Lewis & Clark

Weather and Climate Data from the Expedition Journals

Edited by Vernon Preston

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American Meteorological Society
Boston, Massachusetts

The most recent source for the expedition journals, which provided the most comprehensive data, is "The Definitive Journals of Lewis and Clark," edited by Gary E. Moulton (University of Nebraska Press 2002). The editors of this monograph are indebted to Moulton's work on the journals.

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To my honored parents, David and Ruth Mary, who believed
that history must be experienced, not just read;
who took our family to tour the West and its history;
who taught us to respect the land and its peoples; and
who encouraged my meteorological pursuits.

"This is our present Situation,! truly disagreeable. About 12 oClock the wind Shifted about to the NW and blew with great violence for the remainder of the day at maney times it blew for 15 or 20 minits with Such violence that I expected every moment to See trees taken up by the roots. Many were blown down. Those Squals were Suckceeded by rain, !O how Tremendious is the day. This dredfull wind and rain Continued with intervales of fair weather all the latter part of the night. O! How disagreeable is our Situation dureing this dreadfull weather."

—Captain William Clark
November 28, 1805
Mouth of the Columbia River

"About 12 oClock we arived in Site of St. Louis. Drew out the canoes then the party all considerable much rejoiced that we have the Expedition Completed and now we look for boarding in Town and wait for our Settlement and then we entend to return to our native homes to See our parents once more as we have been So long from them."

—Sergeant John Ordway
September 23, 1806
Return of Expedition to St. Louis

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Foreword

By Terry Nathans

The weather and climate of the trans-Mississippi west was virtually unknown at the beginning of the nineteenth century. This changed dramatically shortly after the Louisiana Purchase was signed in 1803, which set the stage for acquiring the first systematic weather measurements of the trans-Mississippi west. The framework for obtaining these measurements was outlined in the now famous June 20, 1803 letter from President Thomas Jefferson to his protégé and personal secretary, Captain Meriwether Lewis. In that letter, Jefferson instructed Lewis to plan and carry out an overland expedition to the Pacific Ocean for the purposes of commerce, and to observe and record a broad range of natural history subjects, including the

> …climate, as characterised by the thermometer, by the proportion of rainy, cloudy & clear days, by lightning, hail, snow, ice, by the access & recess of frost, by the winds prevailing at different seasons, the dates at which particular plants put forth or lose their flower, or leaf… (Jackson 1978, p. 63).

Jefferson's instructions to Lewis, which were part of his decades-long ambition of launching an expedition to explore the interior of North America, were made at the threshold of what Fleming (1990) has called the "expanding horizons" in meteorology. During this period, more reliable meteorological instruments began to emerge allowing for a more comprehensive and systematic acquisition of weather data. Prior to Lewis and Clark's time, few advances were made in "meteorological science." Most of what was commonly known at the time about weather and climate was rooted in the theories first proposed by the philosophers of ancient Greece (Lamb 1977). Their theories, which related the character tendencies of the various peoples of the world to the warm, cold, and middle zones on Earth, were based on an axiomatic approach, wherein self-evident truths were postulated and built upon by deductive reasoning to reach conclusions about the natural world. It wasn't until the Enlightenment and the emergence of the scientific revolution in the seventeenth century that this Aristotelian philosophy was replaced with rationalism and the scientific method (Bowler 1993).

Jefferson was a product of the Enlightenment and, by the time the Louisiana Purchase was signed, he was uniquely positioned to propose and implement a broad-based exploratory expedition of the West. He was elected the third president of the United States and thus had political leverage as well as access to the resources of the government. He was a member of the American Philosophical Society (APS) in Philadelphia, the nexus of scientific thought at the time. And he had a unique and deep intellectual curiosity about ethnography, geography, science and climate, particularly of the land west of the Mississippi.

To lead his exploratory expedition of the West, Jefferson chose Meriwether Lewis, whom he believed to be the most qualified for the job, despite Lewis's lack of formal scientific training. Jefferson's rationale for choosing Lewis to lead the expedition is made clear in a March 2, 1803 letter to Robert Patterson, professor of mathematics at the University of Pennsylvania and fellow member of the APS. Jefferson wrote:

> I am now able to inform you…, that we…are likely to get the Missouri explored…I propose to send…a party…with Capt. Lewis, my secretary, at their head. If we could have got a person perfectly skilled in botany, natural history, mineralogy, astronomy, with at the same time the necessary firmness of body & mind, habits of living in the woods & familiarity with the Indian character, it would have been better. But I know of no such character who would undertake an enterprise so perilous. To all the latter qualities Capt. Lewis joins a great stock of *scientific* accurate observation on the subjects of the three kingdoms which are found in our own country but not according to their scientific nomenclatures…and I shall be particularly obliged to you for any advice or instruction you can give him (Jackson 1978, p. 21).

Lewis's "scientific training" for the expedition mostly occurred during May and June of 1803, when several of Jefferson's fellow APS members tutored Lewis on a variety of subjects, including surveying, botany, and medicine. Professor Robert Patterson provided instruction on various scientific instruments; Major Andrew Ellicott provided instruction on surveying; Benjamin Smith Barton, who wrote the first American textbook on botany, advised on the collection of scientific data; Casper Wistar, who wrote the first American textbook on anatomy, advised on zoology; and Dr. Benjamin Rush, the preeminent physician of the time, counseled him on medical issues. To round out his training, Lewis also purchased several scientific books that would serve as his traveling library. These books included *Elements of Botany* by Barton, *Elements of Mineralogy* by Kirwan, *A Practical Introduction to Spherics*, and *The Nautical Almanac and Astronomical Ephemeris* (Ambrose 1996).

There is no written evidence that has been found suggesting that Lewis's scientific training in Philadelphia formally included meteorology. This may at first be surprising since Philadelphia could arguably be viewed as the nation's center for meteorological thought during the eighteenth and early nineteenth centuries. For example, Philadelphia already had a long history of its citizenry keeping weather diaries (Ludlum 1966). Thomas Jefferson, in fact, made his first entry into his weather diary while in Philadelphia (Malone 1970). Benjamin Franklin, longtime resident of Philadelphia and founder of the American Philosophical Society, not only kept weather diaries but conducted the seminal experiments on lightning and planted the first intellectual seeds that eventually led to theories on the circulation of coastal storms, the connection between heated air and small-scale vortices such as waterspouts, and the equator-to-pole atmospheric circulation (Fleming 1990). One of the leading medical institutions at the time, Philadelphia's College of Physicians, included in its charter the importance of meteorological observations in linking diseases with weather (Hindle 1956), a link already hypothesized by Dr. Benjamin Rush (Rush 1789).

In view of the intellectual resources available in Philadelphia and Jefferson's longtime interest in recording weather data, why didn't Lewis receive formal meteorological training? First and foremost was that meteorology was not considered a formal science in the way chemistry and physics were. Broad, contemporaneous meteorological measurements were decades into the future and the laws governing atmospheric motion had yet to be established. For the learned men and the populace at large, weather was most important for the role it played in agriculture. Thus formal meteorological training of Lewis was neither possible nor essential; daily recordings of the weather—wind, temperature, cloud cover etc.—which required no special skill, would suffice.

Following Lewis's scientific training, there were two key communiqués. On June 19, Lewis wrote a letter to longtime friend and former military superior, William Clark, asking him to co-lead the expedition. Clark accepted several weeks later. On June 20, Jefferson wrote a letter to Lewis, which formally laid out the plans for conducting an exploration of the trans-Mississippi west. The letter is remarkable for its far-reaching vision, clarity of scientific goals, and ultimate impact on our nation's history. Jefferson wrote:

> …The object of your mission is to explore the Missouri river, & such principal stream of it, as, by [its] course and communication with the waters of the Pacific ocean, …, for the purposes of commerce…You will take, *careful* observations of latitude and longitude, at all remarkeable points on the river…make yourself aquainted …with the names of the nations and their numbers,…their language; their ordinary occupations in agriculture…Other objects worthy of notice will be the soil and face of the country…; the animals of the country; …the mineral productions;…climate (Jackson 1978, pp. 61–63).

The letter formally mapped out a broad-based mission whose objectives were to provide new information on the economic, ethnographic, geographic, and scientific aspects of the West. Executing the mission required the cooperation of several branches of government, funding for supplies and equipment, and scientific training in several disciplines. As noted by historian James Ronda, this was the United States' first foray into what is now called "big science" (Ronda 1998).

By the time the Lewis and Clark expedition came to fruition in the early nineteenth century, several scientific instruments had been invented that became an integral part of the expedition. Among these instruments were an octant and sextant for determining latitude, a theodolite and chronometer for determining longitude, a telescope, a surveying compass, and a spirit level. Lewis and Clark also carried three thermometers, which had been invented more than 175 years before the expedition.

A barometer was not carried on the expedition, despite being more than a century and a half old by the time Lewis and Clark began their journey. At the time it was well known that the barometer measured the pressure of a column of air above the gauge and could also be used to measure elevation. The fragility of the barometer, however, made it impractical for transport. It was likely for these reasons that Lewis and Clark did not carry a barometer. Even if they did, the connection between barometric pressure and air masses and fronts was unknown. Such knowledge would have to wait for the development of the telegraph in 1843 when the contemporaneous acquisition of weather data over large areas began. The theory of air masses and weather fronts didn't occur until around 1920, more than a century after Lewis and Clark.

From late June until the end of August, Lewis and Clark spent most of their time obtaining additional supplies, maps, and books, commissioning men for the expedition, purchasing a pirogue, and having a keelboat made in Pittsburgh, which was completed on August 31. By eleven o'clock that morning the boats were loaded and Lewis and several recruits were headed down the Ohio River for their eventual mid-October rendezvous with Clark.

On August 31, Lewis makes the first entry in what is known as the Lewis and Clark Journals. September 1 marks the first entry about the weather, and on September 2, Lewis recorded the first temperature of the expedition. In the September 1 entry Lewis speculates about the origin of the fog on the Ohio River:

> …the Fog appears to owe [its] origin to the difference of temperature between the *air* and *water* the latter at this season being much warmer than the former; the water being heated by the summer's sun dose not undergo so rapid a change from the absence of the sun as the air dose consequently when the air becomes cool which is about sunrise the fogg is thickest and appear to rise from the face of the water like the steem from boiling water… (Moulton 1986, p. 67).

Lewis's speculation about the origin of the fog, which we now know as evaporation-steam fog, touches on two key scientific points, neither of which was fully understood by science at the time. One is related to condensation and evaporation and the other to the difference in specific heat capacity between water and air. First, Lewis states that the *fog* "*owe[s] [its] origin to the difference between the air and water.*" Lewis's statement is indeed correct and is related to the role of temperature in the condensation and evaporation of water vapor. Although instruments to measure the amount of water vapor in the atmosphere were around since the fifteenth century, theories regarding the condensation and evaporation of water vapor were only beginning to emerge in the mid-eighteenth century (Middleton 1969). A full explanation of the processes involved in the formation of fog would have to wait until the late nineteenth century when the kinetic theory of gasses was well established and the seminal experiments on condensation were being carried out (Mason 1957).

Lewis's second point regards "*…the water being heated by the summer's sun dose not undergo so rapid a change from the absence of the sun as the air.…*" Lewis is making a statement about how the difference in specific heat capacity between water and air favors fog formation in the morning. Like condensation and evaporation, the scientific foundation for explaining Lewis's observation on specific heat had yet to be fully developed.

Lewis and Clark rendezvoused in mid-October on the north side of the Ohio River in Clarksville, Indiana Territory. After a couple of weeks in Clarksville selecting enlisted men for the expedition, the party moved down the Ohio then up the Mississippi. On December 13, 1803, they arrived at their winter camp on the Wood River, near the mouth of the Missouri River. Lewis and Clark would spend five months at the Wood River camp. During their stay at the camp they were busy collecting and describing the local flora and fauna, practicing using their celestial instruments, and recording the daily weather.

On May 21, 1804, the Lewis and Clark expedition, which became known as the Corps of Discovery, was on the eve of its epic journey, a journey that would carry them through several climate zones. Based on the twentieth-century Köppen system for climate classification, the Corps of Discovery would pass through five major climate zones: humid subtropical, humid continental, mid latitude steppe, highland, and marine west coast. Lewis and Clark would formally document, for the first time, the continental climate of the Northern Plains, the highland climate of the Rocky Mountains, and the marine west coast climate of the Pacific Northwest, all of which were far outside their life experience and sharply counter to Jefferson's erroneous assumption that they would be traveling through a region of "moderate climate" (Jackson 1978, p. 12).

At 6:00 a.m. on May, 22, 1804, under cloudy skies, the Corps of Discovery began its first full day as a unit, moving upstream against the powerful Missouri River. Until the party reached the site of their winter quarters at Fort Mandan near today's Bismarck, North Dakota, in November, the party toiled against powerful river currents, recorded information on flora and fauna new to science, traded with the local Indian tribes, and made weather observations.

From St. Louis to Fort Mandan, the party traveled through what the Köppen system broadly classifies as a humid continental climate. This climate class is characterized by severe winters and no dry season. During this leg of the journey the expedition experienced the capriciousness of the continental summertime climate: oppressive humidity followed by dry, northerly winds; torrential downpours and high winds followed by calm; and dense fog followed by sunshine. Weather extremes were common. On July 29, while on the Missouri between today's South Dakota and Iowa, Lewis notes the destruction caused by an apparent tornado: "*… above this high land & on the S. S. passed much falling timber apparently the ravages of a Dreadfull harican which had passed obliquely across the river from N.W. to S.E. about twelve months Since, many trees were broken off near the ground the trunks of which were Sound and four feet in Diameter,…*" (Moulton 1986, p. 427).

By early November the party was at the site of their winter quarters, Fort Mandan, named after the local Mandan Indians. Located about 45 miles northwest of present-day Bismarck, North Dakota, the region is notorious for its severe winters. While at Fort Mandan, Lewis and Clark systematically recorded the daily weather, producing the first long-term, systematic tabulation of weather data west of the Mississippi. Comments on the weather were included in the regular journal entries as well as in a separate weather diary. The weather diary also contained tables that listed the weather observations. These tables, which were similar to Jefferson's weather tables, included the temperature, wind direction, and state of the river. The temperature and wind direction were recorded twice a day, at sunrise and at four o'clock, which Jefferson believed to be the coldest and hottest times of the day, respectively (Jefferson 1955, p. 78).

In comparing current weather observations with those tabulated by Lewis and Clark during their stay at Fort Mandan, Solomon and Daniel (2004) conclude that "*On balance, …the temperatures documented by Lewis and Clark…were not unusual compared to typical modern observations.*"

In early April, when the ice had broken up on the Missouri, the thirty three-member party loaded their boats and proceeded on. The party was slowly entering terra incognita, today's Montana, where the geography, Indian cultures, and climate were virtually unknown. The arid climate of this region—the steppe climate of the Northern Plains—was outside of their life experience. Here, potential evapotranspiration exceeds precipitation, and the winters are severe and the summers hot and dry. Lewis found the low humidity noteworthy enough to carry out a crude experiment:

> [May 30, 1805]… circumstances indicate our near approach to a country whos climate differs considerably from that in which we have been for many months. the air of the open country is asstonishingly dry as well as pure. I found by experiment that a table spoon full of water exposed to the air in a saucer would evaporate in 36 hours when the mercury did not stand higher than the temperate point at the greatest heat of the day; my inkstand so frequently becoming dry put me on this experiment (Moulton 1987, p. 221).

The periods of very low humidity were often punctuated by severe thunderstorms, which were accompanied by torrents of rain, hail, and flash floods.

By mid-August, the Corps of Discovery was making its arduous trek across the continental divide near today's Lehmi Pass in southwestern Montana. The corps encountered steep cliffs, confusing and narrow ravines, and lack of game, all of which were exacerbated by the cold temperatures of the highland climate. Traveling was dangerous. The horses frequently fell, and on September 3 the last of the three thermometers was broken. Clark summed up the situation on September 16: "*…began to Snow about 3 hours before Day and Continud all day…I have been wet and as cold in every part as I ever was in my life…*" (Moulton 1988, p. 209). The grueling journey across the mountains was completed by late September.

In preparation for their journey to the coast, dugout canoes were made, and on October 7, the party was on the Clearwater River heading for the junction with the Snake River. In three days the party reached the Snake River, and two weeks after that, the Columbia River. As the party traveled down the Columbia from the east to the west side of the Cascade Mountains, there was a dramatic change in climate. The steppe climate east of the cascades rapidly transitioned into a marine west coast climate. The arid, thinly timbered landscape of the steppe gave way to another that was moist and heavily timbered.

The marine west coast climate of the Pacific Northwest is distinguished by mild temperatures throughout the year, no dry season and a warm summer. The region is renowned for powerful, moisture-laden storms that buffet the region throughout the winter. Upon the party's arrival to the region in early November, rain, fog, and strong winds were becoming increasingly common. By mid to late November, powerful storms were occurring almost daily. The inclement weather and the lack of permanent shelter were proving extremely difficult to the party. Clark wrote: "*[November 22, 1805] …the wind increased to a Storm from the S.S.E. and blew with violence throwing the water of the river with emence waves out of its banks almost overwhelming us in water, O! how horriable is the day…*" (Moulton 1990, p. 79).

On December 8, 1804, the party began the first full day at the site that would become Fort Clatsop, named after the local Clatsop Indians. Although Lewis and Clark noted in October a change in climate as they paddled down the Columbia from the east to the west side of the Cascades, they now realized that they were in a winter climate that was foreign to them.

The nearly relentless rainfall and relatively mild temperatures of the Pacific Northwest contrasted sharply with the cold, snowy winters that Lewis and Clark experienced in the East. The distinct climate of the Pacific Northwest is noted by Lewis on January 3, when he writes, "*I am confident that the climate is much warmer than in the same parallel of Latitude on the Atlantic Ocean tho' how many degrees is now out of my power to determine*" (Moulton 1990, p. 259).

Lewis's inferred connection between climate and latitude was known since the time of the ancient Greeks. However, not so well known at the time was the role that ocean currents and land–sea heating contrasts played in climate, factors that largely account for his observed difference in climates between the Pacific Northwest and locations of similar latitude on the East Coast.

From the beginning of the party's stay at Fort Clatsop on December 8 until their departure on March 23, the weather remained stormy. Of the 106 days that the party stayed at Fort Clatsop, there were 90 days of precipitation, of which there were 17 days of snowfall. There were only 12 days without precipitation; the sun shone fair for only six days.

Based on comparisons with averaged conditions for today's Astoria, Oregon, which is near the site of Fort Clatsop, Nathan (2005) has shown that the winter of 1805–06 at Fort Clatsop was indeed atypical. The frequency of precipitation, the frequency of snowfall, and the persistent southwesterly winds were all dramatically different than present-day measurements. Nathan speculates that the winter of 1805–06 was a La Niña year.

Lewis and Clark departed Fort Clastop on March 23, 1806. They continued to make daily weather observations on their return trip. At twelve o'clock on September 23, 1806, the party arrived to St. Louis and "*…were met by all the village and received a harty welcome from [its] inhabitants…*" (Moulton 1993, pp. 370–371).

Pursuant to Jefferson's instructions, Meriwether Lewis and William Clark successfully completed an expedition that spanned more than 28 months and covered more than 8,000 miles. They recorded for science more than 170 new plant species and more than 120 new animal species, and they produced hundreds of pages of cartographic, ethnographic, and scientific information. Moreover, the Lewis and Clark journals provide the first systematic instrumental and proxy data of the trans-Mississippi west. The continuous temperature measurements at Fort Mandan and the keen descriptive comments on the weather throughout the journey, which are contained within this monograph, can be combined with documentary, dendroclimatic, and ice-core evidence to form a more complete picture of the regional and global weather patterns during the early nineteenth century. Lewis and Clark's pioneering weather observations add another small piece to the climate puzzle, serving as an overarching link between early nineteenth century climate data and our efforts to model climate change today.

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Preface

This immence river so far as we have yet ascended, waters one of the fairest portions of the globe, nor do I believe that there is in the universe a similar extent of country, equally fertile, well watered, and intersected by such a number of navigable streams.

—Meriwether Lewis
March 31, 1805
Letter to his mother Lucy Marks while at
Fort Mandan, North Dakota

In the annals of American scientific exploration and discovery, one journey that stands the enduring test of time and leads us on to new discoveries is that of Meriwether Lewis and William Clark. The two captains, with more than three dozen participants, explored across the heart of the vastly uncharted North American continent, from St. Louis up the Missouri River across the Continental Divide and down the tributaries of the Columbia River to the mighty Pacific Ocean. Inspired by President Thomas Jefferson and following years of planning and failed attempts, the successful Lewis and Clark "Corps of Discovery" journey established a foundation of commerce, science, and knowledge in what would become the expanding domain of the United States of America (Appleman 1975; Ambrose 1996, 68–79; Hayes 2001; Ronda 2001, viii, 1–16; Wheeler 1904). Historian Roy Appleman (1975, 3) notes that "In its scope and achievements, the expedition towers among the major explorations of the North American Continent and the world." This expedition between 1803 and 1806 vastly increased the knowledge of flora, fauna, geography, geology, native peoples, commerce trade possibilities, and routes. This special edition of the journals describes the systematic climatological, hydrological, and meteorological events the explorers encountered during their journey.

The journals kept by members of the Corp of Discovery contain archaic spellings, misspellings, and inconsistencies in spacing. The editors of this volume have endeavored to edit the excerpts only slightly in order to clarify meaning. Brackets are used to set off text not contained in the original journals, i.e., text that has been added by the source for these excerpts (in these cases most often Moulton, 2002) or by this edition's editor to clarify meaning. Parentheses in journal excerpts were originally included by the journal writer or, in keeping with the convention used by Moulton, they indicate a word once there and erased by the journal writer or a word added by the journal writer after the fact.

This Countrey may with propriety I think be termed the Deserts of America, as I do not Conceive any part can ever be Settled, as it is deficent in water, Timber & too Steep to be tilled.

—William Clark
May 26, 1805
Central Montana

Acknowledgments

This project was inspired by many members of my family, both immediate and extended. This idea came to fruition because of my love for camping along the Lewis and Clark Trail, extended readings of the journals and various books depicting the journey, a Ken Burns and Dayton Duncan movie, and a billboard. Traveling through Missoula, Montana, I came across a commemorative billboard sponsored by the State of Montana intended to remind drivers about the upcoming Lewis and Clark Bicentennial, and the idea of developing a special National Weather Service (NWS) safety webpage for the millions of travelers expected over the four years of the Bicentennial (2003–06) was born. At the end of September 2002, Carl Gorksi, Deputy Director of the NWS Western Region Meteorological Services Division, and Tanja Fransen, Warning Coordination Meteorologist for NWS Glasgow, Montana, prompted me to pursue this project. To them, I am truly indebted.

I am particularly grateful to Mr. Dean Hazen, Science and Operations Officer at the Pocatello, Idaho, National Weather Service for providing valuable suggestions, comments, criticisms, and constructive design concepts. His knowledge of meteorological prose and style has helped this project blossom.

Thanks go to my fellow staff members at the weather forecast office in Pocatello for their encouragement and support during the long hours of research and typing. Thanks also go to the Western Region Headquarters personnel who strongly believed in the importance of this project and assisted in final publication.

Lest we forget, thanks go to those who have gone before us. Many thanks and appreciation to those dedicated authors and historians who spent many years researching the Lewis and Clark Expedition. In particular, Nicholas Biddle, Elliott Coues, Reuben Thwaites, Milo Quaife, Ernest Osgood, Donald Jackson, and Gary Moulton for their timeless work in editing the main baseline of Lewis and Clark journals and letters. To Ken Burns, Dayton Duncan, and Stephen Ambrose for reinvigorating public interest in Lewis and Clark through their excellent film rendition. And those authors who helped my understanding: Appleman, Bakeless, Burroughs, Cutright, DeVoto, Frisinger, Large, Ronda, and countless others.

Finally, much affection to my family for their support. And just as Lewis noted of Private McNeal who "*exultingly stood with a foot on each side of this little rivulet and thanked his god that he had lived to bestride the mighty & heretofore deemed endless Missouri*" on August 12, 1805, I thank mine for His inspiration and guidance on completion of this project.

Part I Meteorology and the Corps of Discovery

Chapter 1 Meteorological Synopsis of the Expedition

"Saw a black cloud rise in the west which we looked for emediate rain we made all the haste possable but had not got half way before the Shower met us and our hind extletree broke in too we were obledged to leave the load Standing and ran in great confusion to Camp the hail being So large and the wind So high and violent in the plains, and we being naked we were much bruuzed by the large hail. Some nearly killed one knocked down three times, and others without hats or any thing about their heads bleading and complained verry much…The plains are so wet that we could doe nothing this evening."

—Sergeant John Ordway
June 29, 1805
Along the Portage Route around the
Great Falls of the Missouri, Montana

"In the afternoon, there arose a storm of hard wind & rain; accompanied with amazing large hail at the upper camp. We caught several of the hail Stones which was measured & weighed by us, there were 7 inches in Surcumference and weighed 3 ounces—Captain Lewis made a small bowl of punch out of one of them. As luck would have it, we were all…Safe…the party that was at the upper camp, were under a good shelter, but we feel concerned about the men on the road with the baggage from the lower Camp—"

—Private Joseph Whitehouse
June 29, 1805
White Bear Island, Upper Portage Camp
Southwest Great Falls, Montana

For decades, exploration of inland portions of the North American continent had been a goal of many governments worldwide, and lucrative trade with Indian nations led many countries to develop remote trading posts. Thomas Jefferson was intrigued by the idea of an expedition up the Missouri some twenty years prior to the Lewis and Clark Expedition. He tried to interest General George Rogers Clark in making the expedition in 1783, but lack of funding prevented an attempt. While serving in Paris, Jefferson tried to engage John Ledyard to cross Russia, enter North America by way of Alaska, and explore eastward to St. Louis. This too fell through as Ledyard was stopped by Russian officials while trekking through Siberia. Jefferson's concern over who would control interests in the Pacific Northwest was further aroused when he learned of overland journeys by British explorer Alexander Mackenzie. Mackenzie made two westward trips from northern Alberta's Lake Athabasca. During his first journey in 1789, Mackenzie led a small party northwest to the Arctic Ocean down a broad river (later named for Mackenzie). On his second journey in 1793, Mackenzie made a trek to the Pacific Ocean down the Peace River and later Fraser River. Arriving at the coast, he threw down the gauntlet to other countries by painting the rocks near the shore with the following inscription: "Alexander Mackenzie, from Canada, by land, the twenty-second of July, one thousand seven hundred and ninety-three" (Mackenzie 1801; Bakeless 1947; Salisbury 1950; DeVoto 1953; Gilbert 1973; Allen 1975; Appleman 1975; Wood and Thiessen 1985; Ambrose 1996; Ronda 2000;

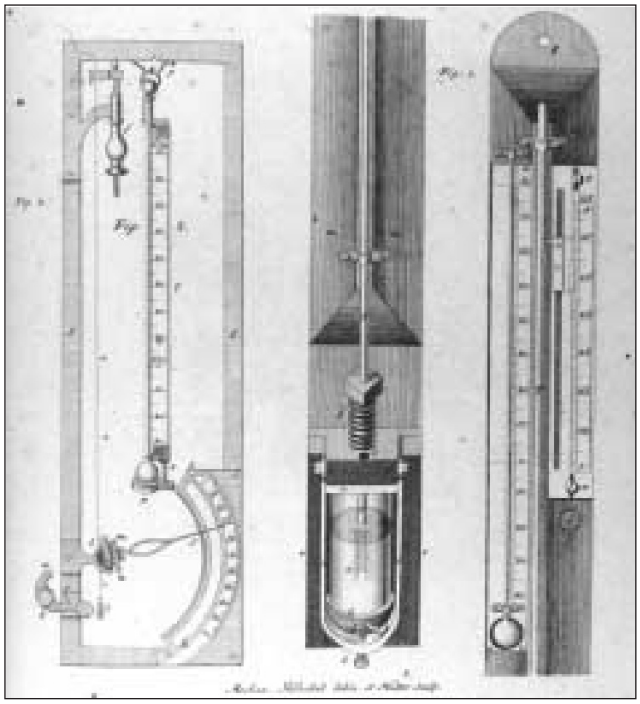
Hayes 2001; Ronda 2001; Saindon 2003). As a twist of irony, the Lewis and Clark Expedition took liberties of a similar nature during their journey, and one of these markings still remains at Pompey's Pillar near Billings, Montana; it is the only remaining physical evidence of their journey on the landscape.

Undaunted by other setbacks, Jefferson tried once again to enlist an explorer to tour the Missouri River system. In 1793, backed by the American Philosophical Society, Jefferson tried to hire Andre Michaux, a French botanist, to make the journey. The plan failed when it was learned Michaux was a French spy attempting to stir up trouble between the Americans and Spaniards (Salisbury 1950; Steffen 1977).

Thomas Jefferson found himself in a better position to promote an expedition when he became president of the United States. On January 18, 1803, he submitted a confidential message to Congress (see Appendix A). Near the end of the message was a small paragraph requesting "an appropriation of $2,500 for the purpose of extending the external commerce of the United States" (Richardson 1897; Bruun and Crosby 1999). On February 28, 1803, Jefferson received word from Congress that they had approved the journey. Meriwether Lewis, President Jefferson's personal secretary, was selected to lead the expedition and spent the spring of 1803 in Philadelphia preparing for the journey. Lewis requested a co-leader for the journey and chose his former army captain, William Clark. While in Philadelphia, Lewis also completed training in astronomy, natural history and sciences, health and medicine, and ethnology. In addition to his studies, he spent time purchasing and obtaining a vast array of materials needed to complete the journey successfully (Biddle 1814; Jackson 1978; Botkin 1995; Burroughs 1997; Burns 1997; Chuinard 1998; Paton 2001; Peck 2002; Cutright 2003; Patient 2003). Included in his packing list were three thermometers (see Appendix B).

Meteorological Instruments

There is uncertainty as to the type of thermometers used on the Lewis and Clark Expedition. Although not discovered until the late 1600s, the basic principle behind thermometers was known as far back as the third century B.C.E. Galileo is credited with inventing the first thermometer sometime around 1593. By 1641, Ferdinand II, Grand Duke of Tuscany, developed a sealed thermometer. Other advancements were made by Robert Boyle, who recognized the need for a standard scale. Various trials took place using water, air, liquor, spirits, alcohol, linseed oil, and finally, mercury as the measuring element within a thermometer. As science advanced during the 1700s, Robert Hooke increased the accuracy and established a fixed measurement for the freezing point of water. Dutch mathematician Christian Huygens is credited with suggesting two fixed points, the second being that of boiling water. Sir Isaac Newton chose a scale using fixed points of melting snow and of the human body. In 1714, Gabriel Fahrenheit developed the first mercury thermometer with a reliable scale. He established the first point of his scale by dipping the thermometer into a solution of ice, water and sal ammoniac, and/or sea salt, and designated it zero. A second point was assigned at 32° F when the instrument was placed in a mixture of water and ice only. The third point of 96° F was based on the temperature reached when the thermometer was placed in the mouth or armpit of a healthy man. Swedish astronomer Anders Celsius provided another alternative in 1742. He used two fixed points: that of boiling water, which he assigned zero on his scale, and the temperature of melting ice, 100, with equal marks between. It was Jean Pierre Christin of Lyons, however, who inverted the scale as it appears today. In fact, by 1779 there were as many as nineteen temperature scales in use (Middleton 1969; Frisinger 1983; Middleton 2003).



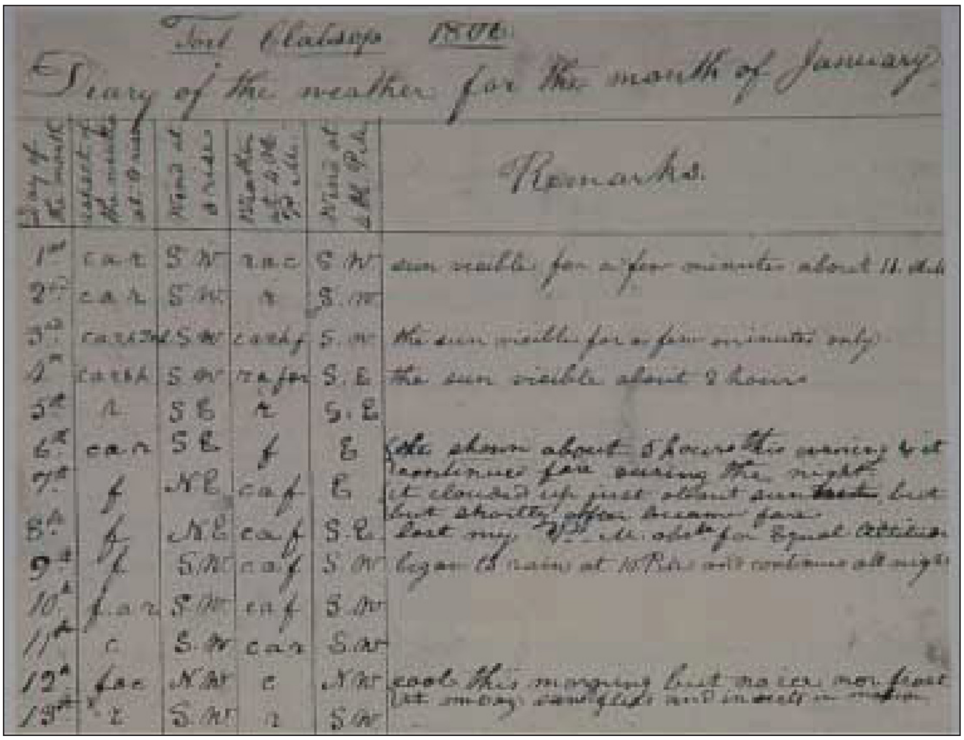
Examples of 18th-century thermometers, as seen in *Beschreiburg der meteorologischen Instumente* by Augusin Stark, published in 1815. Courtesy NOAA Photo Library.

A chronometer was an instrument used for determining time and noon-day sun. Lewis used this instrument for determining the two basic meteorological observation times each day. Photograph taken at Lewis and Clark National Historic Trail Interpretive Center, Great Falls Montana. (See May 17, 1806.)

A sextant used for astronomical observations to determine latitude for navigation. Photograph taken at Jefferson National Expansion Memorial. (See April 5, 1806.)

A portion of the famous map of the western portion of North America made by William Clark and formally published in 1814. Photograph by Vernon Preston, courtesy of the American Philosophical Society/U.S. National Park Service.

The front of a journal that was filled by Meriwether Lewis while the expedition spent the winter of 1805/06 at Fort Clatsop, near present day Astoria, Oregon. Photograph by Andrea Laliberte, USDA-ARS, and courtesy of the American Philosophical Society/U.S. National Park Service.



The Lewis and Clark Expedition Weather Diary entries for January 1, 1806 through January 12, 1806. During this time the Corps of Discovery was in winter quarters at Fort Clatsop, near present-day Astoria, Washington. Photograph by Vernon Preston, courtesy of the American Philosophical Society/U.S. National Park Service.

Which scale was chosen for the Lewis and Clark Expedition? On their first entry (January 1, 1804) in what would become known as the "Weather Diary" (which was also referred to as the "Book of Thermometrical Observations" and the "Meteorological Register"), they performed experiments to determine errors in their thermometers by dipping them in a mixture of water and snow and marking the freezing point, and then making a similar mark when inserting them into boiling water. Lewis and Clark noted that they made these observations using "Ferenheit's Thermometer," which would imply they were using the Fahrenheit scale. It is not certain when they conducted these particular experiments, but during January 17–31, 1803, they made mention of current ambient air readings nearly hourly. Nowhere else during the journey did they write such entries. Clark at various times used words like "Ferenthiers" and "Ferents" thermometer and Lewis used "Ferrenheit," which help confirm what scale they were using (Clark, June 22, 1804; Lewis, September 3, 1803). Another mark they placed on the thermometers was an arbitrary summer temperature commonly known as "Summer heat," which was usually 75° or 76° F (Moulton 1986, 2:316).

It is believed that the three thermometers noted on the requirements list were made in Philadelphia (see Appendix B) (Moulton 1986, 2:69). In his January 3, 1804 entry, Clark makes mention of a particular company that made a thermometer: "John Donegan (or Denegan) and Joseph Donegany (Donegani) were making thermometers in Philadelphia in 1785. Although thermometers are among Lewis's list of requirements for the trip, there is no direct evidence that any were purchased" (Moulton 1986, 2:146). Other stories abound as to their origin. Historian Donald Jackson (1978, 75) notes that "an undocumented family tradition," first related by Dye and renewed by Meany, declares that St. Louis physician Antoine Saugrain made thermometers for Lewis and Clark by scraping the mercury off the back of his wife's mirror. Saugrain had social contacts with the explorers before and after the expedition, but it is not likely that he made thermometers for them. Lewis kept temperature records on his way down the Ohio in the fall of 1803. Clark continued the practice at the Wood River (Dubois) Camp in the early months of 1804, and there is no evidence that the thermometers obtained in Philadelphia were not used. The last one was broken on September 3, 1805 when it was accidentally struck against a tree. The instruments must have been similar to that described by Jefferson in a request on June 5, 1804 to Isaac Briggs for two thermometers: "The kind preferred is that on a lackered plate slid into a mahogany case with a glass sliding cover, these being best exposed on exposure to the weather."

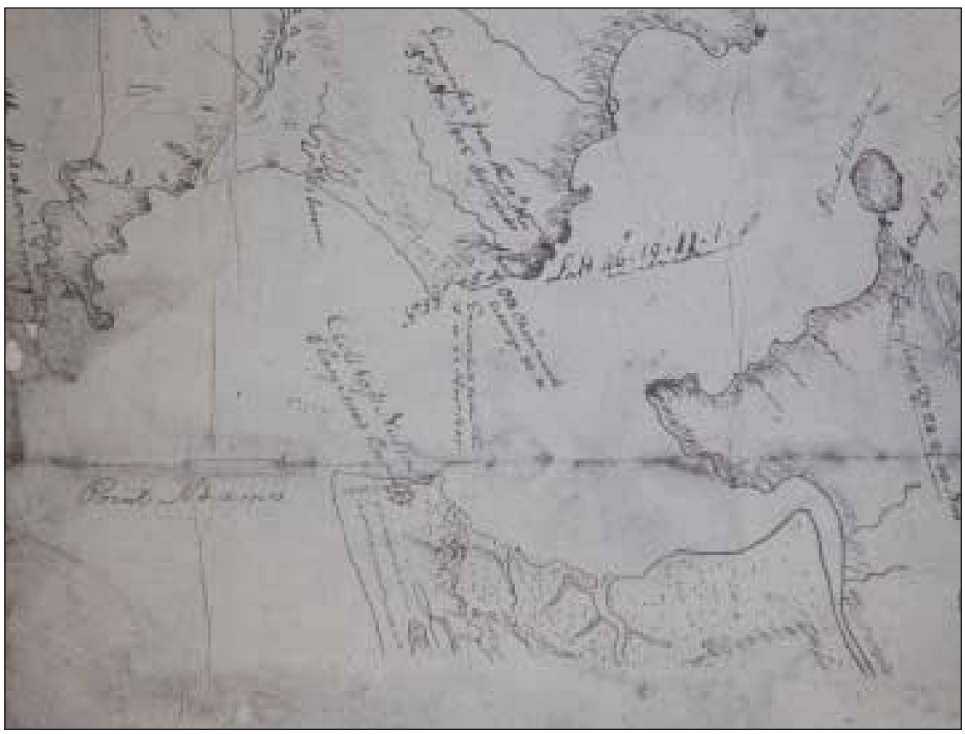
To further confirm this, the Weather Diary entry on September 6, 1805 notes *"Thermometer broke by the Box strikeing against a tree."* No other meteorological instruments are known to have been carried by the expedition. Except for temperature recordings, all other meteorological observations were taken using the natural senses or with other instruments used for navigation and measurement. To determine wind direction, they would stand facing the wind with a compass to determine a direction. For rise and fall of the river water, various marks were made on the bank and measured later with marked sticks, poles, or chains which used the English scale of inches and feet (Large 1986).

Final Instructions

Jefferson sent final instructions to Lewis in June 1803 giving specific directions on the scientific and commercial goals for the expedition (see Appendix C). As fortune would have it, Lewis returned to Washington, D.C. on July 4, 1803 to learn that Napoleon had decided to sell France's Louisiana territory to the United States. This changed the expedition's initial intent

and expanded their commission to conduct diplomatic meetings with the various Indian nations and study the geography of the newly acquired landmass. Lewis went to Pittsburgh, Pennsylvania, via Harpers Ferry, Virginia, to load the many materials needed for the expedition as well as to obtain a keelboat and pirogues (large flat canoes). On August 31, 1803, he left Pittsburgh and headed down the Ohio River, moving slowly due to low water brought on by drought. Lewis noted the extremely low water of the Ohio as well as the perpetual morning fogs in his journal writings. In addition, he conducted mini-experiments by taking temperature readings of the ambient air and the surface water of the river and made interesting conclusions as to the cause of the fog: "*Fog appears to owe it's orrigin to the difference of temperature between the air and water the latter at this seson being much warmer than the former; the water being heated by the summer's sun does not undergo so rapid a change from the absence of the sun as the air dose consiquently when the air becomes most cool which is about sunrise the fogg is thickest and appears to rise from the face of the water like the steem from boiling water*" (Lewis, September 1 , 1803).

Lewis arrived at the Falls of the Ohio near Clarksville, Indiana/Louisville, Kentucky on October 14, 1804. Here he met William Clark and more recruits. As acclaimed author and historian Stephen Ambrose (1996, 117) noted, "When they shook hands, the Lewis and Clark expedition began." They set out from Louisville on October 26, arriving at the confluence of the Ohio and Mississippi rivers on November 14, 1803 and moved up the Mississippi near St. Louis by December 11. Heading up the Mississippi was made difficult by low water and strong currents, and became more burdensome with strong northwest winds from late-fall cold fronts pushing against the boats (Quaife 1916; Osgood 1964).



William Clark's drawing of the landmass around the mouth of the Columbia River and Pacific Ocean. Photograph by Vernon Preston, courtesy of the American Philosophical Society/U.S. National Park Service.

Segments of the Journey

Camp Dubois — Winter 1803/04

On December 12, 1803, Clark established Camp Dubois (Wood) at the mouth of the small Wood River on the east side of the Mississippi directly across from the confluence of the soon-to-be-explored Missouri River. The winter scene at Camp Dubois was fraught with boredom, endless drilling, and preparation of the boats for the journey. Clark kept a log during this time, known as the Camp Dubois Field Notes. However, it was not in the original manuscripts and was printed for the first time in the Moulton edition of the journals (1986). The weather that winter seems typical of the latitude. Their first recorded snows were on the day they established Camp Dubois. By December 22, ice was beginning to form in the rivers, and they settled in for the long winter. They had a white Christmas.

The new year started off with an inch of new snow. Entries began on January 1, 1804 in what today is known as the Weather Diary. This particular diary noted sunrise and 4 p.m. weather observations of temperature, wind direction, the state of weather, river rise and fall, and general remarks. The pattern of entries is very similar to President Jefferson's style of weather diary writings. It also follows the pattern Jefferson directed his friend James Madison to keep while conducting an experiment to debunk arguments by naturalist Comte de Buffon in the 1780s and 1790s. Buffon wrote scathing articles stating that the North American continent's "supposed" inferior weather patterns would lead to degenerated fauna (Druckenbrod 2003). In addition to the Weather Diary remarks, Clark routinely placed comments about weather or river conditions in his daily narrative journal entries. Ever vigilant to conduct quality scientific observations, Lewis and Clark seemed to take care in the placement of the thermometers to obtain the truest temperature readings possible. As many notes show, they found locations under trees out of direct sunlight. One such example contained in Lewis's notes was on July 22, 1805: *"I placed my thermometer in a good shade as was my custom about 4 PM."*

The winter season brought bouts of arctic outbreaks. Almost every day between January 17 and 31, Clark's narrative journals noted hourly temperature observations. No word is given as to why this was done, but it could be that they were conducting experiments to determine any errors on the scale that had been inscribed next to the thermometer. Late winter brought bouts of rain and snow, but fair weather set in by the middle of March, and the ice was off the rivers by the first day of spring. The horizon was occasionally obscured by smoke. A special treat greeted the camp on April 1, as red northern lights (aurora borealis) danced across the sky around 10 p.m. They watched with anticipation the river's daily rise and fall as the flood season progressed. Their first thunderstorm came on the leading edge of a cold front that passed by on April 5. Plants and trees were budding by the end of March, but Clark took special note on April 18, as he stated "*Vegetation appears to be Suppriseingly rapid for a fiew days past*."

Starting up the Missouri — May 1804

After several days of falling river conditions and warming May days, the "Corps for Northwestern Discovery" left Camp Dubois. They pushed across the Mississippi, entered the mouth of the Missouri River, and moved upriver on a cloudy, showery May 14, 1804. At St. Charles (in today's Missouri) they stopped for a few days to readjust the loads in the keelboat and pirogues. Here they met Lewis, who was finishing diplomatic business in and around St. Louis.

Map showing the route of the Lewis and Clark Expedition from its origins in Virginia to St. Louis and on to the Pacific Coast. Image courtesy of NOAA Geodetic Survey.

The expedition finally set off from St. Charles on May 21. Going slowly upriver against the current, the party moved at 5 to 15 miles a day. Driftwood, snags, strong currents, and falling riverbanks from spring floods kept the Corps at a slow pace. Occasionally they would hoist a sail and use the wind to their advantage, but most of the time they poled, rowed, or towed by rope the boat and pirogues. Typical of the sultry Missouri climate, morning fogs were replaced by hot afternoon breezes. The occasional thunderstorm caused concern for the boats. Not much is known of the actual temperature readings during this part of the journey, as no record has been discovered. However, remarks from the daily narrative journal entries show it was hot and humid during the late spring and early summer on the Missouri. Some members had heat stroke, and many got sunburned. They passed present-day Kansas City, Missouri, on June 26. The highest temperature (96° F) the expedition would record for the entire journey occurred on June 30 as they neared present-day Leavenworth, Kansas.

On July 4, they stopped by a small stream and named it after the special day. Clark made special mention of the area: "*One of the most butifull Plains, I ever Saw, open & butifully diversified with hills & vallies all presenting themselves to the river covered with grass and a few scatttering trees. Nature appears to have exerted herself to butify the Senery by the variety of flours Delicately and highly flavered raised above the Grass, which Strickes & profumes the Sensation, and amuses the wind throws it into Conjectering the cause of So Magnificent a Senerey in a Country thus Situated far removed from the Sivilised world to be enjoyed by nothing bu the Buffalo Elk Deer & Bear in which it abounds & Savage Indians*." A few days later, Clark and Sergeant Ordway noted the effects of the extreme heat on expedition members. "*Worthy of remark that the water of this river or Some other Cause, I think that the most*

Probable throws out a greater prepson. of Swet than I could Suppose Could pass thro: the humane body Those men that do no work at all will wet a Shirt in a Few minits & those who work, the Swet will run off in Streams" (Clark and Ordway, July 6, 1804).

On July 12, in what would become an expedition ritual, Clark climbed a nearby hill to take celestial observations and inscribe his name, day, and month near an Indian pictograph of animals and a boat. Summer thunderstorms brought relief from the excessive humidity but also brought perilous moments, as the boats were nearly capsized or run ashore by the strong winds and waves.

Passing north of present-day Omaha, Nebraska, the Corps found a swath of large- diameter trees twisted and mowed down. Clark's observation notes say "*passed much fallen timber apparently the ravages of a Dreadfull haricane*." These trees were probably part of a recent tornado path. Farther up the river, they began to note how much of the prairie had been burned. As they would learn, starting a prairie fire was a way of notifying Indian nations that travelers were nearby or that their presence at a council was requested. Later, they would find bluffs with seams of coal on fire producing a sulphurous odor.

August continued sultry, with afternoon and evening showers and thunderstorms. Clark began to note changes in the air as they moved north: "*the air is pure and helthy So far as we can Judge—*." As they entered the Great Plains and left the protection of the dense forests of Missouri, the strong daily breezes on the prairie acted as both a blessing and a curse to the expedition. On many days, the prevailing southeast winds assisted their upstream progress against the rapid current, but sudden changes as frontal boundaries pushed through in late summer delayed their departure many times until late in the afternoon. The loose sands near the river often acted as a "summer blizzard" by reducing visibility, irritating their eyes, and filling everything full of gritty menace. The party became concerned one August day as they rounded a bend and saw the river full of white feathers that continued for three miles. Tension mounted, as they were fearful of meeting hostile Indians. A few miles later they came upon a flock of pelicans who were shedding their feathers in preparation for new growth, something the Corps had never seen before. Throughout the summer months bugs plagued the party, most notably the mosquito. In fact, for nearly the entire journey, mosquitoes became a scourge and generated a plethora of comments.

By September 8, the expedition had pushed into South Dakota and was headed toward the "Great Detour of the Missouri." The first cool rains of the early fall season met the Corps just downriver from the Big Bend of the Missouri, or as they called it, the Grand Detour. A few days later, the Weather Diary mysteriously ends its silence as daily observations resumed on September 19 with no explanation as to their previous absence. These were the first entries since leaving Camp Dubois on May 14. They noted the change of seasons by remarking that the leaves of the cottonwood were fading and the brant and plover were starting to migrate southward. Clark further expounded on a remarkable change in the humidity. On September 23, the Weather Diary entry noted, "*aire remarkably dry-plumbs & grapes fully ripe— in 36 hours two Spoonfuls of water aveporated in a sauser*." Lewis would again experiment with evaporation rates in Montana the following spring (Lewis, May 30, 1805) (Large 1986).

During what seemed like an early fall, the party began to note the changes in the flora and fauna and experienced their first frost of the season on October 5. Brisk north winds swept cold, dense gray clouds (black flying clouds, as Lewis called them), indicating the first clue of a harsh winter to come. The expedition pushed into North Dakota in mid-October and received freezing rain and their first snow of the season just north of Bismarck, the present-day capital of North Dakota, on October 21. Having decided to winter near the Hidatsa/Mandan Villages, they established Fort Mandan west of present-day Washburn, North Dakota, on November 2, 1804.

Fort Mandan — Winter of 1804/05

Continuing to note special circumstances, the narrative journals and Weather Diary entries show that the winter of 1804/05 at Fort Mandan was somewhat colder and wetter than modern observations (Burnette 2002). Tragedy struck the Mandan villages on October 29, as wind-whipped fire swept across the prairie into the Indian village, killing a man and woman and severely burning others. The Corps barely escaped and noted the fire passed the camp "*with great rapidity and looked Tremendious*." Other unique occurrences during the winter of 1804/05 included a spectacular appearance of the aurora borealis (November 6) and the onset of ice in the river (November 13). Repeated heavy frost was noted many times, and one event impressed Sergeant Ordway on November 16: "*the Trees were covered with frost which was verry course white & thick even on the Bows of the trees all this day. Such a frost I never Saw in the States*." Several instances of frostbite and snow blindness were recorded, along with heavy snowstorms, such as the one on November 29 when 13 inches fell. Corps members experienced additional hazards as winds stirred up blizzard conditions and produced significant snowdrifts. Another white Christmas was noted and celebrated by cannon fire in the morning and feasting during the afternoon. Extreme cold, which none of them had ever experienced, caused them to change the guard as often as once every half hour during the coldest times. December 17 marked the coldest temperature recorded during the journey, as the mercury fell to –45° F. They also experienced many visual oddities during the winter, including parhelion (sun dogs, December 8 and 11); a halo around the moon (January 12, 1805); several mirages; and even an eclipse of the moon on January 14. As the first year of the expedition came to a close, Private Whitehouse gave his summation of events at Fort Mandan: "*nothing particular occured Since christmas but we live in peace and tranquillity in our fort. The weather continued pleasant & the Air Serene— .*"

The year 1805 began with a mild 34° F, but by early evening a light sprinkle of rain gave way to overnight snow. The Corps learned about various Indian customs during their stay with the Mandans. One of particular note was how they kept their horses during the winter. During the daytime, they let them roam about, but the horses would return to the large mound lodges and spend the night inside with the families. Sometimes, during hunting parties, the Indians were forced to stay out all night in the subfreezing temperatures. Sergeant Gass noted one particular incident when an Indian survived by cutting branches from trees and lying on them to keep his body off the snow while also covering himself with a buffalo robe. Clark was so impressed with their heartiness that he commented "*…a man Came in who had also Stayed our without fire, and verry thinly Clothed, this mans was not the least injured— Customs & the habits of those people has ancered [inured them] to bare more Cold than I thought it possible for man to indure— .*"

Realizing they needed to prepare for the spring thaw, the party attempted to remove the boats from the river ice during January and again in February. Many ingenious methods were employed to cut through or thaw the ice. They finally succeeded just a couple of weeks before the river started to break up in early March. The snow began to melt and spring was just around the corner. On March 3, they saw a large flock of ducks, and their first insect on March 27. With the snow nearly gone, they witnessed the Indian nations preparing for the return of the buffalo by setting the prairie on fire. They learned that this would stimulate early grass growth and lure the herds toward their village (Moulton 1987, 3: 309). By late March, the party was preparing to depart as they watched geese and swans return from their winter migrations. They experienced several ice jams near the end of the month as large chunks broke loose well above their location but became stuck in a river bend. To their amazement, the Indians began jumping from one cake of ice to another in an attempt to catch buffalo as they floated down.

Their first thunderstorm of the season occurred on April 1. Lewis provided some additional observations on this particular day: "*A fine refreshing shower of rain fell about 2 PM this was the first shower of rain that we had witnessed since the fifteenth of September 1804 tho' it several times has fallen in very small quantities, and was noticed in this diary of the weather. The cloud came from the west, and was attended by hard thunder and Lightning. I have observed that all thunderclouds in the Western part of the continent, proceed from the westerly quarter, as they do in the Atlantic States. The air is remarkably dry and pure in this open country, very little rain or snow ether winter or summer. The atmosphere is more transparent than I ever observed it in any country through which I have passed*."

Moving Toward the Rockies — Spring and Summer 1805

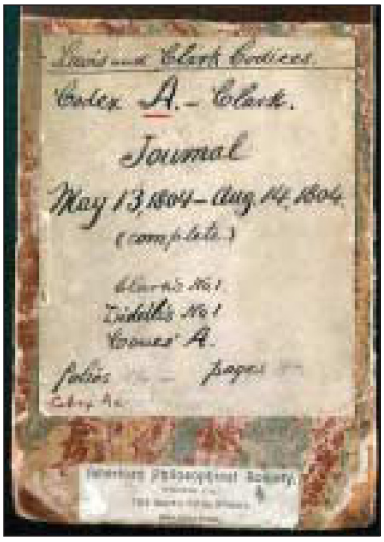
On April 7, 1805, the permanent party of thirty-three left the Mandan villages for the unexplored land to the west. A smaller party took the keelboat packed with journals containing the expedition's discoveries and specimens collected during the previous year's travel up the Missouri back to St. Louis. Specimens including various plants, animals, and minerals were shipped to President Jefferson. Some of these items are still on display at Monticello, Virginia, and in Harvard's Peale Library. As they headed up the Missouri, Lewis had time to note the significance of the date: "*Our vessels consisted of six small canoes, and two large perogues. This little fleet altho' not quite so rispectable as those of Columbus or Capt. Cook were still viewed by us with as much pleasure as those deservedly famed adventures ever beheld theirs; and I dare say with quite as much anxiety for their safety and preservation. We were now about to penetrate a country at least two thousand miles in width, on which the foot of civillized man had never trodden*."

Incessant winds racing across the prairie plagued the expedition during their ascent of the Missouri into present-day Montana. Many times in April and May, they had to stop by 9 a.m. and did not return to the river until 3 p.m. The strong winds caused several near-mishaps as canoes would tip and nearly sink with their valuable cargo. More importantly, a few Corps members barely escaped drowning. Ordway also noted how bad the winds were: "*The Sand blew off the sand bars & beaches so that we could hardly see, it was like a thick fogg*." The sandstorms drew complaints of sore eyes from the men, and as Lewis noted, "*So penitrating is this sand that we cannot keep any article free from it; in short we are compelled to eat, drink, and breath it very freely*." The dust rose to great heights in immense columns and was visible for several miles.

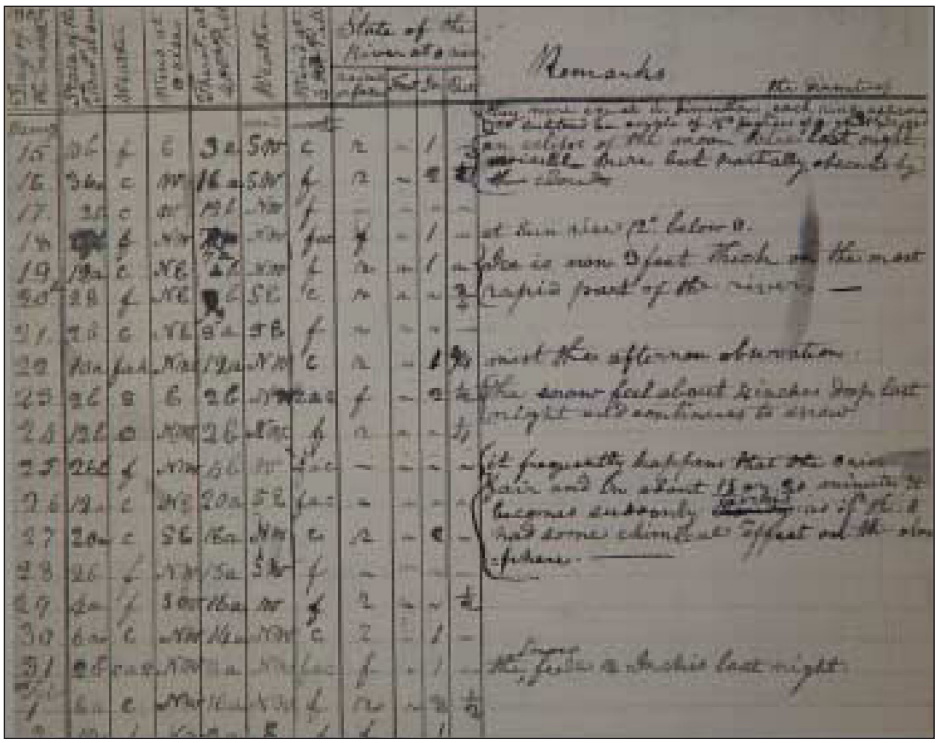
Just two days into the ascent, their old nemeses were back. As Ordway succinctly put it on April 9, "*The Musquetoes begin to Suck our blood this afternoon*." As spring progressed, their flora and fauna notations in this newly explored land increased dramatically. By the end of April, they began to note the plants had scarcely changed in their growth patterns and may have been at even earlier stages than those at the Mandan villages. Although not perceptible to the Corps, they were experiencing the effects of the higher-elevation plains as they neared the Rocky Mountains, as well as the higher latitude, which has a shorter growing season.

The expedition reached the confluence of the Missouri and Yellowstone rivers near the end of April and pushed toward central Montana. Spring brought normal changes including many morning frosts, water freezing on their oars, and occasional bouts with fog and snow. A couple of late-spring snowstorms shocked the party as they remarked how hearty the plants must be to tolerate such drastic weather changes. Clark expounded, "*The Snow which fell to day was about 1 In deep, verry extroadernaley Climate, to behold the tree Green & flowers Spred on the plain, & Snow an inch deep*" (Clark, May 2, 1805). As they passed from the flat barren plains toward central Montana, navigation became more difficult as the river grew more

Clark drew exquisite maps of the river and its environs. In this image he noted the large areas of trees, which he described in the journal as "*much fallen timber apparently the ravages of a Dreadfull haricane.*" The trees were likely affected by downburst winds or a tornado. (See July 29, 1805.) Photograph by Vernon Preston, courtesy of the American Philosophical Society/U.S. National Park Service.



The front of journal that was filled by William Clark while the expedition was traveling up the Missouri River from St. Louis toward present-day Omaha, Nebraska. Photograph by Andrea Laliberte, USDA-ARS and courtesy of the American Philosophical Society/U.S. National Park Service.



The Lewis and Clark Expedition Weather Diary entries for January 15, 1805 through February 2, 1805. During this time the Corps of Discovery was in winter quarters at Fort Mandan, near present-day Washburn, North Dakota. Photograph by Vernon Preston, courtesy of the American Philosophical Society/U.S. National Park Service.