Describe the valley and ridge north of Peters mountain.

What evidences do you find that these ranges were made by the folding of the earth's crust?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78 — Domed Mountains

Purpose — To study the structure of domed mountains.

Materials — Henry mountains (Utah) topographic sheet.

Henry mountains (Utah) sheet.

Locate this area upon your United States map.
What evidences of erosion do you find?

How is this erosion represented upon the map?

Locate the four principal mountains in this area.
How do they compare in shape?

How far are they apart? (Record each distance from Mt. Ellsworth northward.)

What is the altitude of
Mt. Ellsworth?
Mt. Holmes?
Mt. Hillers?
Mt. Pennel?

Are these mountains situated in the volcanic region of the United States?
Are there any evidences of intruded lava in this section?
Where is this lava located?

Where are the igneous rocks found?

What has brought these rocks to the surface?

What must have been the original shape of these mountains?

What shape do all laccolithic mountains have?

Describe the valley of Pine Alcove creek.

Sketch a profile of Mt. Holmes from the 5,000 contour line and dot its probable former shape.

79 — Life History of Mountains

Write a full account of the life history of mountains.

IV. THE ATMOSPHERE

80 — The Composition of the Atmosphere

Purpose — To study the composition of the atmosphere.

Materials — Ruler, pencil.

Composition of the atmosphere:

	per cent.
Oxygen	20.60
Nitrogen	77.18
Water vapor	1.40
Carbon dioxide	.04
Other gases	.78

Draw a diagram two inches square. Divide this to show the proportion of gases and vapor in the atmosphere.

Of what use is oxygen to all forms of life?

Explain rapid combustion (burning).

Explain slow combustion (oxidation).

How does oxygen get into the rocks?

How does the plant use oxygen?

How does oxygen return to the air?

What plants take nitrogen directly from the air?

How do they do this?

What is the function of nitrogen in the air?

What effect has carbon dioxide on the climate of the earth?

Is CO_2 ever found in the earth's crust?

What is the " choke damp " of mines?

Why is it necessary to ventilate a room?

Draw a diagram showing how the atmosphere diffuses the light of the sun at twilight. Contrast with conditions at noon.

Which travels the faster in the atmosphere, light or sound waves?

Illustrate.

How does the atmosphere distribute moisture?

Illustrate.

81 — Atmospheric Pressure

Purpose — To study atmospheric pressure.

Materials — Glass tumbler, piece of cardboard (large enough to completely cover mouth of tumbler), large-mouthed bottle, pan, small candle, cork, scales.

Fill the tumbler full of water and place the cardboard over the top.

Invert the tumbler, holding the cardboard in place with the fingers. Carefully remove the fingers.

What occurs?

Why does the cardboard remain over the mouth of the tumbler?

Hold the tumbler in different positions.

Does the cardboard fall off?

Does air press upon the cardboard in all directions?

Compute the weight of the water in the tumbler by weighing it empty and then full of water.

How much must have been the air pressure upon the mouth of the tumbler? (The total pressure of the air was of course greater than this figure.)

Why could not this experiment have been done without the cardboard?

Partially fill the pan with water. Attach the lighted candle to the cork and float it upon the water. Invert the large-mouthed bottle over the candle with its mouth below the surface of the water but not on the bottom of the pan.

What occurs?

What causes the candle to rise in the bottle?

How high does the water rise in the bottle?

Where does the water in the bottle come from?

What causes the water in the pan to pass into the bottle?

What is the atmospheric pressure per square foot?

What is meant by " an atmosphere? "

What causes this weight of the atmosphere?

Does this weight vary any from day to day?

Does it vary with altitude?

82 — The Barometer

Purpose — To construct and study a barometer.

Materials — Glass tube 36 inches long closed at one end, glass tumbler, small glass funnel, support for tube, mercury, ruler.

Fill the tube with mercury by using the glass funnel. Holding a finger over the open end, invert the tube in the tumbler partly filled with mercury. Remove your finger and fasten the glass tube in the support.

What was in the glass tube before the mercury was inserted?
Was there any air in the tube after it was filled with mercury?
What has become of this air?

Describe what happened when the tube was placed in the glass of mercury and the finger was removed from its end.

Would this have happened if the top of the tube had been open?
What is in the tube now?
Is there any air in the tube above the column of mercury?
Give reasons for your answer.

How high is the top of the mercury column above the mercury in the glass?
What is supporting this column of mercury?
Explain this fully.

What would cause the height of this column to vary?
If the air pressure was increased, what would happen to the column of mercury?
What would happen if the pressure were decreased?
How would a barometer show the variations of air pressure?

How would a barometer show the changes of elevation?

Would the barometric column rise or fall if you ascended a mountain?
Why?

Would the barometric column rise or fall when it rains?
Why? (Explain fully.)

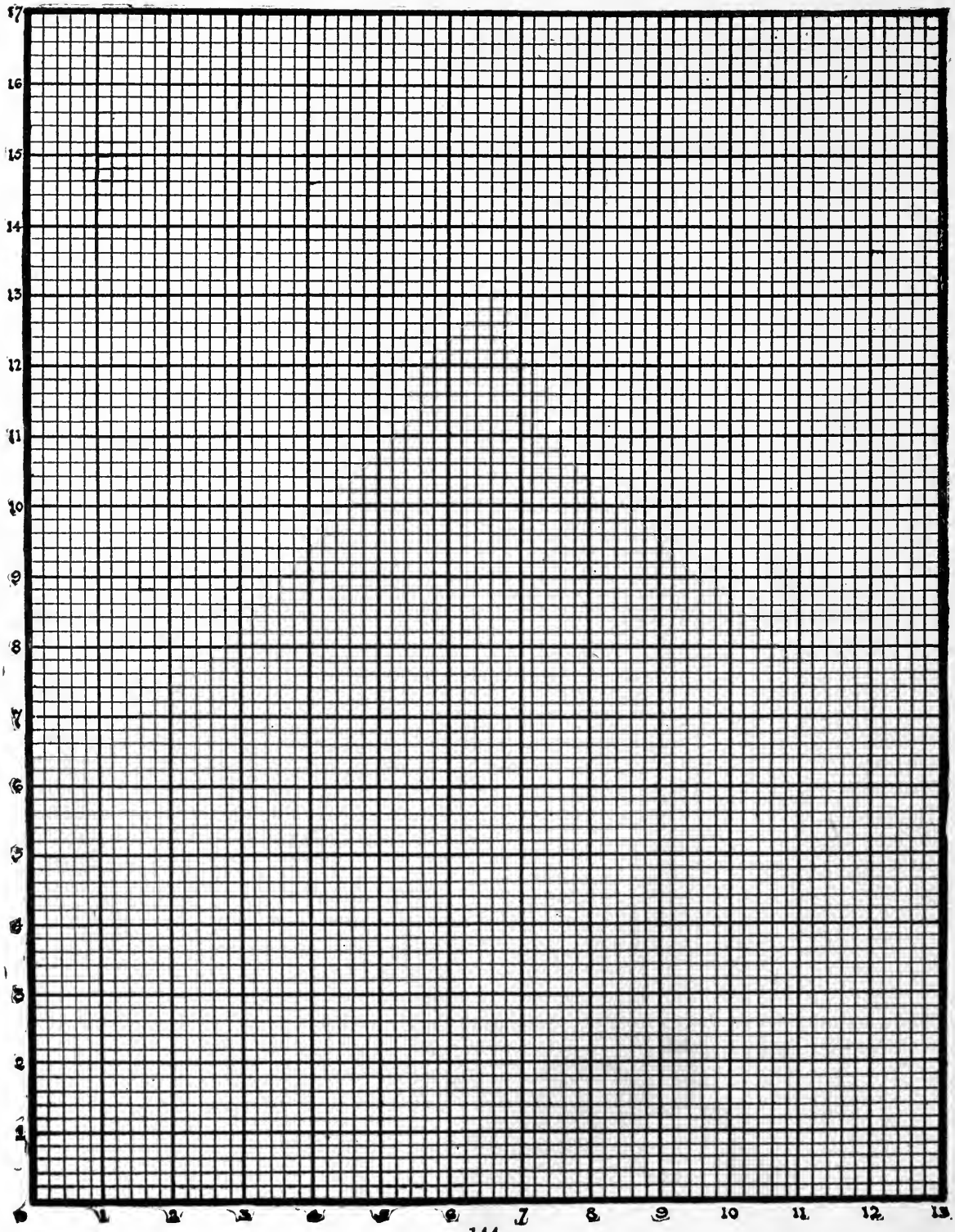
Compare the barometer you made with a commercial one.

Make a drawing of the apparatus used in making your barometer.

Construct a pressure curve on the cross-section paper from the following barometric readings:

Day.	8 a. m.	Noon.	8 p. m.	Midnight.
Monday	29.70	29.80	29.90	30.00
Tuesday	30.30	30.10	30.40	30.50
Wednesday	30.20	30.00	29.60	29.40
Thursday	29.20	29.70	30.00	30.20
Friday	30.30	30.60	30.50	30.40
Saturday	30.30	30.30	30.40	30.50
Sunday	30.60	30.30	30.10	30.00

Construct other curves taken from the readings of the school barometer. (Daily readings for a week at a time will furnish enough data for the construction of these curves.)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83 — Isobars

Purpose — To study and plot isobaric lines.
Materials — Colored pencils.

Upon the United States weather map, draw isobars from the pressure figures given in the following table. (Use a different colored pencil for each isobar.)

Mark the high and low pressure areas.

Abilene, Tex	29.9	Los Angeles, Cal	30.0
Asheville, No. Ca.	30.0	Meridian, Miss.	30.0
Atlanta, Ga.	30.0	Modena, Utah	29.8
Augusta, Ga.	30.1	Moorhead, Minn.	29.6
Baker City, Oreg.	29.7	Mount Weather, Va.	30.0
Bismark, No. Dak.	29.4	Norfolk, Va..	30.1
Boise, Idaho	29.6	North Platte, Neb.	29.6
Charlotte, No. Ca.	30.1	Oklahoma, Okla.	29.9
Chattanooga, Tenn.	30.0	Pensacola, Fla.	30.0
Cheyenne, Wyo.	29.5	Pierre, So. Dak.	29.5
Cincinnati, Ohio	30.1	Pittsburg, Penn.	30.0
Cleveland, Ohio	30.1	Pocatello, Idaho	29.5
Davenport, Iowa	30.1	Port Arthur, Can.	30.1
Del Rio, Tex.	29.9	Rapid City, So. Dak.	29.3
Des Moines, Iowa	30.0	Red Bluff, Cal.	30.0
Devil's Lake, No. Dak.	29.5	Roseburg, Oreg.	29.9
Dodge City, Kans.	29.8	Salt Lake, Utah	29.6
Duluth, Minn.	29.9	San Francisco, Cal.	30.1
Durango, Colo.	29.7	San Louis Obispo, Cal.	30.1
Eureka, Cal.	30.0	Sante Fe, N. Mex.	29.8
Fort Smith, Ark.	30.0	Shreveport, La.	30.0
Fresno, Cal.	30.0	Spokane, Wash.	29.6
Grand Junction, Colo.	29.6	Springfield, Ill.	30.1
Harrisburg, Penn..	30.0	Springfield, Mo.	30.0
Helena, Mont.	29.3	St. Paul, Minn.	29.9
Huron, So. Dak.	29.6	Tacoma, Wash.	29.8
Jupiter, Fla.	30.1	Tampa, Fla.	30.1
Kalispel, Mont.	29.4	Topeka, Kans.	29.9
Knoxville, Tenn.	30.0	Williston, No. Dak.	29.3
La Crosse, Wis.	30.1	Winnemucca, Nev.	29.9
Lander, Wyo.	29.3	Yankton, So. Dak.	29.7
Lewiston, Idaho	29.5	Yuma, Ariz.	29.9
Lincoln, Neb.	29.8		

What are high pressure areas?
What are low pressure areas?
What conditions of the atmosphere produce each of these areas?
What are isobars?
In what general directions do the isobars extend?
Note any marked irregularities in the isobars.

EXPLANATORY NOTES.

Observations taken at 8 a. m., seventy-fifth meridian time. Air pressure reduced to sea level.

ISOBARS, or continuous lines, pass through points of equal air pressure.

ISOTHERMS, or dotted lines, pass through points of equal temperature.

SYMBOLS indicate state of weather: ○ clear; ◑ partly cloudy; ● cloudy; (R) rain; (S) snow; (M) report missing; ⚡ thunderstorm. ARROWS fly with the wind.

Shaded areas when used show regions of precipitation during past 24 hours.

"T" in table, indicates amount too small to measure.

WIND-BAROMETER INDICATIONS.

When the wind sets in from points between south and southeast and the barometer falls steadily a storm is approaching from the west or northwest, and its center will pass near or north of the observer within 12 to 24 hours with wind shifting to northwest by way of southwest and west. When the wind sets in from points between east and northeast and the barometer falls steadily a storm is approaching from the south or southwest, and its center will pass near or to the south or east of the observer within 12 to 24 hours with wind shifting to northwest by way of north. The rapidity of the storm's approach and its intensity will be indicated by the rate and the amount of the fall in the barometer.

84 — Air Density

Tell concisely what is meant by air density.

Explain fully the terms volume, mass, and density as applied to solids.

What causes the density of the air to vary? (Explain fully.)

What effect upon life does this variation of air density have? (Explain fully.)

What evidences do you find that air is compressible?

What force compresses the atmosphere?

In what part of the earth's atmosphere will friction be greatest?

Why?

Describe the so-called " falling stars."

85 — Atmospheric Temperature

Purpose — To study the distribution of atmospheric temperature.

Materials — Thermal maps of the world for July and January, colored pencils.

Describe carefully how the atmosphere is warmed and cooled.

What effects upon temperature have pressure, latitude, altitude?

Upon the map of the world locate the greatest heat belt. (Use a red colored pencil for this purpose.)
Locate the cold belts. (Use a blue colored pencil for this purpose.)

What is the average July temperature for the 30th parallel? The 40th parallel? The 60th parallel? The 80th parallel?

What is the average January temperature at these places?

In which hemisphere are the land areas the largest?
In which hemisphere are there the greatest extremes of temperature?

Why?

Describe the seasonal changes of temperature at your home and give reasons for same.

Which section of the earth will receive the greatest amount of heat on March 21st? June 21st? September 21st? December 21st?
Give the relative proportions of heat received by the North Pole on these dates.

Describe the variations of heat at the 60th parallel between December 1st and June 1st.

Mark your home town upon the map of the world. Locate the antipodes of this place. Compare the seasonal changes of temperature of these places.

Plot temperature curves for the following places:

Place	Lat.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1 Singapore . . .	0	79	80	81	81	82	82	82	81	81	80.5	80	79
2 Galveston . .	29	51	58	63	71	78	81	83	79	76	60.0	58	51
3 Boston	42	37	29	35	51	60	71	78	77	71	59.0	47	35
4 Your home . .													

Which month is warmest in curve 2?

In curve 4?

Why are these months the warmest?

What is the seasonal range in each curve?

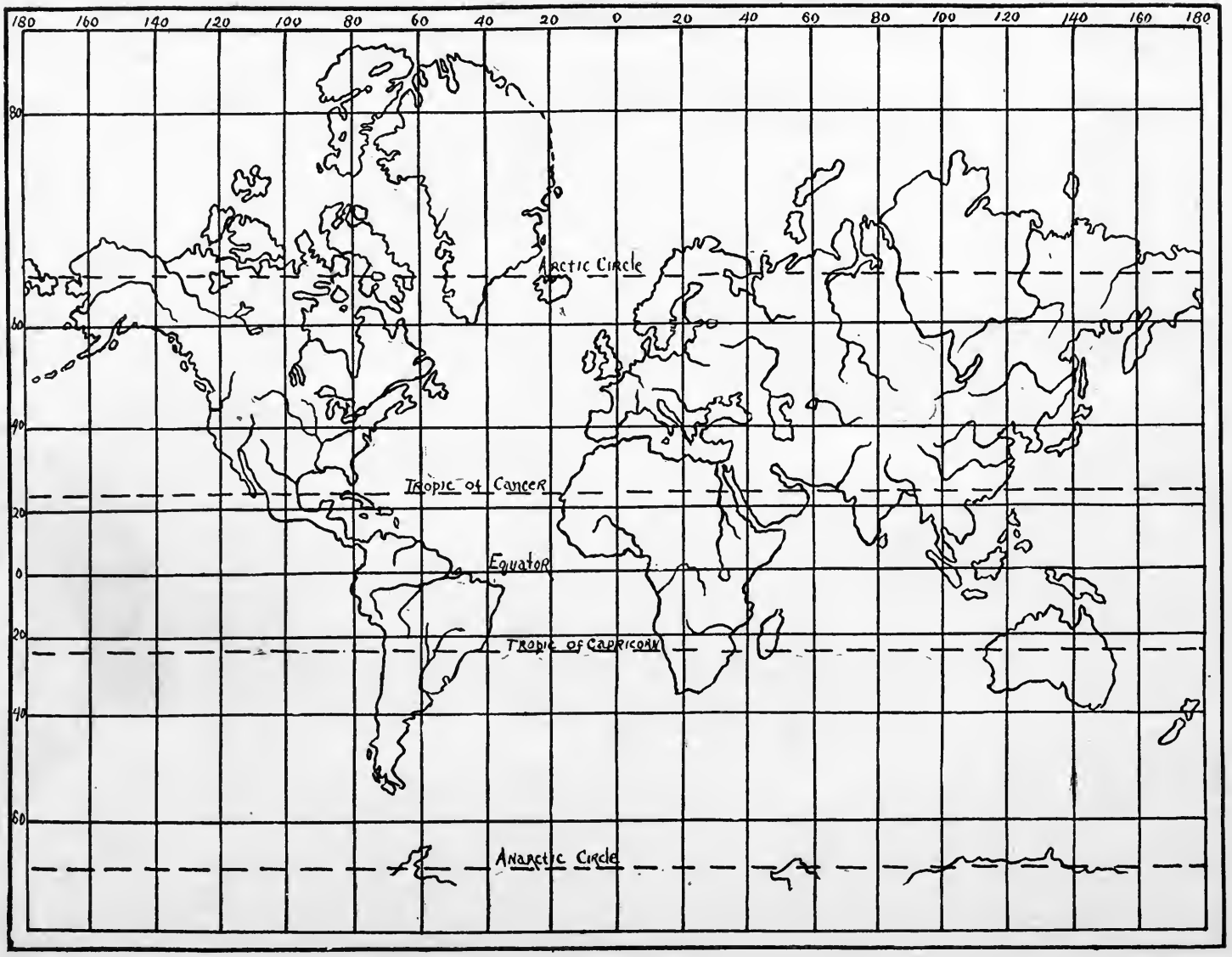
1 —

2 —

3 —

4 —

Consult temperature records of other cities and explain any differences found.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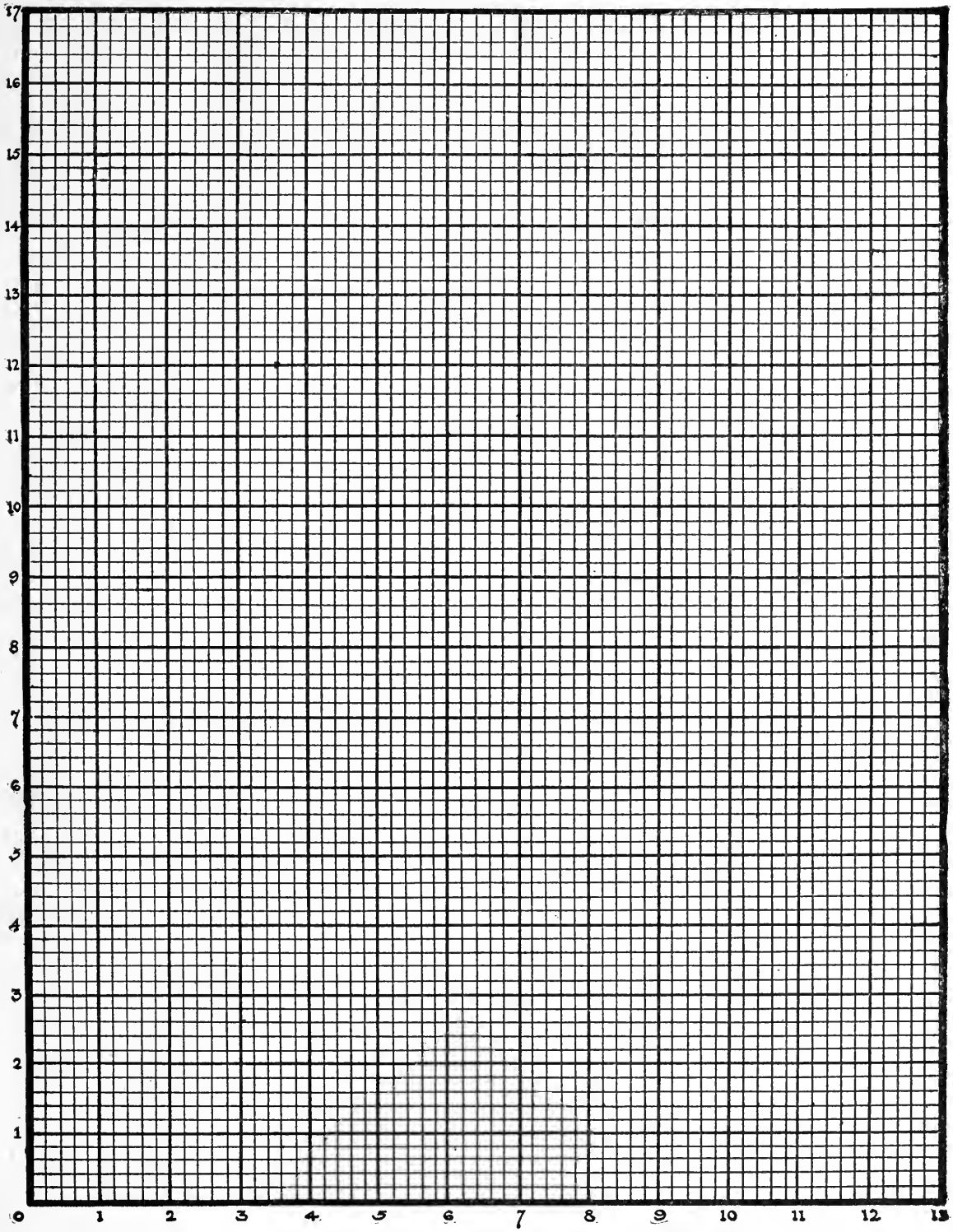
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86 — The Thermometer

Purpose — To study the thermometer.

Materials — Two small thermometers.

Describe the structure of a thermometer.

What are the limits of temperature under which a mercurial thermometer may be used? Why?

When would an alcoholic thermometer be used?

Describe the Fahrenheit scale on the thermometer.

Why is the Centigrade scale better than the Fahrenheit?

How would you change Fahrenheit readings to Centigrade readings?

How would you change Centigrade readings to Fahrenheit readings?

Of what use is a wet bulb thermometer?

Explain how it acts.

To one of the two thermometers attach a piece of wet cloth about the bulb; whirl the thermometer in the air to hasten evaporation. Record the readings of the two thermometers in the following table. Compare the results.

Time	Monday		Tuesday		Wednesday		Thursday		Friday	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
8.00										
10.00										
12. m.										
2.00										
4.00										
6.00										

87 — Isotherms

Purpose — To study and plot isothermal lines.

Materials — Colored pencils.

Upon the United States weather map draw isothermal lines from the temperature figures given in the following table. (Use a different colored pencil for each isotherm.)

Asheville, N. C.	30	Missoula, Mont.	10
Atlanta, Ga.	40	Mobile, Ala.	50
Baker City, Ore.	30	New Haven, Conn.	20
Billings, Mont.	0	New Orleans, La.	60
Birmingham, Ala.	40	Norfolk, Va.	30
Bismark, No. Dak.	10	Qu'Appelle, Can.	10
Brownsville, Tex.	50	Pensacola, Fla.	50
Burlington, Vt.	10	Phoenix, Ariz.	50
Chattanooga, Tenn.	40	Pierre, So. Dak.	20
Cheyenne, Wyo.	30	Pittsburg, Penn.	30
Cincinnati, Ohio	40	Port Arthur, Can.	20
Cleveland, Ohio	30	Portland, Me.	10
Corpus Christi, Tex.	60	Red Bluff, Cal.	40
Devil's Lake, No. Dak.	10	Roseburg, Oreg.	40
Duluth, Minn.	20	Roswell, N. Mex.	50
Flagstaff, Ariz.	40	Salt Lake, Utah	30
Fort Smith, Ark.	50	San Luis Obispo, Cal.	50
Green Bay, Wis.	30	Santa Fe, N. Mex.	40
Hannibal, Mo.	40	Savannah, Ga.	40
Havre, Mont.	10	Sheridan, Wyo.	10
Helena, Mont.	10	Sioux City, Iowa	30
Huron, So. Dak.	20	Spokane, Wash.	30
Jacksonville, Fla.	50	St. Paul, Minn.	30
Kalispel, Mont.	20	Syracuse, N. Y.	20
Key West, Fla.	70	Tacoma, Wash.	40
Lander, Wyo.	20	Tampa, Fla.	60
Lansing, Mich.	30	Wichita, Kans.	40
Los Angeles, Cal.	50	Williston, N. Dak.	0
Memphis, Tenn.	50	Winnemucca, Nev.	30
Meridian, Tenn.	50		

What are isothermal lines?

In what general direction do they extend?
How do they differ in this respect from isobaric lines?
Why do not the isothermal lines follow the parallels in the earth's surface.

Compare the weather maps that you have constructed with maps issued by the United States Weather Bureau.

FORM DD.

EXPLANATORY NOTES.

Observations taken at 8 a. m., seventy-fifth meridian time. Air pressure reduced to sea level.

ISOBARS, or continuous lines, pass through points of equal air pressure.

ISOTHERMS, or dotted lines, pass through points of equal temperature.

SYMBOLS indicate state of weather: ○ clear; ◑ partly cloudy; ● cloudy; (R) rain; (S) snow; (M) report missing; ⌇ thunderstorm. ARROWS fly with the wind.

Shaded areas when used show regions of precipitation during past 24 hours.

"T" in table, indicates amount too small to measure.

WIND-BAROMETER INDICATIONS.

When the wind sets in from points between south and southeast and the barometer falls steadily a storm is approaching from the west or northwest, and its center will pass near or north of the observer within 12 to 24 hours with wind shifting to northwest by way of southwest and west. When the wind sets in from points between east and northeast and the barometer falls steadily a storm is approaching from the south or southwest, and its center will pass near or to the south or east of the observer within 12 to 24 hours with wind shifting to northwest by way of north. The rapidity of the storm's approach and its intensity will be indicated by the rate and the amount of the fall in the barometer.

88 — Temperature Zones

Purpose — To study the temperature zones.

Materials — Colored pencils, mean annual isothermal map of the world.

What is the difference between temperature and quantity of heat? (Explain fully.)

What factors govern the temperature of any place?

What is the heat equator?

Why does this equator move north and south during the year?

What isotherms form the boundaries of the hot belt?

Of the temperate belt?

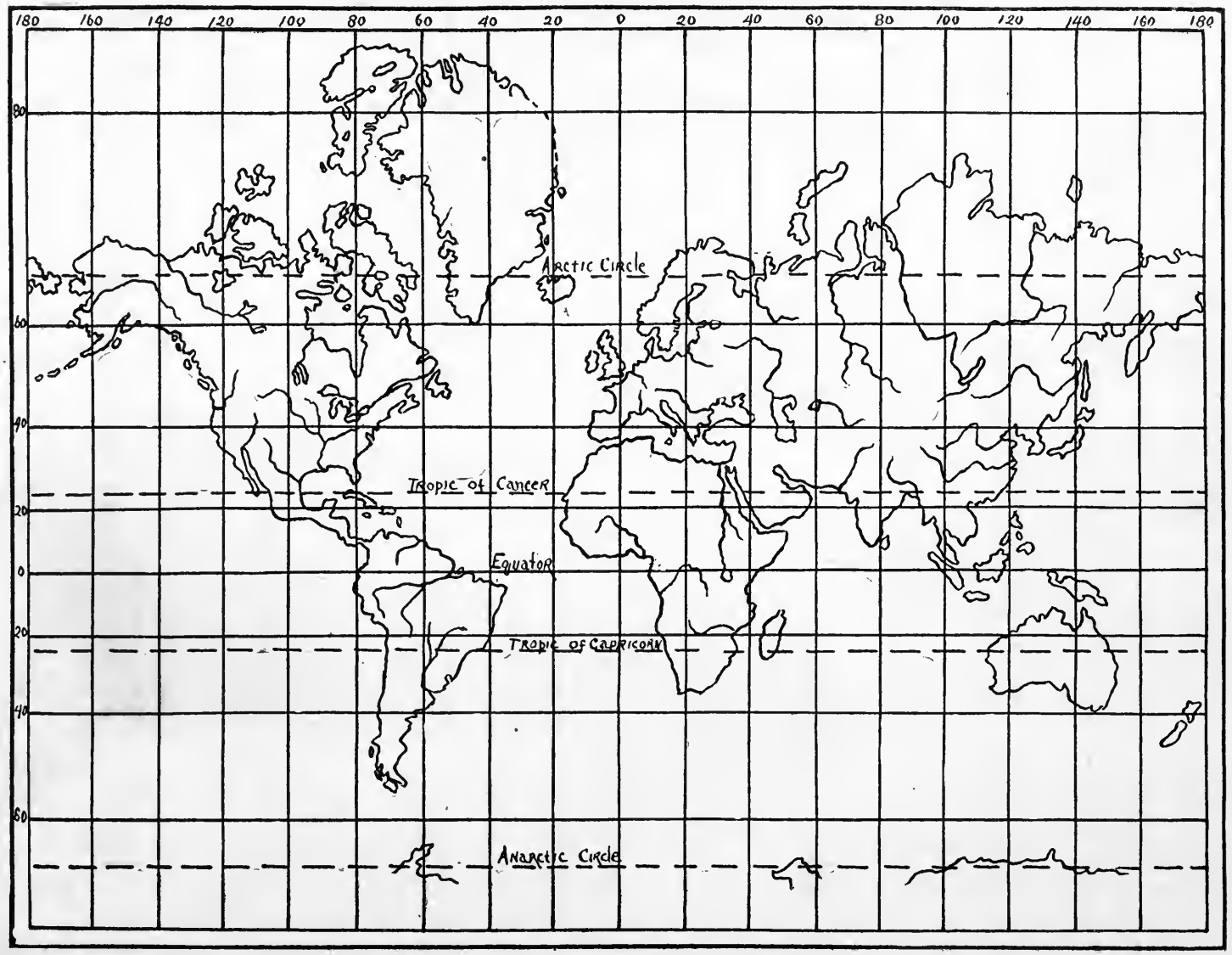
Of the frigid belt?

Why are the temperature zones more irregular in the northern than in the southern hemisphere?

Of what belts are the tropics and the circles the boundaries?

Explain fully your reasons for this answer.

Indicate the hot belt and the two frigid belts upon the map of the world. Name each temperature belt upon your map. (Consult your isothermal map for the boundaries of these belts. Color the warm belt red, the temperate belt green, and the frigid belt blue.)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Arctic Circle
Tropic of Cancer
Equator
Tropic of Capricorn
Antarctic Circle

89 — Insolation

Purpose — To study the effect of insolation.

Materials — A piece of board with a two-inch square opening in the center, thermometer.

Place the board on a level table in the sunlight. Elevate one end of the board so that the opening will face the south. Raise or lower the board until the noon sun will penetrate the opening at right angles to the face of the board.

How does the lighted area upon the table compare with the opening in the board at —

8 a. m.

10 a. m.

12 m.

2 p. m.

4 p. m.

When is the lighted area the smallest?

What is its shape then?

When will the greatest amount of sunshine pass through this opening?

Place the thermometer upon the table so that the bulb will be directly beneath the opening in the board. Record the results in the table below.

Time	Area of light	Temperature	Position of sun	Per cent. of light received
8.00				
10.00				
12.00				
2.00				
4.00				

Compare the results shown in the above table with the effects of different light angles upon the ground. (To do this a southern slope is preferable.)

Apply this principle to seasonal changes. (Explain fully.)

90 — Planetary Winds

Purpose — To map and study the planetary winds.

Materials — Compass, ruler, pencil.

With a radius of two inches, describe a circle to represent the circumference of the earth. Draw the equator and the two 30-degree parallels. Mark the equator L (for low pressure area) and the parallels H (for high pressure areas). Indicate by means of arrows the direction of the wind from these high pressure areas if the earth did not rotate. By means of other arrows show the directions of these winds on the rotating earth. Name the two winds represented.

In what direction do winds blow?

Explain this.

What is meant by high pressure areas?

What is meant by a low pressure area?

How is temperature a factor in creating these areas?

Explain Ferrel's Law.

Explain the anti-trades.

Locate the equatorial belt of calms on your map.
Locate the horse latitudes.
Why are these calm belts?

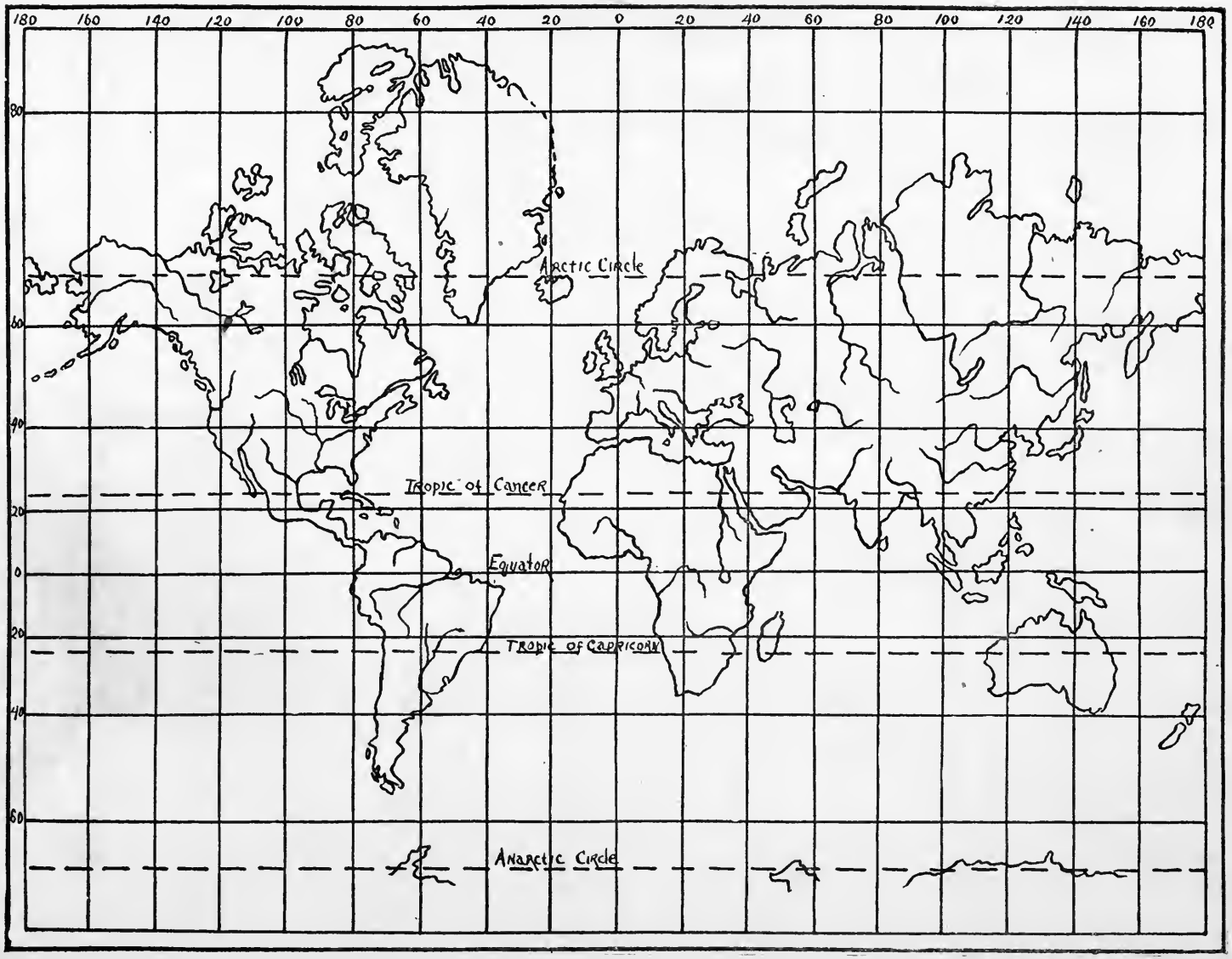
Describe the circum-polar whirl.

Explain the annual movements of these winds north and south.

Upon the map of the world locate the following areas:

Winds: Prevailing southwesterlies, prevailing northwesterlies, northeast trades, southeast trades, monsoons.

Calms: Calms of Cancer and Capricorn, Equatorial Calms, Doldrums.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Arctic Circle
Tropic of Cancer
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91 — Cyclonic Winds

Purpose — To study cyclonic winds.

Materials — United States weather maps covering a week of time.

Write a short account of cyclonic winds.

Write a short account of anti-cyclonic winds.

Study the movements of the high and low pressure areas upon your weather maps. Note carefully the direction of the winds about these areas.

Describe and explain the movements of the cyclonic winds as shown by your weather maps.

92 — Monsoons

Purpose — To study the monsoon winds.

Materials — Colored pencils.

Sketch a map of the peninsular of India and color it green. Indicate the mountains on the north and west with a brown colored pencil. Color the Indian ocean blue. Show by means of black arrows the direction in which the wind blows from January to June. Show by means of purple arrows the direction in which the wind blows from June to January.

Explain fully the causes of the monsoon winds. (Using the above map as an illustration.)

32 — Evaporation

Purpose — To study evaporation.

Materials — Two small pieces of window glass, two tin cups, shallow pan, tumbler, two thermometers, alcohol.

Put a few drops of water on each of the two pieces of glass. Place one of these in the sunshine and the other in the shade. (Be careful that each is kept away from a draught.)

Which of these evaporates faster?
What effect has heat upon evaporation?

Explain why heat causes evaporation to take place.

Repeat this experiment by placing one of the pieces of glass in a strong draught and the other where the draught cannot reach it. (Keep both out of the sunshine.)

Which evaporates faster?
Explain why a draught causes rapid evaporation.

Fill the two tin cups with water. Cover one with the tumbler.

In which cup does evaporation take place more rapidly?
What collects upon the tumbler?

Place equal amounts of water in one of the cups and in the pan.

In which does the water evaporate faster?
Why?

What is the difference in the surface areas of these two vessels?

Note the temperature as recorded by the two thermometers. Drop a little alcohol upon the bulb of one of the thermometers.

What happens?

Explain the cause of this change of temperature.

Drop some warm water upon the bulb of the second thermometer.

What happens?
Explain this change.

94 — Condensation

Purpose — To study condensation of water vapor.

Materials — Flask, glass plate, tumbler, ice, thermometer.

Heat some water in the flask until it boils.

What becomes of the water in the flask?

What is the color of the steam?
What has caused the change from water to steam?

Hold the glass plate above the opening of the flask.

What collects on the under side of the plate?
What causes this vapor to collect?

What causes it to condense?

Is there any vapor collected on the upper side of the plate?

Cool the glass plate as much as possible. Hold it before the mouth and breathe upon it.

Has any vapor collected upon the plate?

Where did this vapor come from?

Why does fog form upon a mountain slope?

What is dew?

How is it formed?

Tell briefly what conditions are necessary for the condensation of water vapor.

Place a piece of ice in a tumbler of water at the same temperature as the room. Stir with a thermometer until moisture begins to form on the outside of the tumbler. Note the temperature of the water as soon as the moisture forms and the temperature of the room.

From the following table find the capacity of the atmosphere in the room for moisture. Repeat this experiment at different times recording the results below.

SATURATED WATER VAPOR IN A CUBIC FOOT OF SPACE AT DIFFERENT TEMPERATURES EXPRESSED IN GRAINS

20° 1.235	40° . . . 2.849	60° . . . 5.745	80° . . . 10.934
22° 1.355	42° . . . 3.064	62° . . . 6.142	82° . . . 11.626
24° 1.483	44° . . . 3.294	64° . . . 6.563	84° . . . 12.356
26° 1.623	46° . . . 3.539	66° . . . 7.009	86° . . . 13.127
28° 1.773	48° . . . 3.800	68° . . . 7.480	88° . . . 13.937
30° 1.935	50° . . . 4.076	70° . . . 7.980	90° . . . 14.790
32° 2.113	52° . . . 4.372	72° . . . 8.505	92° . . . 15.689
34° 2.279	54° . . . 4.685	74° . . . 9.066	94° . . . 16.634
36° 2.457	56° . . . 5.016	76° . . . 9.655	96° . . . 17.626
38° 2.646	58° . . . 5.370	78° . . . 10.277	98° . . . 18.671

Dewpoint	Date	Time	Temperature of water	Temperature of room
1				
2				
3				
4				

RESULTS

1				
2				
3				
4				

95 — Relative Humidity

Purpose — To study relative humidity.

Materials — Two thermometers, small pan, piece of muslin.

Attach the muslin to the bulb of one of the thermometers allowing it to hang down several inches. Fill the pan with water and place the end of the muslin in the water. Fasten the thermometers to a stand so that they may be easily read. Keep water in the pan.

Record readings in the following table:

Day	Time	Dry bulb reading	Wet bulb reading	Difference	Relative humidity
Monday	10.00 12.00 m. 2.00				
Tuesday	10.00 12.00 m. 2.00				
Wednesday	10.00 12.00 m. 2.00				
Thursday	10.00 12.00 m. 2.00				
Friday	10.00 12.00 m. 2.00				
Saturday	10.00 12.00 m. 2.00				

What is meant by saturation?

What is absolute humidity?

What effect upon life growth has excessive humidity?

96 — Classification of Clouds

Purpose — To study cloud forms.

Materials — Colored pencils.

Name and describe briefly the different kinds of clouds. (As much of this work as possible should be done out of doors where the different forms of clouds may be observed.)

1.

2.

3.

4.

2 & 1.

2 & 3.

1 & 3.

Sketch with colored pencils the general forms of the four different kinds of clouds.

1.

2.

3.

4.

97 — Precipitation

Purpose — To study the various forms of precipitation. (This work should be done from observation.)

Rain,—

When will rain occur?

How is the quantity of rain measured?

How much rain fell during the last heavy shower? (This should be measured by the pupil as a home exercise.)

Snow,—

When will snow fall?

Describe the snow crystals. (Charts of snow crystals should be kept in the class room.)

Frost,—

Where does frost form?

What is frost?

Describe the forms of frost?

Dew,—

When will dew form?

What is dew point?

How does dew form?

What atmospheric conditions will prevent dew from forming?

Hail,—

What is hail?

What conditions are necessary for hail to form?

Which of these forms of precipitation are valuable and which are detrimental to agriculture?

98 — Rainfall in the United States

Purpose — To study the rainfall of the United States.

Materials — Colored pencils, map of the average annual rainfall in the United States.

Upon the United States weather map color lightly the following rain areas:

0 inches to 10 inches	brown
10 inches to 20 inches	yellow
20 inches to 40 inches	green
40 inches to 60 inches	blue
60 inches and above	red

Explain the excessive rainfall in the following areas:

1 — The gulf coast.

2 — The northern Pacific coast.

3 — The Tenn.-Ca. highlands.

Explain the lack of rainfall in the following areas:

1 — Nev.-Ariz. plateau.

2 — Southern California.

FORM DD.

EXPLANATORY NOTES.

Observations taken at 8 a. m., seventy-fifth meridian time. Air pressure reduced to sea level.

ISOBARS, or continuous lines, pass through points of equal air pressure.

ISOTHERMS, or dotted lines, pass through points of equal temperature.

SYMBOLS indicate state of weather: ○ clear; ◑ partly cloudy; ● cloudy; (R) rain; (S) snow; (M) report missing; ⚡ thunderstorm. ARROWS fly with the wind.

Shaded areas when used show regions of precipitation during past 24 hours.

"T" in table, indicates amount too small to measure.

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99 — Climatic Conditions

Purpose — To study climatic conditions.

Materials — Colored pencils.

Give a good definition of climate.

Explain how the following are elements of climate:

1 — temperature

2 — humidity

a — relative

b — absolute

c — degree of cloudiness

d — precipitation

3 — winds

Upon the world map, locate the climatic zones according to latitude. (Use a blue colored pencil to mark the boundaries of these zones.)

Why is latitude an unsatisfactory limit for the climatic zones?

Upon the world map, locate the climatic zones according to the prevailing winds. (Use a red colored pencil to mark the boundaries of these zones.)

Is this a better classification than the above method?

Why?

Upon the world map, locate the climatic zones according to isotherms. (Use a green colored pencil to mark the boundaries of these zones.)

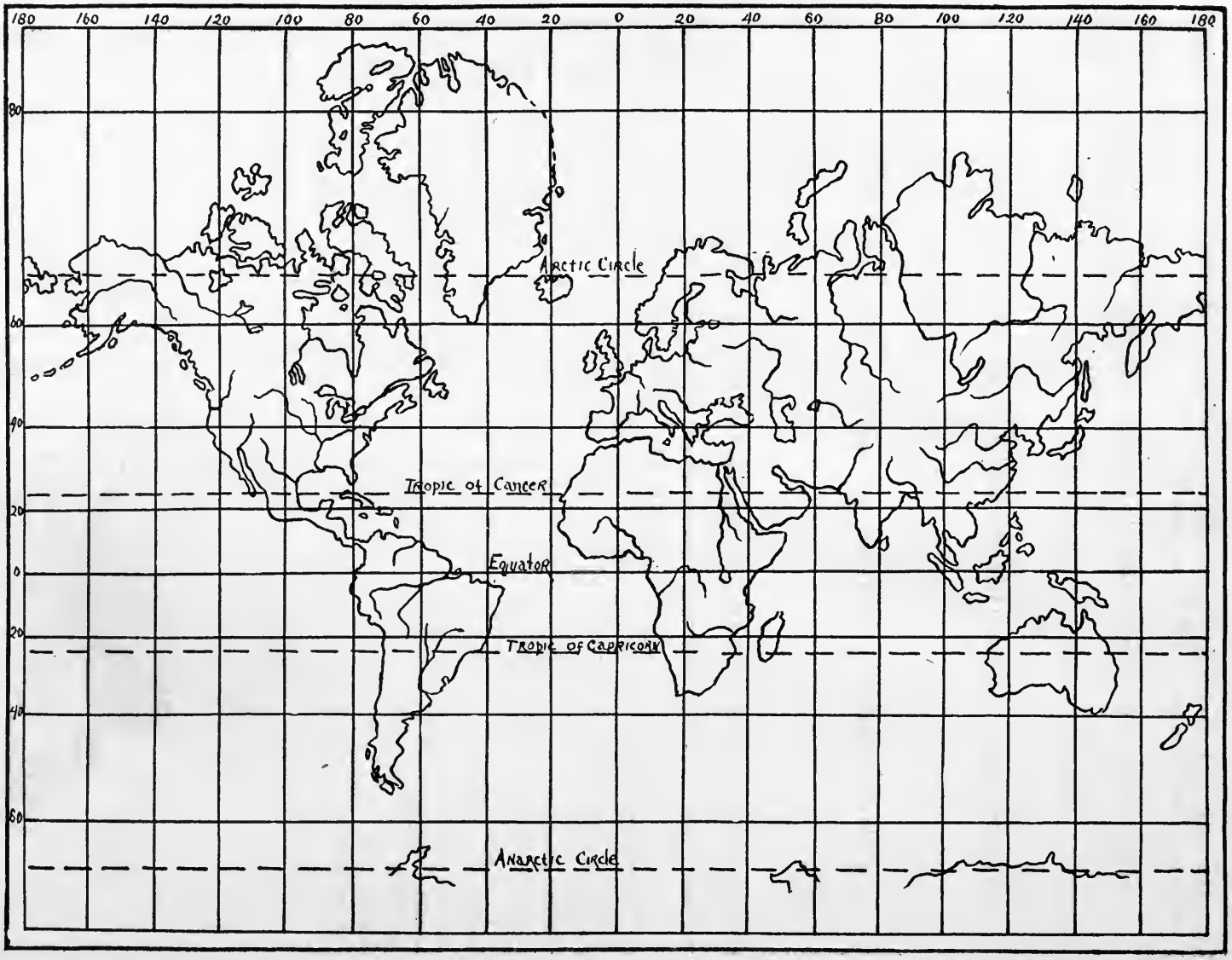
Is this climatic division better than the two previously used?

What objections are there to this isothermal division?

Explain the differences between the oceanic and continental climates.

Draw the temperature curves for the following places (Latitudes 33 to 50):

	Santa Fé	New York	Seattle	Madeira
January	40	30	35	60
February	46	31	37	59
March	55	36	44	61
April	64	47	49	62
May	72	59	56	65
June	84	70	60	67
July	88	73	64	70
August	85	71	65	71
September	76	65	59	69
October	66	55	52	68
November	52	42	45	66
December	44	34	40	61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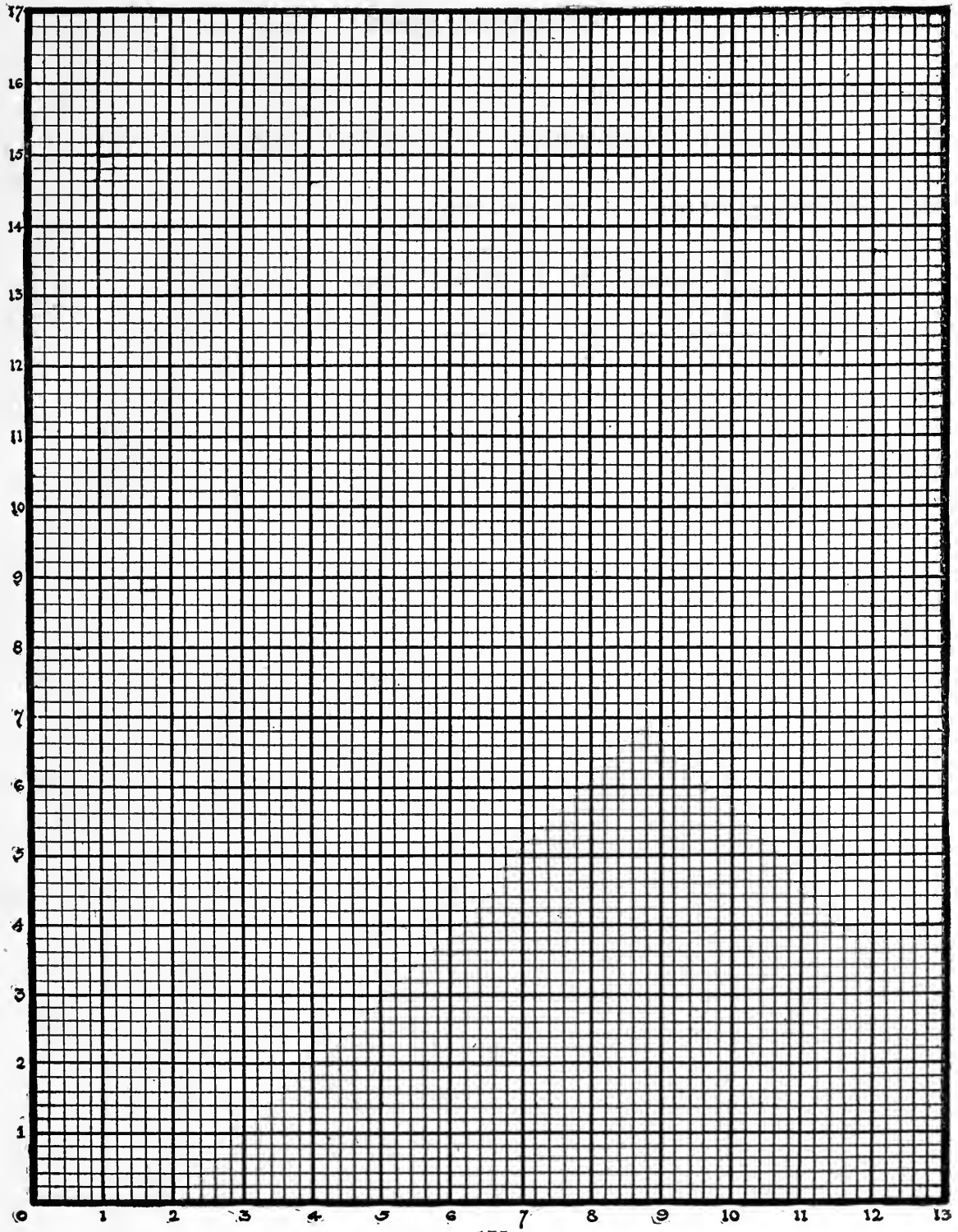
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100 — Weather Record

Purpose — To keep a weather record.

Materials — Wet and dry bulb thermometers, barometer, cup for measuring precipitation.

Fill in the following table from observations made at the school.

Date	Day of week	Hour	Barometric pressure	Wind direction	Kinds of clouds	Temperature	Relative humidity	Amount of precipitation	Rain or snow

Date	Day of week	Hour	Barometric pressure	Wind direction	Kinds of clouds	Temper-ature	Relative humidity	Amount of precipitation	Rain or snow

101 — Weather Conditions

Purpose — To study weather conditions.

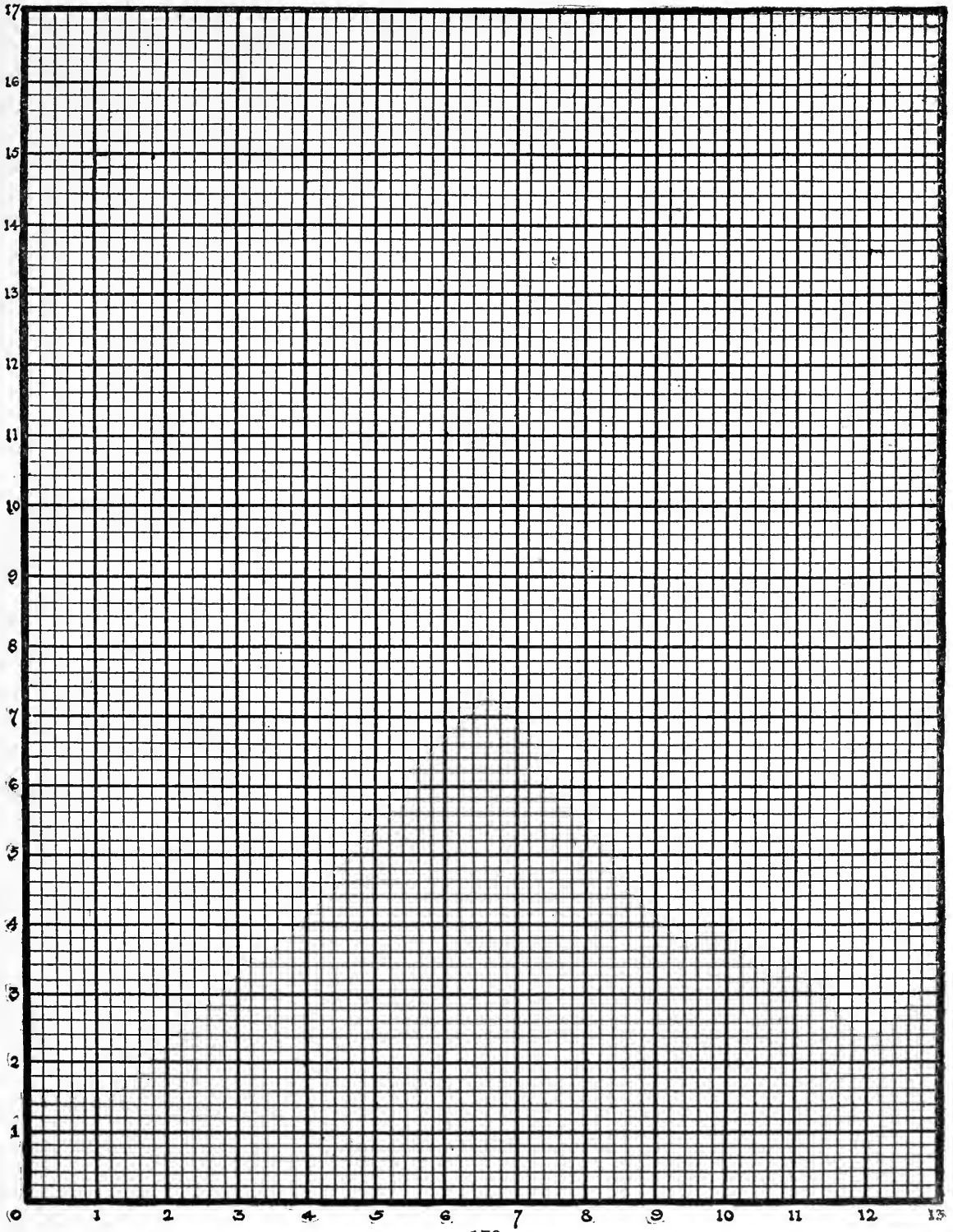
Materials — United States weather maps for week covered in the weather record of previous lesson.

From the table in the foregoing lesson plot curves for the barometric pressure, temperature, relative humidity, and precipitation for a week's time.

Repeat this at later intervals in the school year.

Compare the results with a United States weather map for the same time.

Explain any differences that occur and compare the weather conditions as recorded at your school with those of the nearest large city.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102 — Weather Maps

Purpose — To study the United States weather maps.

Materials — Several weather maps of consecutive dates.

Locate the high and low pressure areas upon the weather map bearing the earliest date.

In what general direction do these areas move?

Where are the high pressure areas twenty-four hours later?

Explain why the high and low pressure areas alternate?

What would cause a high or low pressure area to divide?

Locate the storm centers upon each map and give the directions of the winds about each center.

Describe the movements of any rain area your maps may show.

What has been the average precipitation as shown by your maps at the following places:

Charleston, S. C.	Portland, Me.
San Francisco, Cal.	Winnemucca, Nev.

What has been the average daily temperature at the following places:

Atlanta, Ga.	Helena, Mont.
Boston, Mass.	Memphis, Tenn.
Duluth, Minn.	Portland, Ore.

Describe the method used to show the condition of the weather at any place.

Upon the blank weather map, draw the isotherms and isobars for any one day represented by your weather charts.

FORM DD.


Edmonton
Prince Albert
Battleford
Calgary
Medicine Hat
Regina
Swift Current
Minnedosa
Winnipeg
Kamloops
Victoria
Tatoosh Island
Neah Bay
Seattle
Tacoma
Spokane
North Head
Kalispell
Lewiston
Walla Walla
Portland
Havre
Williston
Helena
Roseburg
Baker City
Boise
Miles City
Yellowstone Park
Bismarck
Moorhead
Devils Lake
Duluth
Port Arthur
White River
Houghton
Sault Ste. Marie
Marquette
Escanaba
Alpena
Parry Sound
Rockliffe
Montreal
Quebec
Father Point
Chatham
Halifax
Eastport
Burlington
Northfield
Portland
Concord
Canton
Oswego
Albany
Boston
Providence
Nantucket
Block Island
Eureka
Red Bluff
Winnemucca
Sheridan
Pocatello
Lander
Rapid City
Pierre
Huron
Minneapolis
St. Paul
Green Bay
La Cross
Milwaukee
Saugeen
Rochester
Syracuse
Ithaca
Buffalo
Port Huron
Grand Haven
Grand Rapids
Detroit
Binghamton
Hartford
New Haven
Scranton
New York
Harrisburg
Philadelphia
Atlantic City
Cape May
Sacramento
Reno
Salt Lake City
Cheyenne
Valentine
North Platte
Yankton
Charles City
Sioux City
Madison
Dubuque
Des Moines
Chicago
Toledo
Sandusky
Cleveland
Erie
Pittsburg
Columbus
Parkersburg
Baltimore
Weather
Mount
WASHINGTON
Richmond
Elkins
Lynchburg
Cape Henry
Wytheville
Norfolk
Kittyhawk
Hatteras
Raleigh
Charlotte
Asheville
Knoxville
Nashville
Chattanooga
Wilmington
Columbia
Augusta
Atlanta
Charleston
Macon
Savannah
Thomasville
Jacksonville
Tampa
Jupiter
Key West
Pensacola
Mobile
New Orleans
Burrwood
Galveston
San Antonio
Del Rio
Corpus Christi
Taylor
Abilene
Fort Worth
Palestine
Shreveport
Vicksburg
Meridian
Montgomery
Annaston
Birmingham
Memphis
Little Rock
Roswell
El Paso
Amarillo
Santa Fe
Oklahoma
Bentonville
Fort Smith
Springfield
Cairo
Evansville
Louisville
Lexington
Indianapolis
Cincinnati
Hannibal
Columbia
St. Louis
Kansas City
Topeka
Iola
Wichita
Dodge
Concordia
Denver
Grand Junction
Pueblo
Durango
Flagstaff
Phoenix
Yuma
Los Angeles
San Diego
San Luis Obispo
San Francisco
San Jose
Fresno
Mount Tamalpais
Tonopah
Independence
Modena
Omaha
Davenport
Lincoln
Keokuk
Peoria
La Salle
Springfield
Statute Miles.
EXPLANATORY NOTES.
Observations taken at 8 a. m., seventy-fifth meridian time. Air pressure reduced to sea level.
ISOBARS, or continuous lines, pass through points of equal air pressure.
ISOTHERMS, or dotted lines, pass through points of equal temperature.
SYMBOLS indicate state of weather: ○ clear; ◑ partly cloudy; ● cloudy; (R) rain; (S) snow; (M) report missing; ⚡ thunderstorm. ARROWS fly with the wind.
Shaded areas when used show regions of precipitation during past 24 hours.
"T" in table, indicates amount too small to measure.
WIND-BAROMETER INDICATIONS.
When the wind sets in from points between south and southeast and the barometer falls steadily a storm is approaching from the west or northwest, and its center will pass near or north of the observer within 12 to 24 hours with wind shifting to northwest by way of southwest and west. When the wind sets in from points between east and northeast and the barometer falls steadily a storm is approaching from the south or southwest, and its center will pass near or to the south or east of the observer within 12 to 24 hours with wind shifting to northwest by way of north. The rapidity of the storm's approach and its intensity will be indicated by the rate and the amount of the fall in the barometer.
W M N

V. LIFE DISTRIBUTION

103 — Life Regions

Purpose — To study the life regions of the earth.

Materials — Colored pencils.

With a red colored pencil, lightly shade the world areas of tropical growth.

Explain why these areas have tropical conditions.

What are some of the characteristic tropical plants to be found in each of the continents of this section?

With a green colored pencil, lightly shade the savanna areas.

What plants and animals will be found in these regions?

With a yellow colored pencil, lightly shade the agricultural areas in the temperate zones.

Explain why these areas are valuable for agricultural purposes.

With a blue colored pencil, lightly shade the plateau sections of the world.

What occupations are to be found in these areas?

Name some of the products found here.

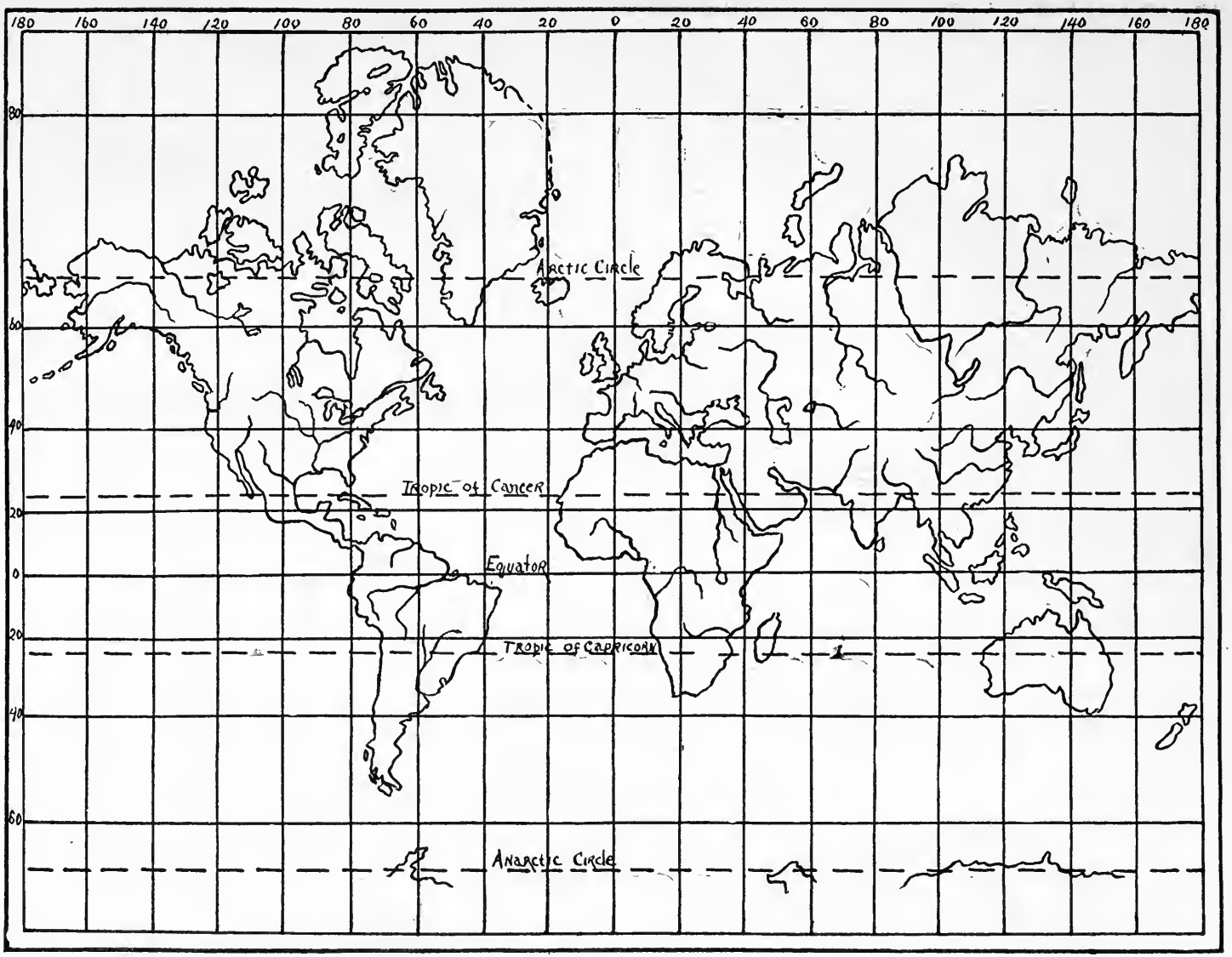
With a purple colored pencil, lightly shade the tundras areas.

Name some of the plants and animals found in this region.

Describe the climatic conditions that prevail in this zone.

Indicate the deserts by dotting the areas where they abound.

Indicate by dotted lines the northern and southern limits of the palms; the northern and southern limits of grain.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Arctic Circle
Tropic of Cancer
Equator
Tropic of Capricorn
Antarctic Circle

104 — Classification of Plants

Purpose — To study plant classification.

Materials — Colored pencils.

Name and describe a few plants that would come under the following classification.

1 — Hydrophytes (water plants)

2 — Xerophytes (desert plants)

3 — Mesophytes (intermediate plants)

Upon the map of North America indicate the following plant zones by shading the different areas.

Write the names of a few plants to be found in each zone.

1 — Boreal zone (purple)

2 — Transition zone (blue)

3 — Upper Austral zone (green)

4 — Lower Austral zone (yellow)

5 — Tropical zone (red)

Fill in the following list of plants found about your home.

Native trees.

Foreign trees.

Common shrubs.

Grains.

Fiber plants.

Water plants.

Wild flowers.

Cultivated flowers.

Common vegetables.

Fruits.


180
160
140
120
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60
40
20
Arctic Circle
Tropic of Cancer

105 — Distribution of Forests

Purpose — To study forest distribution.

Materials — Colored pencils.

Upon the map of North America, locate the great forest areas.

What trees are found the farthest north?

What trees are found highest up on the mountain-side?

What is meant by the timber line?

What trees are characteristic of southern swamp growth?

Where are the cabinet woods found?

Label the areas that abound in the following trees:

chestnut — spruce — ash — mahogany — cypress — redwood — pine — oak — maple — poplar.

Color the forest areas upon the United States map as indicated below.

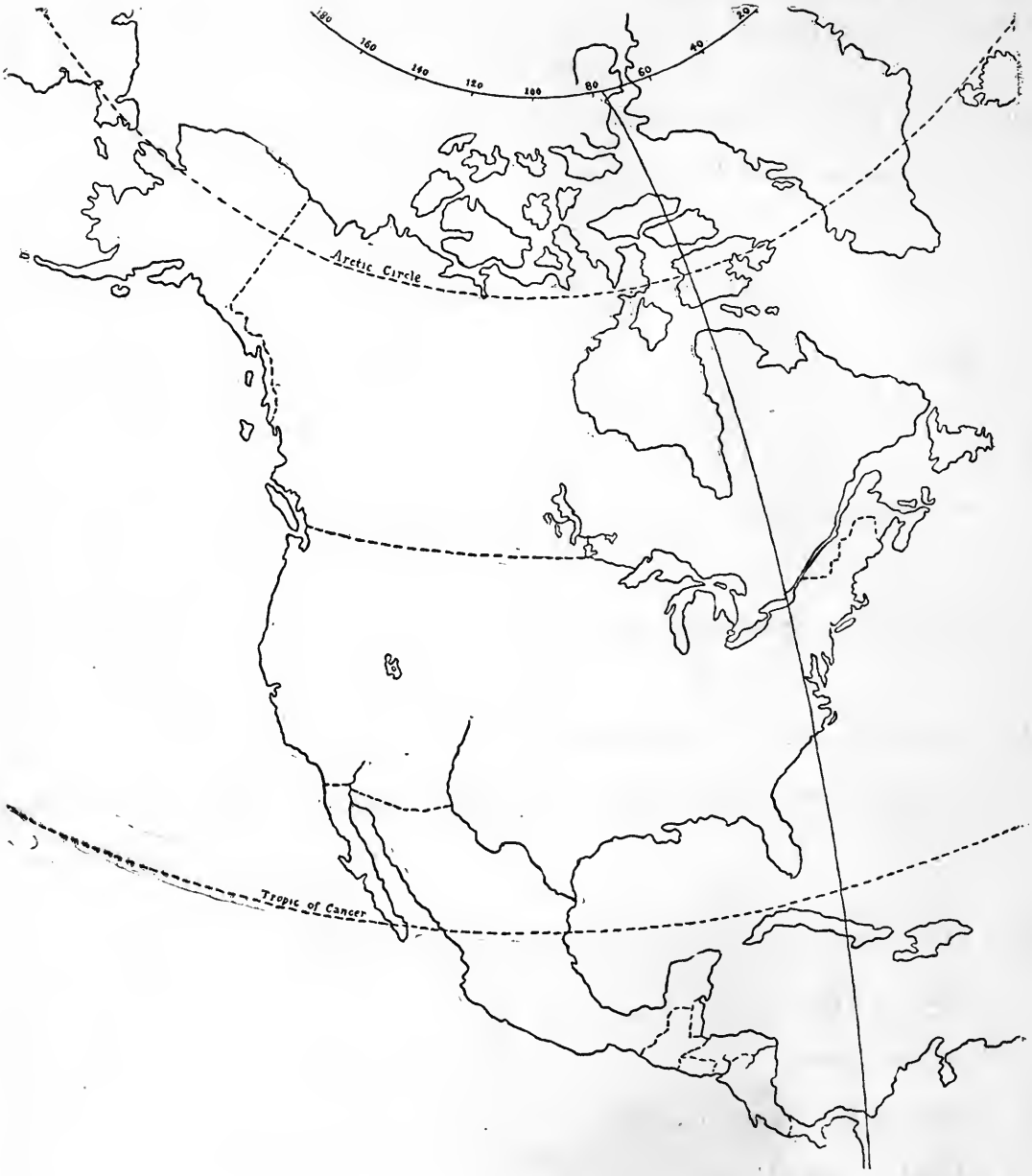
hemlock and spruce (red)

hard pine (yellow)

yellow pine and cypress (orange)

oak and chestnut (blue)

redwood and fir (green)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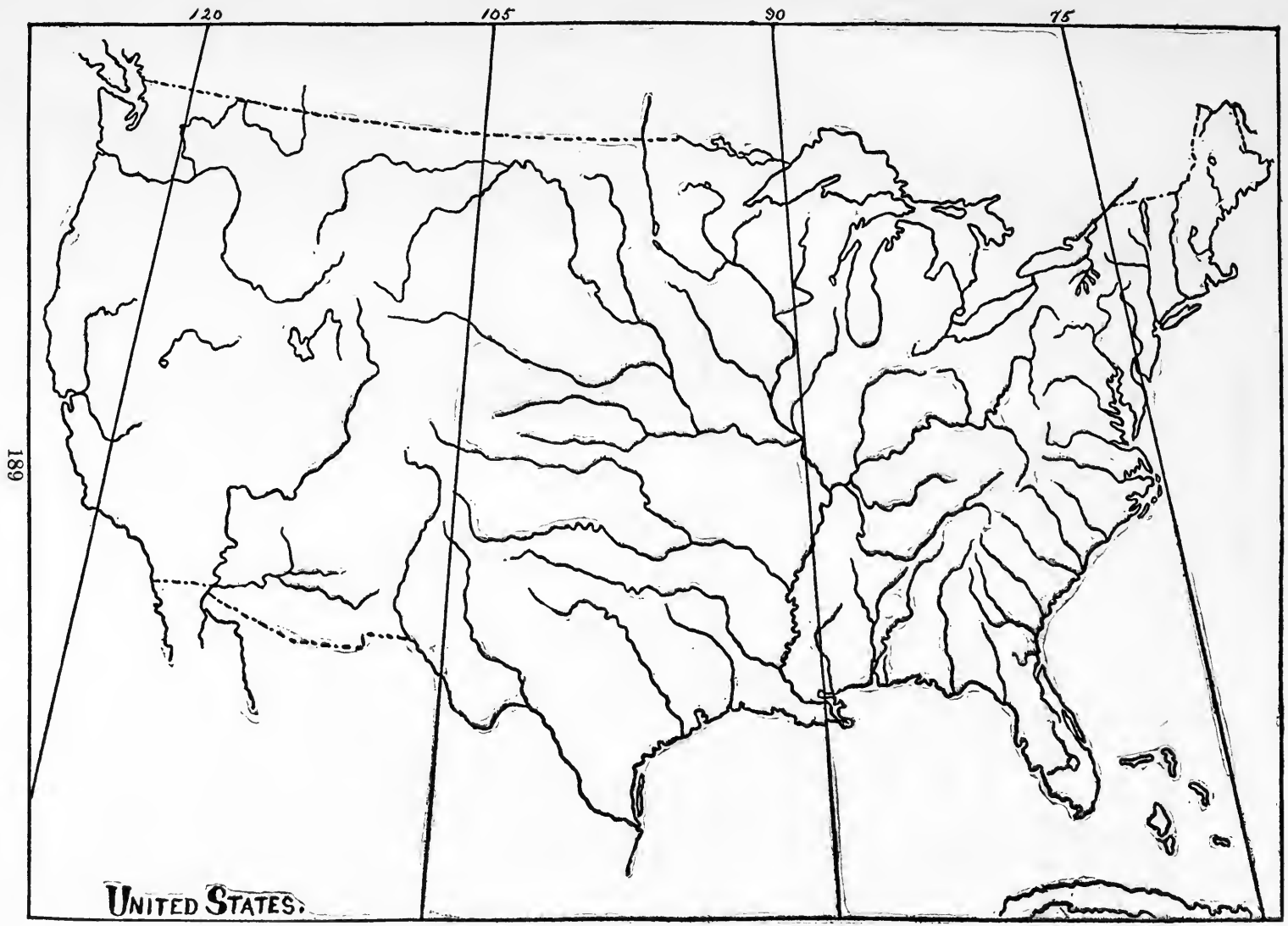
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UNITED STATES.

106 — Crop Maps

Purpose — To study the great crop areas.

Materials — Colored pencils.

Upon the United States map, color the great crop areas as follows:

Wheat (purple)

Corn (blue)

Cotton (green)

Oats (red)

Tobacco (yellow)

Explain the climatic conditions that prevail in each of these areas.

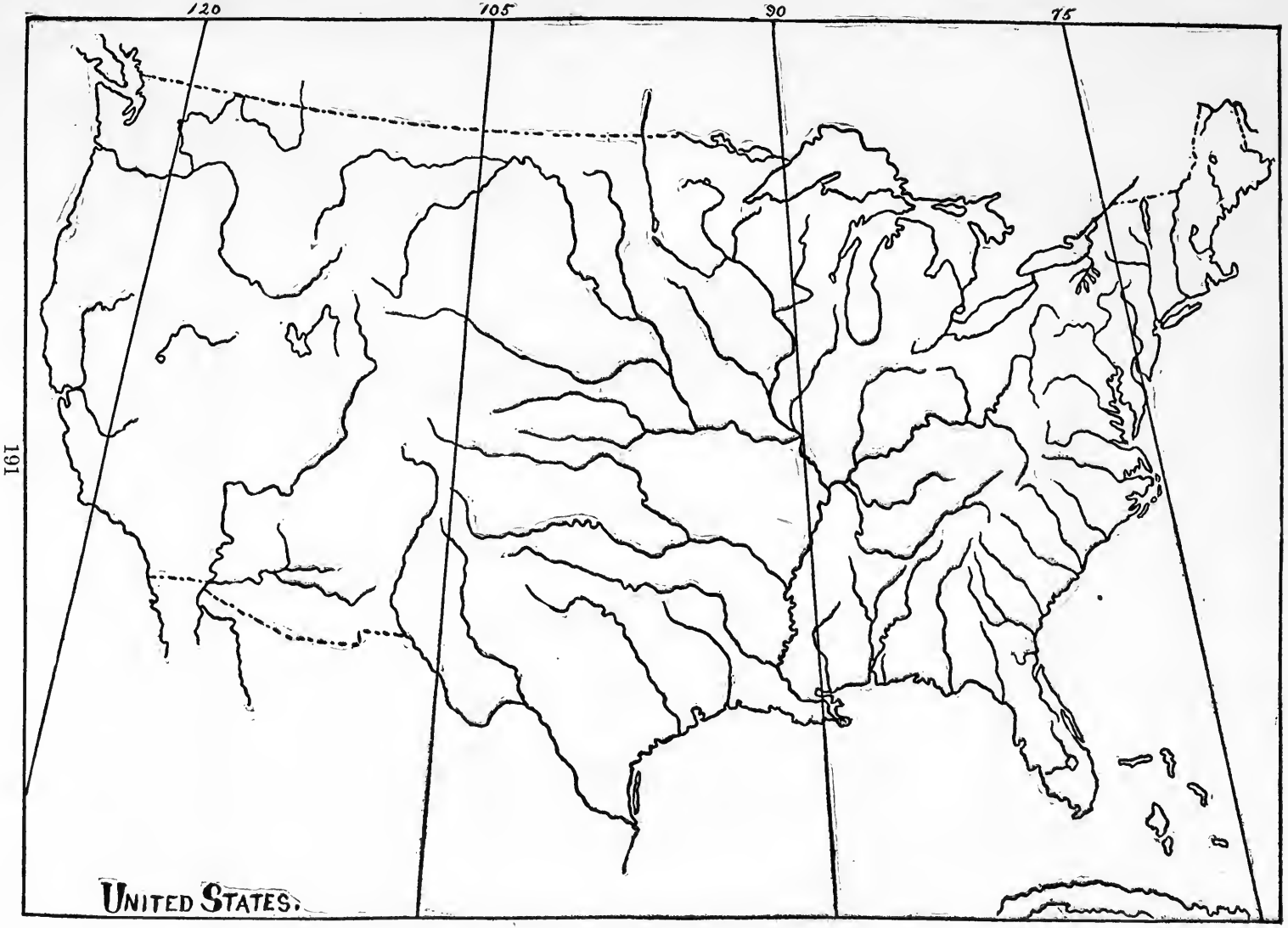
Wheat —

Corn —

Cotton —

Oats —

Tobacco —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107 — Faunal Distribution

Purpose — To study faunal distribution.

Materials — Colored pencils.

Upon the map of the world, shade the faunal areas as indicated below. Name three or four characteristic animals found in each region.

1 — North American (red)

2 — Eurasian (blue)

3 — South American (green)

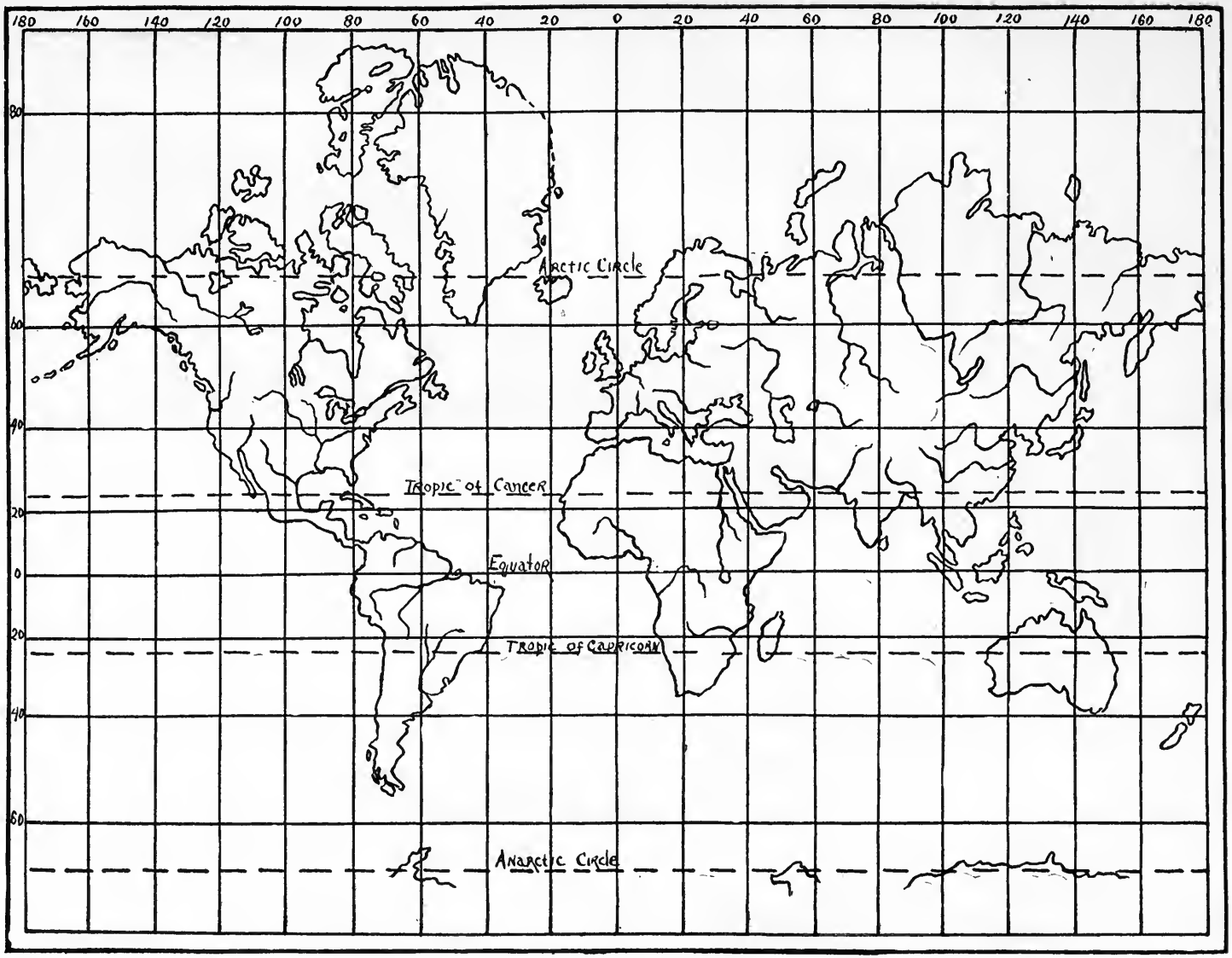
4 — African (yellow)

5 — Oriental (purple)

6 — Australian (violet)

Upon the United States map indicate the areas in which the following animals abound: (The names of the animals should be written in their proper places.)

Horse — cow — sheep — hog — deer — bison — grizzly bear — possum — eagle — buzzard — ostrich — salmon — mackerel — cod — tarpon — oyster — lobster.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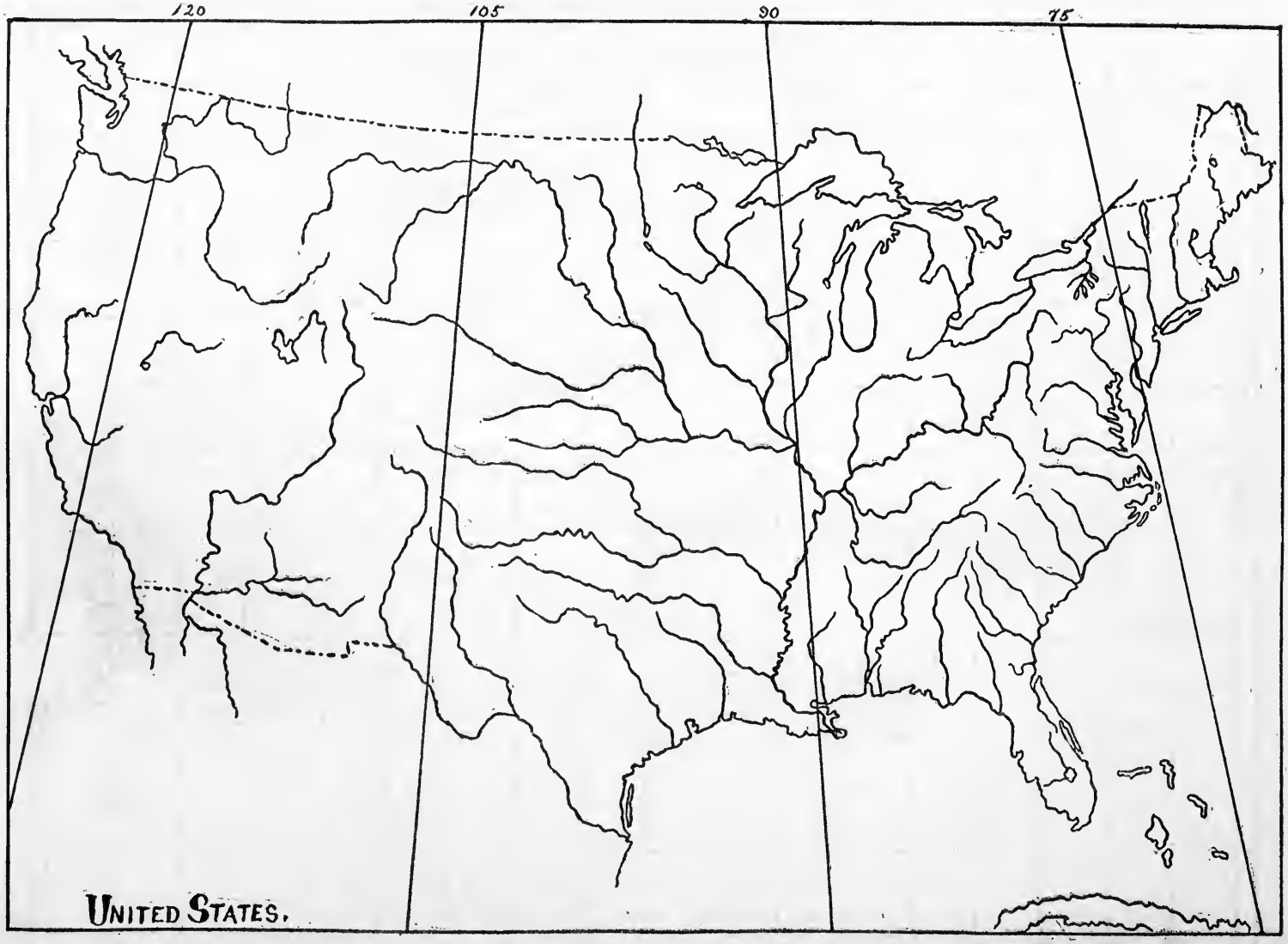
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108 — Distribution of Man

Purpose — To study the distribution of mankind.

Materials — Colored pencils.

Upon the map of the world indicate the areas in which the following races of mankind predominate:

Ethiopian race (purple)

Mongolian race (yellow)

American race (red)

Caucasian race (blue)

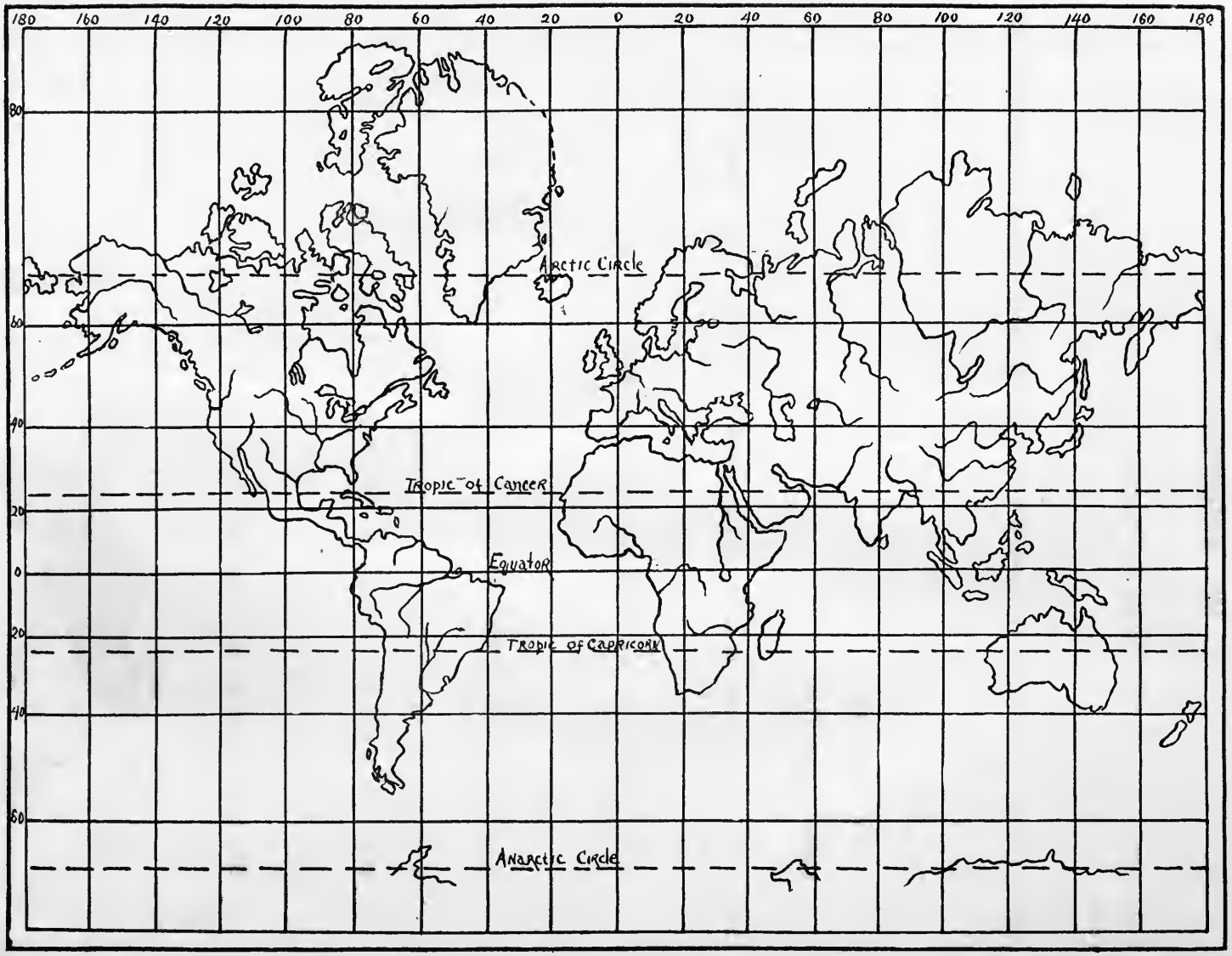
Indicate the original homes of these races by printing the initial letters of their names in the areas from which they came.

What influence has climate had upon racial distribution?

What physiographic features have formed barriers to the spread of mankind?

What natural features has man taken advantage of to further his spread?

How has man influenced the geography of his home?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Tropic of Cancer
Equator
Tropic of Capricorn
Antarctic Circle

VI. PHYSIOGRAPHIC REGIONS

109 — Atlantic Regions

Purpose — To study the Atlantic region.

Materials — Colored pencils, Boston Bay (Mass.), Boothbay (Me.), Sandy Hook (N. J.-N. Y.), Tolchester (Md.) topographic sheets.

(Consult the regional map at the end of these exercises for the limits of this section.)

Sketch the outline of this section upon the following blank page. Locate the following areas upon your map by shading with colored pencils.

1 — Atlantic coastal plain.
- a — Submarine plain.
- b — Tidal flats.
- c — Emerged plain.

2 — The Piedmont region.
(Locate the fall line.)

3 — Appalachian mountain system.
- a — South mountain and Blue ridge.
- b — Great valley.
- c — Allegheny ridge.
- d — Appalachian plateau.
- e — Adirondack mountains.

With the aid of the following topographic sheets, describe the coast line north of Cape Cod.
Boston Bay (Mass.), Boothbay (Me.)

Describe the coastline south of New York.
Sandy Hook (N. J.-N. Y.), Tolchester (Md.)

Place upon your map the important cities located on the Fall Line.
Draw the streams that drain from the Appalachian plateau into the —
1 — Atlantic ocean.
2 — Great Lakes.
3 — Ohio river.

Why is the Mohawk valley an important medium of communication?

What effect has it had upon the development of the city of New York?

110 — The Lake Region

Purpose — To study the Lake region.

Materials — Colored pencils.

(Consult the regional map at the end of these exercises for the limits of this section.)

Sketch the outline of this section upon the following blank page. Locate the following areas by shading with colored pencils.

1 — Superior lowland.
2 — St. Paul-Madison upland.
3 — Green Bay lowland.
4 — Michigan-Huron-Erie lowland.
5 — Lansing upland.
6 — Niagara upland.
7 — Ontario lowland.

Locate the principal lake port towns. Name six and give their principal exports.

1 —

2 —

3 —

4 —

5 —

6 —

Locate the great copper region of this section.

Why is the area about Cleveland, Ohio, a great iron manufacturing center?

Of what importance is the Soo canal? (Locate it on your map.)

Name a few historic events that have occured in this section.

Account for the location of Chicago.

111 — The Central Section

Purpose — To study the Central section.

Materials — Colored pencils, Evansville quadrangle (Wis.), Caldwell (Kans.) topographic sheets.

(Consult the regional map at the end of these exercises for the limits of this section.)

Sketch the outline of this section upon the following blank page. Locate the following areas by shading with colored pencils.

1 — The prairies.
2 — Great Western plains.
3 — Ozark highlands.
4 — Black hills.
5 — Bad lands.

Draw the Mississippi river and its principal tributaries that are found in this section.

Make a list of the six principal drainage areas.

1 —

2 —

3 —

4 —

5 —

6 —

With the aid of topographic sheets describe:

The upper area (Evansville quadrangle).

The middle section (Caldwell).

Locate the principal river cities and explain the topographic reasons for their situation.

What are the " staked plains " of Texas?

Name the principal industries of this section.

Where is the wheat area located?

The corn area?

The apple area?

The grape area?

112 — The Southern Region

Purpose — To study the Southern region.

Materials — Colored pencils, Donaldsonville (La.), Mississippi river delta (Coast survey) topographic sheets.

(Consult the regional map at the end of these exercises for the limits of this section.)

Sketch the outline of this section upon the following blank page. Locate the following areas by shading with colored pencils.

1 — Mississippi delta.
2 — Mississippi flood plain.
3 — Alabama-Georgia cuesta.
4 — Llano Estacado.
5 — Pecos valley.
6 — San Francisco mountains.
7 — Coastal plain (other than Mississippi delta).

Draw the Mississippi river and its tributaries. Draw the principal rivers that flow into the Gulf of Mexico.

Locate the principal river and gulf cities.

Describe the area as shown in the Donaldsonville (La.) sheet.

Describe the Mississippi river as shown in the Mississippi river delta sheet.

To what climatic division does this section belong?

What are its products?

What effect upon the industries and cities of this section will the Panama canal have?

113 — The Interior Section

Purpose — To study the Interior section.

Materials — Colored pencils, Canyon (Wyo.), Henry mountains (Utah) topographic sheets.

(Consult the regional map at the end of these exercises for the limits of this section.)

Sketch the outline of this section upon the following blank page. Locate the following areas by shading with colored pencils.

1 — Rocky mountains.
2 — Wahsatch mountains.
3 — Colorado plateau.
4 — Interior basin.

Locate the principal drainage areas and draw the largest rivers found in each.

Describe the topography of the section shown by the Canyon (Wyo.) sheet.

Describe the section shown by the Henry mountains sheet.

Describe the formation of the Great Salt Lake, Utah.

Locate the principal industrial areas of this section.

Indicate upon your map where the largest cities are found.

Why does this section have an arid climate?

What mountains shut off the westerly winds?

What and where is the National park?

Why are forest reservations necessary?

114 — The Pacific Section

Purpose — To study the Pacific section.

Materials — Colored pencils.

(Consult the regional map at the end of these exercises for the limits of this section.)

Sketch the outline of this section upon the following blank page. Locate the following areas by shading with colored pencils.

1 — Coast ranges.
2 — Sierra Nevada mountains.
3 — Great valley of California.
4 — Columbia plateau.
5 — Sound valley.
6 — Klamath mountains.
7 — Salton valley.

Locate the principal drainage areas and draw the largest rivers found in each.

Describe the canyons of the Snake and Columbia rivers.

Describe the coast line of this section and compare it with the Atlantic coast line.

What are the principal industries of this section? (Locate them on your map.)

Describe the forest areas of Oregon and Washington.

What and where are the important fishing industries?

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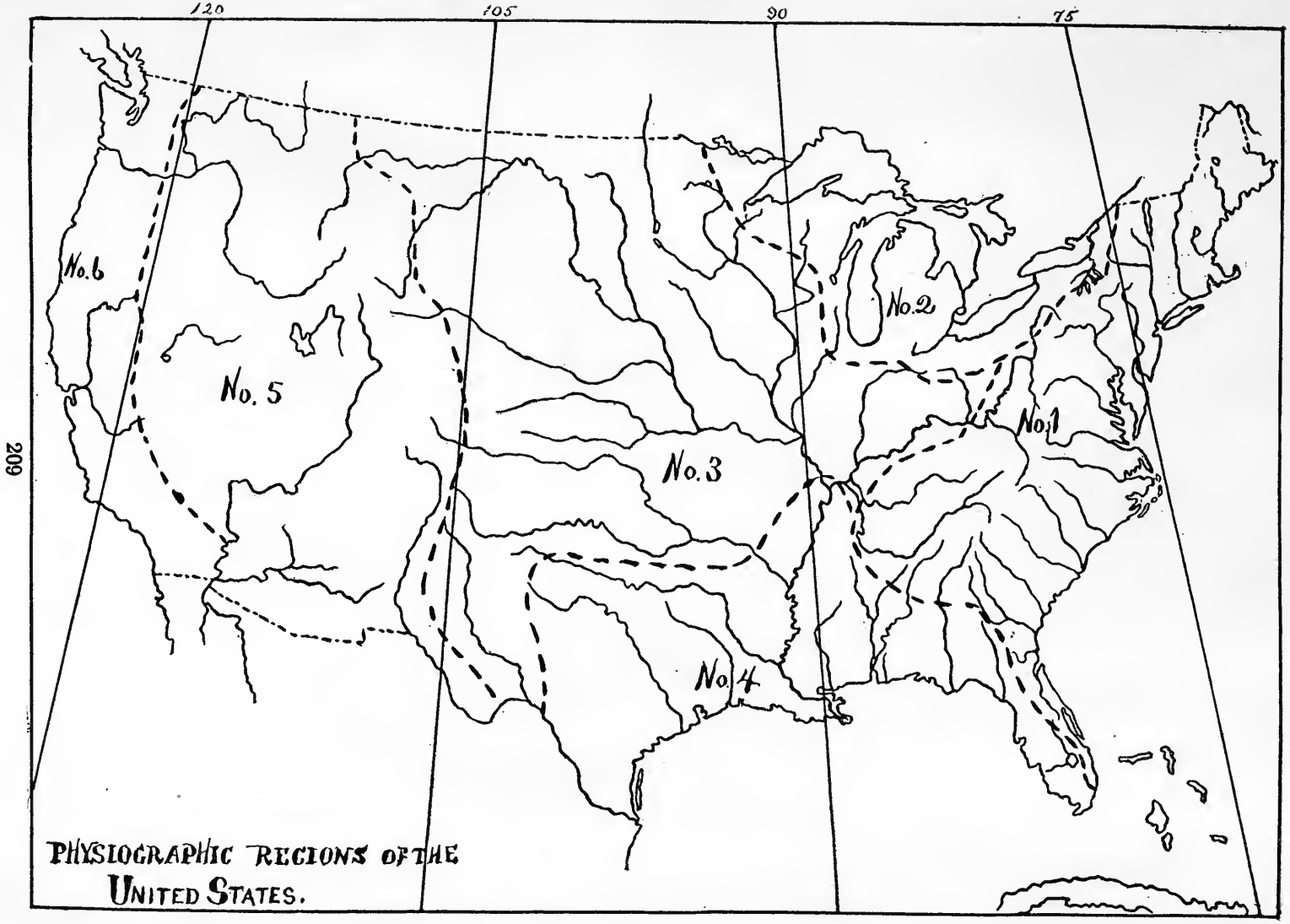
Locate the largest cities upon your map.

Explain why this section has such a mild climate.



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