Quarantine the world of the Mediterranean and its wealth, its inspiration, its resources - even its sea will dry up. The Mediterranean is an arid region. So much water evaporates from the Sea that all the rain falling on it and all the rivers running into it cannot keep it full, and Atlantic Ocean water flows in continuously through the Straits of Gibraltar.

About 7.2 million years ago, Africa collided with Europe at the Straits of Gibraltar and the two continents became one. The Alps were created by this union. Once the Straits were closed, the Mediterranean was cut off from its supply of Atlantic Ocean water and began evaporating. In the next two million years, it disappeared almost completely. Then, about five million years ago the Straits reopened and Atlantic waters poured down onto the dry Mediterranean Sea floor to produce what must have been the greatest flood of all times.

Much geologic evidence for this event is still with us. As the water evaporated, huge deposits of salt accumulated on the dry sea floor. In some places these deposits were buried by dunes and protected from redissolving once the Sea filled again. Cores of sediments from the sea floor still contain thick and extensive layers of this sealed off salt. The rivers also left their mark on the sea floor. As the waters evaporated the rivers had to plunge downward over newly exposed land to reach the shrunken sea. In the process they carved deep canyons that have since been covered by water and largely filled with sediments. Echosondes now reveal the profiles of these choked and buried canyons.

At the height of its Renaissance, the Mediterranean was once again cut off from the surrounding world. For centuries Italy had used the Mediterranean as her private river to transport the current of expensive goods, such as pepper, from the Orient. Then, in 1453, the Turks conquered Byzantium and blocked access to the East. Overnight, prices of Oriental spices skyrocketed and the rest of Europe groaned. The exorbitant costs of these goods gave new impetus to the European voyages of discovery that had already begun under Prince Henry the Navigator.

In 1415 the Portuguese had crossed the Straits of Gibraltar and looted the Moroccan city of Ceuta. Lured by Moslem reports of even greater riches further south in the heart of Africa, Prince Henry of Portugal launched a program of exploration down Africa's Atlantic coast in 1420. In 1434, Gil Eannes rounded Cape Bojador at latitude 26º North, long the southern terminus for superstitious sailors, and discovered lush vegetation beyond the southern fringe of the Sahara. Aristotle had maintained the climate would be unbearably hot in the tropics, but Portuguese sailors and their dreams of wealth proved him wrong.

For the next half century, the Portuguese worked their way further down the coast of Africa. In 1486 Bartholomew Dias rounded the Cape of Good Hope. The fabled wealth of the Indies finally seemed within his grasp but his crew, weakened by scurvy, refused to go further. A few years later, in 1492, Columbus set out to reach the Indies by sailing westward. His discoveries only goaded the Portuguese to further adventure. In 1497 Vasco da Gama began an expedition, commissioned by King Manuel of Portugal, to round Africa and bring back the spices of India. In an arduous voyage that lasted two years, Vasco opened a new trade route and began to transform the Indian Ocean into a Portuguese sea. Overnight, European warehouses were overflowing in pepper and prices plummeted. Northern and Western Europe could finally bypass the Mediterranean. From this time though, the coffers of Italy slowly began to drain.
Politics compounded Italy's tribulations. Jealous of Italy's accumulated wealth and sensing opportunity from her continuous internecine strife, King Charles VIII of France crossed the Alps in 1494 and inaugurated a series of invasions from the north that wasted and plundered Italy for half a century. Spain carved out her own claim to the Kingdom of Naples and tenaciously held on to her gains.

The Church's need for cash increased drastically and transformed the selling of indulgences into a flagrant violation of any religious principle. In Germany, the locus of power and wealth shifted northward toward the Atlantic as a result of the Portuguese and Spanish discoveries. There, far from Rome, resentments over the Church's financial exactions and landed wealth grew to such a pitch that the Reformation became inevitable. In 1516, the year before Luther's famous theses, the papal nuncio, Girolamo Alessandro reported many Germans spoke plainly that they were merely waiting for "some fool" to open his mouth against Rome.

In the tumultuous atmosphere that characterized much of the sixteenth century, man's vision began to turn myopic and parochial. The liberal and far seeing spirit of humanism that the Church had winked at degenerated into a wanton egotism later brought under control by a reactionary and repressive puritanism. Amid these changes, the painters' simplistic and clear vision began to blur. Haze and nightfall darkened and obscured the once pristine Renaissance skies. The air itself became a solid, obstructing entity capable of producing awesome winds and storms, torrential rains and wondrous optical phenomena. An entire world that had lain hidden was now revealed in the death throes of the Renaissance.

Storm and Smoke

Who first noticed the obscuring mists and towering storm clouds that heralded the twilight of the Renaissance? It was none other than Leonardo da Vinci, perhaps the incarnation of the Renaissance spirit.

Leonardo, the illegitimate son of Piero da Vinci and a peasant woman named Caterina, was born in 1452. From an early age, he showed an artistic talent. In 1469, Piero took the boy to Florence where he was apprenticed to Andrea del Verrocchio. The first documented work from Leonardo's hand is the angel and a piece of the landscape background on the far left of Verrocchio's Baptism of Christ (c. 1470-73). The angel already possesses the famous Leonardo smile. Vasari relates the apocryphal legend that when Verrocchio saw this angel he realized Leonardo had already surpassed him as a painter and thereafter never painted again.

During Leonardo's years in Verrocchio's workshop there is little hard evidence of his activities. The Annunciation (c. 1475, Uffizi Gallery) is an exercise in single point perspective but also contains the seeds of certain elements that became central to Leonardo's later masterpieces. The atmosphere is decidedly hazier than in any other contemporary work and distant Apuan Alps rising precipitously on the right are all but obscured by light of the intervening atmosphere. Curiously, the sky contains one small cloud that resembles the decorative cumulus found in many of Domenico del Ghirlandaio's later works (the Annunciation has been attributed to Ghirlandaio and may have been a joint effort), while most of Leonardo's later paintings are cloud free.

Leonardo led a double life as a meteorologist. He purged all ephemeral effects and all disturbing influences from his paintings. These have no storms and only a few unobtrusive clouds, while a haze called sfumato (smoke) reduces glare, softens shadows, and fills all space with diffuse light. But in his drawings, all the power and fury of the weather is unleashed. The thunderstorm is shown in full outline for the first time, and in
his series of 11 drawings entitled, Deluge, swirling clouds fill the air, releasing torrents of rain that so arouse the elements it is difficult to distinguish air, water, and earth. In all his meteorological works Leonardo portrayed the atmosphere in ways no earlier European artist had even dimly conceived.

What led Leonardo to these revolutionary vistas? In 1912, a German art historian argued that Leonardo's sfumato was inspired by landscape scenes painted on Chinese pottery he had presumably seen in the Medici collection (since lost). The Chinese had long focused on two of the atmospheric phenomena, eddying motion and mist, that most interested Leonardo. It is possible that da Vinci began by imitating, and indeed, many of his mechanical drawings are copies or modifications of devices then manufactured by others. But Leonardo's atmospheric repertoire contains discoveries that evolved gradually as a result of observation and experiment, and bespeak a spiritual brotherhood with his Chinese brethren.

Now the air around Florence is much clearer and the atmosphere far more placid than in hazy, stormy China. Had Leonardo remained in Florence he may never have developed his meteorological themes so fully. But in 1482 he left sunny Florence to serve Lodovico Sforza in Milan. There, at the doorstep of the Alps he saw and reflected on atmospheric wonders seldom encountered in the Mediterranean world.

Milan is only 160 miles northwest of Florence yet climatically it is part of another world. Florence lies in the Italian peninsula, which protrudes into the Mediterranean and is ruled by summer drought. Milan lies just north of this peninsula. There the humidity is decidedly higher, the air thicker, and large cumulus more common. The Alps rise within sight of Milan and, like most mountain ranges, give birth to thunderstorms that grow to vent their fury on the earth below.

Like many Chinese landscape painters, Leonardo was a confirmed mountaineer and climbed the mountains for inspiration. He saw the atmosphere tinge the distant lowlands and mountains so that they appeared as if seen through a blue film. He saw petrified seashells encased in rock on the highest peaks and realized that no Biblical Flood could ever account for their origin. He also witnessed the storms that tear away at the mountains and divide the earth into two zones - a lower zone of darkness beneath the storm clouds and an upper zone still bathed in the light of the Renaissance.

And I saw the sky above me quite dark and the sun as it fell on the mountains was far brighter there than in the plains below.

Leonardo never presented such a stormy vista in any of his major paintings, but around 1500 he executed a powerful stormscape in a drawing, a Storm Breaking Over a Valley (Fig. 6-1) that divides the world into two zones. The
brightly illuminated cloud tops slosh against the mountain peaks like waves breaking against a steep shore. Shafts of rain fall from the flat-based cumulus onto the darkened valley floor below and obscure all that lies beyond it. Leonardo noted,

When the rain begins to fall, it tarnishes and darkens the air, giving it a dull colour.... Objects seen through the rain appear confused and of undetermined shape.

The *Storm Breaking Over a Valley* has a dramatic impact not previously encountered in any work of art. It heralded a new age in which nature finally emerged as a monumental force free from any divine presence. Nevertheless, its cumulus is too small to produce such darkness and such a downburst. Only the modest stratus of morning remains so neatly encased within valley walls. The towering cumulonimbus of afternoon dwarf the mountain peaks they sprout from (Fig. 6-2). A mountain crest, ravished by lightning and buffeted by high winds, is almost never bathed in sunlight and is the worst imaginable place to weather out a storm.

Fig. 6-2 Cumulonimbus (viewed from the west) with mushroom anvil and overshooting top. Paul Neiman.

But Leonardo also witnessed and envisioned such grand storms, revealing aspects of their secret structure that meteorologists would not rediscover for centuries.

In the creation of the cloud it attracts to itself the surrounding air, and so becomes condensed, because the damp air was drawn from the warm [upward] into the cold region which lies above the clouds...On one occasion above Milan toward Lake Maggiori, I saw a cloud shaped like a huge mountain, made up of banks of fire, because the rays of the sun which was then setting red on the horizon had dyed it with their color. This great cloud drew to itself all the little clouds which were about it. And the great cloud remained stationary, and it retained the light of the sun on its apex for an hour and a half after sunset, so enormous was its size. And about two hours after night had fallen there arose a stupendous storm of wind. And this [cloud], as it became closed up caused the air which was pent up within it, being compressed by the condensation of the cloud, to burst through and escape [downward] by the weakest point.

Notebooks of Leonardo da Vinci, 761.

Fig. 6-3. Structure, air motions, and appendages of a squall line thunderstorm moving toward the right.
Cumulonimbus, the thundercloud forms when hot, buoyant air rises rapidly from ground level to the stratosphere where it loses buoyancy and spreads out into an anvil-shaped mushroom cap (Fig. 6-3). Anvils have a fuzzy appearance because they consist of a low concentration of falling, evaporating ice particles. Strong winds of the jet stream can stretch the anvil several hundred miles from the parent cloud and warning people living downwind of its approach.

As the air inside the updraft rises and cools, a great weight of water and ice particles accumulates. Downdrafts form as the weight of these particles drags the air down. When the updraft is tilted, the particles fall into drier air at the side of the cloud. As the particles evaporate they intensify the downdraft by cooling the air. The chilled and soaked downdraft then hurts toward the ground, where it splays out and often undercuts the updraft.

Several awe inspiring appendages protrude from severe thunderstorms. A cauliflower-shaped, hemispherical overshooting dome may protrude like a fountain as much as two miles above thunderstorms with strong updrafts. Thunderstorms that punch up into dry air develop smooth, breast like pouches called mamma that extend down from the underside of the anvil. Some of this dry air is entrained into the anvil and mixes with the cloud air. Droplets and crystals evaporate to smooth the cloud edges and cool the air, which then sinks in blobs to form the mamma (Fig. 6-10). The mamma extend downward until all the liquid water has evaporated.

Mamma sometimes line up like strings of pearls as the air on the underside of the anvil curls back toward the central updraft. Located high above the ground, mamma can be seen from miles away and therefore serves as a precursor of an impending severe thunderstorm that may be accompanied by large hail and even a tornado.

Even though artists did not depict violent weather in the 15th century, a few precursors, such as Fra Angelico's *Descent from the Cross* (Fig. 5-38) show cloud features in otherwise placid skies that closely resemble mamma. Hans Memling, must also have seen and remembered the protuberances projecting from the dark base of an approaching thunderstorm, for he painted darkened Crucifixion scenes as early as 1470 (The *Passion of Christ*, Galleria Sabauda, Turin) and continued doing so until his death in 1491. The *Crucifixion* (Fig. 6-4, 1491, Szepmuveseti Muzeum, Budapest, Hungary) is a typical example. The dark cloud base is marked by a bright fringed corrugated underside. It has descended almost to the level of the cross while the clear background sky remains undisturbed with high visibility.

Fig. 6-4. Hans Memling. Crucifixion 1491. Szepmuveseti Muzeum, Budapest, Hungary
A distinctive, wedge-shaped straight shelf cloud or curved arc cloud forms at the leading and/or trailing edge of the base of some severe thunderstorms. It marks the nose or edge of the cold downdraft that has struck the ground, splayed out and turned back up into a vortex that moves out from the storm. When the dark underside of the arc cloud is ragged with gross, rapidly moving protuberances, it consists of rain-soaked air from the downdraft that formed cloud when it turned up inside the nose. When the top of the arc cloud is smooth it resembles a mountain wave cloud, because it consists of warm, humid air that has been forced to surmount the nose. Smooth arc clouds that protrude from the base are called pedestal clouds.

The potentially violent air motions that take place in the outflow below arc clouds cannot be seen unless the air is rendered visible by some tracer such as dust. This is precisely what Leonardo did in series of 11 drawings entitled Deluge (Fig. 6-5), drawn in his last years.

Deluge scenes represent the consummation of Leonardo’s study of fluid motions and vision of storms. Here, the placid bright zone above the cloud tops is gone. The neat distinctions between air, water and earth have practically been obliterated, and all nature appears on the verge of crumbling into chaos. Only the flow patterns, the cold rain-filled downdrafts issuing from the bases of clouds, remain unmistakable.

Similar whirling spirals appear in the waters of Mesopotamian art and on the capitals of inverted Ionic columns, while Chinese artists went so far as to depict the swirling flow of air in clouds. But Leonardo surpassed them all, showing the flow of invisible air. He first depicted such flow patterns in water poured into a reservoir (c. 1505). To render these flow patterns visible, he poured dyed water into reservoirs of clear water, or spread sawdust on the surface of water flowing around obstacles. Then he extrapolated the flow patterns of water to those of the air beneath the clouds, noting "that in all cases the motion of water conforms to that of air." The result is the descending jets of air in the Deluge that first diverge and then curl back up like a vortex ring when they encounter the ground.

Meteorologists should have studied Leonardo more carefully, for Tetsuya Fujita did not rediscover the downbursts beneath thunderstorms until 1975, and Fernando Caracena did not hypothesize their vortex outflow patterns until 1982. Photographs (Fig. 6-6) then quickly confirmed what Leonardo had known all along.

Fig. 6-5. Leonardo da Vinci. Deluge. c. 1515. Royal Library, Windsor. # 12380.

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Fig. 6-6. Photographic profile of a downburst showing the nose. NSSL Photograph.

Leonardo also learned to appreciate atmospheric obscuration more fully during his stay in Milan. Not only is Milan stormier than Florence, it is the fog capital of Italy. Fog often
drains into the Po River Valley, where it gets trapped if winds are light. Even when the fog burns off, many afternoons in Milan remain hazy. But interestingly, Leonardo did not introduce the thoroughly smoky or hazy quality to Renaissance painting until about the time he returned to sunny Florence. And the work he chose to introduce this revolutionary vision was the *Mona Lisa* (1503, Louvre).

During Leonardo's years in Milan, when his interest in science grew, atmospheric obscurcation and fog concerned him deeply, and he wrote repeatedly about their effects in his Treatise on Painting and elsewhere in his Notebooks. He understood why, as I have already pointed out, obscurcation caused by mist can add to a painting's sense of monumentality. He realized that the sky is whiter near the horizon as a result of its greater thickness there. He even had some inkling of why the sky is blue, noting,

as an illustration of the color of the atmosphere I will mention the smoke of old and dry wood, which as it comes out of a chimney, appears to turn very blue when seen between the eye and the dark distance.

Leonardo's explanation of why distant mountains appear blue remains unsurpassed.

Whatever be the colour of distant objects, the darkest... will appear the most tinged with azure....The air tinges with its own colour more or less in proportion to the quantity of intervening air between it and the eye....

He also observed correctly that,

Buildings or towns seen through a fog, or the air made thick by smoke or other vapours, will appear less distinct the lower they are.... The inferior or lower extremities of distant objects are not so apparent as the upper extremities. This is observable in mountains and hills, the tops of which detach from the sides of other mountains behind. We see the tops of these more determined and distinctly than their bases; because the upper extremities are darker, being less encompassed by thick air.

Leonardo used these discoveries in the *Mona Lisa* and in the *Virgin and Child with St. Anne* (Fig. 6-7). He labored over the *St. Anne* for many years, doing a cartoon for it in 1501, and returning to it sporadically about a decade later. It is almost certainly unfinished. The transition between the brown foreground and the blue-gray mountains of the background is abrupt. Even so, there is enough to revel in. We are raised to the gateway of the Alps of da Vinci’s mind. The mountains consist of the vertically thrust strata he loved so much and knew so well. Ridge after ridge rises in ranks that dissolve in the distance. The nearest ridges are darkest while the furthest are scarcely distinguishable from the sky. All the remote valleys are filled with an obscuring light gray mist that almost disguises a misty lake nestled against the edge of the mountains on the left. Not one cloud disturbs the breathless sky.

Fig. 6-7. Leonardo da Vinci. Virgin and Child with St. Anne. c. 1508-1513, Louvre.

The painters of the Middle Ages had omitted the sky because it always served to
place the events within a prescribed time and space frame. In the Virgin and Child with St. Anne, Leonardo showed how the motionless substance of air could bring the eternal and infinite within reach.

Leonardo's great works of sfumato, the Mona Lisa and the St. Anne remained in his private possession until his death. His notebooks and drawings did not become part of the public domain until long after that. Still, the next generation of painters including Raphael, Giorgione and Titian were aware of Leonardo's aerial innovations and their works show it. Once Leonardo focused attention on atmospheric obscuration and storminess, the next generation saw hazier skies and larger, more amorphous clouds. After Leonardo blurred the distinction between air, water and earth, the younger generation outgrew the need to conceive of nature as a static assemblage of separate objects. Increasingly, the separate, individual fifteenth century clouds congealed into cloud fields while continuous walls of greenery overgrew the lollipop trunks that had marked the edges of forests. John Ruskin noted these changes, remarking

The dignified and simple forms of clouds in repose are often by these fifteenth century painters sublimely expressed, but of changeful cloud form they show no example. *Modern Painters*. Volume 1. p 76.

The stylistic transformations that took place largely between 1500 and 1550 involved a deemphasis of form. Italian clouds became less identifiable as they grew more massive. Gradually, visibility began to decrease.

Leonardo may have accelerated these changes but they would have come about without his influence. The changing tenor of society finally allowed the artists to see the corporal and disturbed nature of the atmosphere. Heinrich Wölfflin noted that the evolution of artistic style always involves a transition from the so-called linear, in which the outline and form of objects are stressed to 'painterly', in which form is downplayed or even dissolved and shading or tonal differences are emphasized.

Even the techniques of painting underwent a parallel evolution. Giorgione was apparently the first to dispense with detailed underlying preparatory drawings and to apply paint directly to the blank canvas. Later, Tintoretto and Titian began freely applying paint with broad brushstrokes that were no longer disguised.

The weather also helped to cloud and obscure the skies and blur the sharp outlines in Italian paintings. Even before haze was 'discovered', Andrea Mantegna, Giovanni Bellini and Vittore Carpaccio, working in and around Venice, produced larger and more convincing clouds than most of their more southerly compatriots. After 1500, when the economies of Florence and Rome began to suffer, the main center of painting shifted northward where it was nurtured by the cloudier climate of Venice.

Venice was at her zenith in 1500 and, despite the opening of the Atlantic, remained wealthy throughout the century. But the times were certainly stormy. After being routed by the French army in 1509, Venice briefly relinquished most of her mainland possessions and retreated to her watery fortress. While imprisoned there by the French or by wealthy patrons, her artists made one of the periodic rediscoveries of the pastoral ideal. This was a time that cities all around Europe were growing large and crowded enough to generate a mood of scenic longing. As Frederick Hartt has observed

It is a curious fact that at the moment when the aged Bellini and the young Giorgione were bringing landscape and the beauties of nature closer to us than ever before in the history of artistic endeavor, Venice herself then possessed
little nature to enjoy. It may well be that an essential ingredient of romantic interest in landscape is the absence of landscape from daily experience.

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In any event, some time between 1505 and his death in 1510 from the plague, Giorgione produced the *Tempest* (Fig. 6-8). Here are two of art's most mysterious and solitary figures. An innocent young man stands wrapped in a daydream while an almost naked woman suckles her infant. Both are apparently unaware they are about to be engulfed in the downburst of a thunderstorm that has already darkened the sky. This is one of the first storms shown from below rather than in profile. The storm has not quite begun, for there are no rain streaks and a reflection of the bridge can still be seen in the as yet unruffled waters. The *Tempest* thus captures the instant between the first bolt of lightning that illuminates the sky and the thunder that follows on its heels. It is an allegory of the initial response of Venice, and indeed of all civilizations, when first confronted with the prospect of annihilation by barbarians.

Fig. 6-8. Giorgione. The Tempest. c. 1505-10. Accademia, Venice.

North of the Alps, smoke and storm clouds were also filling the air. Superstition and irrationality had been cleansed from painted skies during the century of light and clarity but they continued to pervade everyday life. Toward 1500, protests rose against the excesses of witchcraft, demonology, Satanism, sorcery, and other occult beliefs and practices that remained so common among the populace despite all advances of knowledge. One of the express purposes of the Inquisition was to root out these various heresies and heretics, for all but the most enlightened minds of the time believed them to possess magical powers.

No one better expressed the paradoxical and contradictory aspects of the times than Hieronymus van Aken, better known as Bosch. Born around 1453 and dying in 1516, he was almost an exact contemporary of da Vinci, but otherwise not much is known about him. Both his father and grandfather were painters so that art was in his blood from birth. He was probably born in the Dutch town of 's-Hertogenbosch where he remained until his death. From that somewhat provincial but not isolated vantage point Bosch visually confirmed the world's irrationalities.

Around 1475 Bosch painted a table top entitled the Seven Deadly Sins (Prado, Madrid). In most of the scenes the sky is treated conventionally. Each scene in a circular annulus illustrates a different sin while circular scenes at each of the four corners provide further moral lessons. All but one of these have the clear, color graded skies and high visibility of the fifteenth century. The sole exception is the scene of Hell. In it, infernal fires near the horizon produce dark smoke plumes and cast an orange glow that offsets the subterranean darkness. Bosch was to rework these fires throughout his career.

Bosch often used his skies to illustrate the duality of human nature - that the adventurous and inquisitive spirit responsible for much human creativity and progress is accompanied by a darker, irrational side we may hide but cannot exorcise. A sky with such a dual nature appears in the center panel of the *Temptation*
of St. Anthony (Fig. 6-9). On the right side of the panel the sky is clear and the visibility is almost infinite. In the distance on the left a town is consumed in fire and all that lies beyond is hidden by an impenetrable curtain of smoke. On the right, all is clarity and light; on the left, all is obscurity and night.

Fig. 6-9. Hieronymus Bosch. The Temptation of St. Anthony. c. 1500, Museo Nacional de Arte Antigua, Lisbon.

Volumes have been devoted to the sources and meaning of Bosch's iconography. The grotesque figures and their absurd actions were not random inventions but reveal Bosch as a sophisticated moralist and ingenious illustrator of proverbs. Bosch, like Shakespeare, borrowed well known themes freely and gave them his own unique flavor. His main contribution may well be the manner in which he was able to incorporate the weird caricatures into everyday scenes and elevate them to the status of high art.

Two examples from The Temptation, analyzed by Dirk Bax in Hieronymus Bosch: His Picture Writing Deciphered, suffice to show how Bosch operated. St. Anthony, the central figure, has just been confronted by a beautiful queen, who is really Satan in disguise. The queen's true nature is betrayed by the long train and serpentine tail of her gown, which also satirizes the then current fashion of long trains. The queen is dispensing charity to an old woman merely to tempt the Saint to carnal love. The woman is identified as a procuress by her sharp nose and chin, features Bosch used elsewhere to mark women of that calling. At the time, these physiognomic features were associated by the common man with evil, according to the rhyme,

Pointed nose and pointed chin,  
There sits the devil in!

The Saint is not the least bit fooled by these professed acts of charity. He turns away from the corruption and holds up two fingers in an act of exorcism.

The fire and smoke are also permeated with symbolic significance. To Bosch, fire represented carnal love, while smoke represented impurity. A host of symbolic objects also clogs the air. A toad carrying a banner of Carnival sits astride a winged egg and is followed by a flock of ravens as it is propelled through the sky. To this day toads are often thought of as poisonous, diabolic animals, while the egg was a symbol of licentious revelry, folly, and sexual incontinence. The crows represented the devil and often appeared in Carnival scenes. Bax maintains further that the scene parodies the revelry that took place during Carnival on Shrove-tide, the evening prior to Lent.

Despite all the fire and smoke and all the monstrosities, Bosch's works fail to terrify the modern viewer. Perhaps there is too great an element of humor in the detailed depiction of disembodied freaks or impaled anuses. But what is more crucial is that each perversion occupies its own well-defined niche, remaining out in the open and seemingly under control. All the fires and smoke are restricted to the distant horizon and do not threaten to spread very far. The lovely farmhouse in front of the
burning town is situated in a precarious position but not a trace of smoke approaches it, so its doom has not been foreordained.

Bosch thus failed to capitalize fully on the principal atmospheric ingredient that marks all true nightmares - obscuration. More than 250 years after Bosch painted the Temptations of St. Anthony, Edmund Burke, drawing from the first century Roman work, the Sublime of Pseudo-Longinus, diagnosed the crucial elements of all painted nightmares in his essay, On the Sublime and Beautiful. In it he wrote,

Hardly anything can strike the mind with its greatness which does not make some sort of approach toward infinity. When painters have attempted to give us clear representations of these very fanciful and terrible ideas, they have almost always failed... all the designs I have chanced to meet of the Temptation of St. Anthony were rather a sort of odd, wild grotesques, than anything capable of producing a serious passion...

Edmund Burke. On the Beautiful and Sublime.

Burke was probably not aware of the work of Matthias Grünewald. Mathis Gothart Neithart (i. e. Grünewald) took up where Bosch left off and produced some of the most nightmarish spectres in the history of art. Grünewald was also an architect and engineer, so a strongly practical side cohabited with the visionary. Like Bosch, he was aware of the advances of fifteenth century European civilization yet he remained deeply religious. He too produced a series of scenes involving St. Anthony in his famous Isenheim Altarpiece (c. 1510-1515).

The Isenheim Altarpiece contains three layers of panels and includes one the most horrifying of all Crucifixion scenes. The Altarpiece was displayed prominently in the chapel of the lodge of the Hospital Order of St. Anthony to be viewed by its patients as part of their treatment. Many of these were suffering from syphilis, an epidemic that spread through Europe like wildfire after 1493 and had already claimed many victims. It was Grünewald's express purpose to depict in remorseless detail the unparalleled magnitude of Christ's physical suffering. The emaciated body of Christ, full of purulent and festering sores and wounds, is twisted to the breaking point.

The Crucifixion prepares the viewer for the Temptation of St. Anthony (Fig. 6-10). The Temptation is seen when the Altarpiece is fully opened. The Saint lies prostrate, utterly incapable of warding off the attacks of the grotesque monsters that surround him. The one at bottom left is suffering from a syphilitic outbreak. These monsters are workers of the devil and are depicted in minute detail.

The landscape setting adds greatly to the overall effect. It seems to suggest that St. Anthony has been completely cut off from the world of the living. The foreground is brown and lifeless. Moss drips down from bare limbs, symbolizing a condition of swampy decay. Behind these dead limbs rise mountains reminiscent of da Vinci's St. Anne or Mona

Fig. 6-10. Matthias Grünewald. Temptation of St. Anthony from the Isenheim Altarpiece. c. 1510-1515. Musée d'Unterlinden, Colmar.
Lisa. These however, dissolve more rapidly in mist than any work of the Renaissance. The contrast between the explicitness of the immediate foreground and the obscuration of the background is one of the shocking aspects of the work. It is precisely this atmospheric effect that provides the intimation of infinity that Burke thought painting lacked. After Grünewald, painters would make only refinements in the visualization of terror.

Fig. 6-11. Lucas Cranach. *Crucifixion*. 1503. Alte Pinakothek, Munich.

Grünewald drew on several sources for the composition of the Temptation of St. Anthony. The idea of the monsters encircling the saint was based on a woodcut done in 1506 by another German artist, Lucas Cranach. Even so, the work of Cranach was worlds apart from Grünewald’s unrelieved intensity. Throughout a long career, Cranach maintained almost infinite visibility in his landscapes and most of his skies are crystal clear. If clouds are present they are tiny shreds, much like the thin wisps of gossamer he used to cover his playfully seductive young maidens.

Fig. 6-12. Mamma beneath a cumulonimbus anvil.

But Cranach was also an artist of the Reformation, aware of the religious turmoil then seething throughout Germany. In 1503, he painted a *Crucifixion* (Fig. 6-11). As in most of his works, the visibility is almost infinite, but the boiling underside of a severe thunderstorm arches over Christ. Fantastic, swirling globular mamma extend from the overhanging cloud base. The mamma have been stylized to match the folds and knots of Christ's windblown garment, but Fig. 6-12 strongly suggests that Cranach witnessed such a severe thunderstorm and was stamped with a lifelong impression.

Cranach painted several other crucifixion scenes with mamma including The *Crucifixion with Cardinal Albrecht of Brandenburg* (Fig. 6-13), long after he had moved to Wittenburg, the seat of Luther's activities. In 1515, Albrecht had taken out a huge loan to purchase three high Church offices. To repay his debts
and make good his investment, Albrecht greatly increased the sale of Papal Indulgences right in Martin Luther's backyard.

Can there be beauty without disturbance, passion without restraint and wonders without obstruction? If air molecules did not scatter light as it penetrates the atmosphere, the sky would be as black as night and would not display any of its magnificent colors. If ice crystals did not refract sunlight there could be no halos. Similarly, only when sunlight strikes falling raindrops is a rainbow produced.

Throughout fifteenth century art, atmospheric clarity remained too high to produce optical phenomena such as rainbows. As a result hardly any progress was made in the representation of atmospheric optical phenomena. When 15th century rainbows were painted, as in the right wing of Hans Memling's triptych, *St. John the Baptist and the Evangelist* (Fig. 6-14), they were invariably ethereal misfits, grafted onto otherwise natural settings. These bows are riddled with such a host of errors as to make even the most devout of souls burn.

Despite all the errors in fifteenth century bows, a few words can actually be said on their behalf. They usually formed parts of circular arcs, as in reality, and the color sequence of the primary bow, progressing in some manner through the spectrum from red on the outside to blue or violet on the inside, was generally presented in the correct order. In many of the paintings, two rainbows, still compelled to serve as Christ's seat and footstool, are properly shown as concentric circular arcs.

When a rainbow arches across the sky it is often accompanied by a second bow (Fig. 6-15). The inner bow is called the primary bow and it is almost always far brighter than the outer or secondary bow. Casual observers easily see the primary bow, but seldom notice the faint secondary.

**Atmospheric Optical Phenomena: No Beauty Without Disturbance**
The primary bow often has pronounced coloration. It is always red on the outside and grades almost imperceptibly through the spectrum to violet on the inside. The colors of the secondary bow appear in reverse order with red on the inside, but are much fainter.

The rainbow also affects the overall brightness of the sky. The sky is brightest beneath the primary bow and darkest between the two bows. The relatively dark region between the two bows has been named Alexander's dark band after Alexander of Aphrodisias, head of the Lyceum from 198-211, who first commented on it.

Sometimes an unusually bright halo, such as the circumhorizontal arc, will be mistaken for a rainbow. But virtually all halos are seen when facing the sun, while rainbows always appear on the opposite side of the sky from the sun. In his Opus Majus (1266-1267), Roger Bacon was the first to note that the primary rainbow is always found at a 42° angle in any direction from the shadow of the observer's head. The secondary bow appears 51° away from the observer's shadow. Bacon also observed that as the sun goes up the observer's shadow and rainbow simultaneously go down.

Since there are seldom many raindrops between your eyes and the ground, rainbows cannot be seen much below the horizon unless you are standing on a lofty perch or are flying. Thus, if the sun is more than 42° above the horizon it is too high to produce the primary rainbow. As a result, rainbows are not seen around midday during spring and summer. But when the sun goes down, shadows lengthen and the rainbow rises. Thus, the largest rainbows are seen at dawn or sunset, when they are semicircles that reach almost half way to the zenith. When the sun is above the horizon, the rainbow forms less than a semicircle but its large angular radius of 42° remains the same.
The fact that rainbows appear opposite the sun indicates they consist of sunlight that has been reflected. It was suspected for centuries that rainbows are produced when sunlight strikes and penetrates raindrops and then is reflected. The main geometrical features of the rainbow were first explained by Rene Descartes in 1637. He began by accepting the argument that it is only necessary to consider how light passes through a single spherical raindrop! This argument had first been put forward independently by Theodoric in Europe and Qutb al-Din in Persia shortly after 1300. Descartes carried this reasoning a crucial step forward, expanding on the approach taken by Johannes Kepler to explain the optics of the human eye. Descartes traced not just one, but a range of paths light can take through a raindrop. Then, after an ingenious experiment and many careful mathematical calculations, he finally provided the first convincing explanation of the rainbow.

Descartes correctly assumed that raindrops are spheres (contrary to the popular image, raindrops are not tear-shaped) and that the light will pass through a circular cross section of the drops. In making this assumption Descartes had obtained a spherical flask and filled it with water. This was his raindrop. He then aimed a narrow beam of light at various points on the drop and produced a rainbow at the correct location, 42º from the shadow of the light beam.

The paths that light must take through each raindrop in order to produce the primary and secondary rainbows are shown in Fig. 6-16. The beam for the primary bow is refracted as it penetrates the drop. The light then proceeds to the back of the drop where it is reflected. Finally, the light is refracted a second time as it leaves the drop. A fraction of the light is lost to the bow at each of these junctures and limits the intensity of the rainbow.

The secondary bow is produced by light that has been reflected twice within the drop. The additional spreading and light lost at the second reflection render the secondary bow both fainter and broader than the primary.

In order to calculate the location of the bows, Descartes had to know both the geometry of the circle and the law of refraction. The geometry of the circle had been understood since the time of Euclid but the correct law of refraction had eluded Greek and Arabic scientists for 2000 years. It was finally discovered by 1621 by Willebrod Snel van Royen and is called Snell's law everywhere except in France, where it is named for Descartes. Snel never completed his manuscript, but Christian Huyghens used it and it may have been available to Descartes. Descartes, however, claimed he discovered the law independently, and certainly published the first account of it in 1637 in the second of the three appendices to *A Discourse on Method*. The third appendix, *Les Meteores*, contains Descartes' solution to the rainbow problem.

As soon as Descartes began the calculations, he must have realized that the problem was not going to be so simple. The angle of deviation of a light beam through a
drop is not constant but depends on where the light strikes the drop. A beam that strikes the drop exactly in the center will not get refracted at all. After penetration and reflection, the beam will return directly back toward the light source.

Descartes overcame the obstacle to solving the rainbow problem. This is how he described it.

The principal difficulty still remained, which was to determine why, since there are many other rays which can reach the eye after two refractions and one or two reflections when the globe [raindrop] is in some other position, it is only those of which I have spoken which exhibit the colors.

I then took my pen and made an accurate calculation of the paths of the rays which fall on different points of a globe of water to determine at what angles after two refractions and one or two reflections they will come to the eye and then I found that after one reflection and two refractions there are many more rays which come to the eye at an angle of forty-one to forty-two degrees than any smaller angle and none which come at any larger angle. I found also that, after two reflections and two refractions there are many more rays which come to the eye at an angle of from fifty-one to fifty-two degrees than at any larger angle, and none which come at a smaller angle.

Appendix to *A Discourse on Method*

The bows are thus produced by the least divergent and most highly focused rays of light that reemerge from the drop (Fig. 6-17). Furthermore, by showing that light could be deviated either by less than 42º or more than 51º, but not between, Descartes simultaneously explained Alexander's dark band.

Despite all his laborious calculations, Descartes could never explain the colors of the bow. This was a job left to future generations of scientists. Isaac Newton, who some 30 years later performed his famous experiments with light and prisms, took the next giant step. Newton realized that the drops act like prisms when sunlight passes through them raindrops, and refract each color of the spectrum by a slightly different angle. The rainbow is about 2º degrees wide because the red appears about 42º from the observer's shadow and the violet only about 40º. Newton also invented the calculus and, when he applied it to Descartes' problem, solved it more accurately and with infinitely greater ease.

But there were certain discrepancies that Newton could not explain. Both the coloration and thickness of rainbows vary. Some rainbows have one or more additional bands, known as supernumerary bows, inside the
main bow. If raindrops acted exactly as prisms then all bows should have identical coloring and thickness and there should not be any supernumerary bows.

In 1803, Thomas Young, a physician who was concerned with the physiology of vision, demonstrated that the variations in the rainbow constitute proof that light consists of waves. He then stated correctly that the width and color sequence of the bows depends on the size of the drops. The wave properties of light can be ignored for the larger drops, which produce narrow bows with pronounced spectral coloration. As the drops become smaller, the wave properties of light grow more pronounced, and it is no longer possible to treat the light simply as a ray. The supernumeraries appear and the bows gradually whiten, broaden and ultimately disappear. This is why rainbows are almost never seen within clouds themselves. The droplets that make up clouds are too small to produce rainbows because they are only a few times larger than visible light waves.

The sunlit sides of clouds are also simply too bright to produce rainbows. The most vivid rainbows are those seen against a dark backdrop. Too thick a veil of sunlit drops tends to drown out the bow by disproportionately increasing the illumination of the background. The most spectacular rainbows are therefore produced by modest veils of raindrops through which more distant objects can easily be seen. This makes rainbow a translucent apparition, and all the more wondrous and alluring.

When fifteenth and sixteenth century artists began to paint their rainbows, the state of knowledge was so rudimentary and uncollated that they effectively had to rediscover everything about bows on their own. Their paintings may even have helped focus scientific attention on the rainbow, and it is not surprising they made mistakes when transcribing their impressions of these fleeting visions.

Memling's *St. John the Evangelist on Patmos* is a good starting point for a diagnosis of painted rainbows. The Saint is seated in the foreground and is at work composing the book of the *Revelation of Saint John the Divine*. Above and beyond the Saint is an almost literal transcription of his apocalyptic visions.

7. The first angel sounded, and there followed hail and fire mingled with blood, and they were cast upon the earth: and the third part of trees was burnt up, and all green grass was burnt up.

2. And he opened the bottomless pit; and there arose a smoke out of the pit as the smoke of a great furnace; and the sun and the air were darkened by reason of the smoke of the pit.

*King James Bible. Revelation of Saint John the Divine* Chapters 8 and 9.

In *Early Netherlandish Visions*, Shirley Blum pointed out that this was the first time an artist had recorded Saint John's visions in such naturalistic detail. Because of the nature of the Saint's visions the work contains much fire and smoke, thereby placing it in a class with some of Bosch's earliest fiery works. Still, Memling held reins on his imagination for he was tied to the placid 15th century.

The *Revelation* also tells of a rainbow surrounding the Enthroned One and another bow upon the head of a mighty angel. Depending on how the various rings and arcs of light are interpreted, it is possible to count as many as seven bows! The two main bows are the ones surrounding the entire heavenly host. Part of the outer bow is reflected in the water of the foreground. There is another angel in the sky surrounded by an oval ring of light and seated on a bow. At the horizon the mighty angel is standing under a bow and a reflection of this bow appears in the water.

Every one of these bows is saddled with errors. Artists have repeated some of the rainbow errors so routinely that they deserve...
special titles such as the opaque rainbow, the miscolored rainbow, the striped rainbow, the miniaturized rainbow and the material rainbow. The two main bows of the Revelation are opaque and striped. They are depicted as blocked-out bands of color through which nothing can be seen. Assuming that the outer bow corresponds to a secondary bow, it should not be so bright and its color sequence should be reversed, making it a miscolored rainbow. The bow at the horizon is also an example of a miniaturized rainbow. Since the rainbow always appears at the same 42° angle from the observer's shadow, its apparent size is the same whether it is nearby or far away.

Because rainbows occupy the same angular size no matter what their distance, they behave as if they were located an infinite distance away! This paradoxical property leads to some surprising and unexpected consequences and provides a test of whether an artist used his observational powers or his intellect.

Rainbows, like the moon or the sun, do not get larger as you approach them. They also seem to move with you, even if they are produced in the spray of a hose a few feet away. The rainbow's reflection in a body of water such as a pond also acts strangely. If you are standing above the pond at an elevated vantage point, the rainbow's reflection will appear just as far below the horizon as the bow appears above it. By contrast, the reflection of any other nearby object will appear further below the horizon than the object appears above it (Fig. 6-18). Thus, while you can plainly see in unruffled water the reflections of objects situated below you on the far shore, you can never see the reflection of any part of the bow that appears beneath the horizon.

The mirror image of the sun reflected from a water surface can also produce rainbows in the sky. These bows are called reflected light rainbows. (I do not know of a single painting of a reflected light rainbow.). Since a sunbeam reflected from a smooth body of water would produce a shadow in the sky, the rainbows produced by a reflected sunbeam are centered above the horizon and so are more than semicircles. The normal and reflected light rainbows join at the horizon where they reinforce each other and may be very bright (Fig. 6-19). A slightly ruffled water surface will have no effect on the normal rainbows but will make the reflected light rainbows more nearly vertical at the horizon.

Fig. 6-18. Paths of light for (a) reflections of rainbows and (b) a nearby flag.

Fig. 6-19. Reflection and regular rainbows. Alan Laws, Photographer
In the water of the foreground of St. John the Evangelist on Patmos, Memling was presumably trying to depict a reflection of the lower right portion of the outer main bow. He apparently misused the law of reflection by treating the bow as a material rainbow at a finite distance, and incorrectly placed the image much further below the horizon than the bow is above it. He also painted the impossible when he showed the reflection of part of the rainbow below the horizon.

All 15th century bows were misplaced inserts into the landscape. Pisanello arched a small bow over two hanged men in the otherwise black sky of his St. George and the Princess, (c. 1435, Church of Sant'Anastasia, Verona). Even Paolo Uccello's Sacrifice of Noah (c. 1446-1448, Sta. Maria Novella, Florence), which shows the aftermath of the flood, divorces the rainbow from a naturalistic sky so that it can arch over God the Father.

The first artist to convincingly integrate a rainbow into the landscape was Bernadino di Betto, better known as Pintoricchio. Pintoricchio showed an interest in rainbows as early as 1486 when he included one as a misplaced afterthought in a miniature of a Crucifixion. Then, in 1502 he was commissioned to paint a series of ten episodes from the life of Aeneas Silvius Piccolomini prior to his election as Pope Pius II and used the opportunity to paint a real rainbow.

The rainbow mural is the Departure of Aeneas Silvius Piccolomini for Basel (Fig. 6-20). The rainbow arches above a more or less topographic view of the port of Talamone, facing due south toward Mt. Argentario. No rainbow can ever be seen during the day in such a setting because rainbows appear opposite the sun, and the sun never appears in the north in Italy.

The rainbow was transplanted from a storm that Aeneas had encountered somewhat earlier at sea. The storm appears in the left distance where it disrupts the otherwise infinite visibility characteristic of fifteenth century art. It is not exactly a raging storm but still represents a significant departure from earlier paintings. At last, something besides an infernal fire was allowed to disturb the atmosphere.

Fig. 6-20. Pintoricchio. Departure of Aeneas Silvius Piccolomini for Basel. 1502-1508. Piccolomini Library, Cathedral of Siena.

The storm consists of a cluster of modestly sized, flat-based, triangular cumulus. These clouds are probably too small to produce heavy showers but that is exactly what they are doing. Dark, comma shaped rain swaths fall from their bases, almost completely obstructing the view of the distant town across the bay. The sky below and in the gaps between the clouds assumes the dull orange color commonly seen when an advancing thundercloud has covered all but the distant horizon.

The rainbow, presumably due to clouds above the painting, arches over all the theatrical darkness and bluster. It consists of part of a circular arc and is also translucent, but is a bit small and is composed of three almost neutrally colored stripes - a striped rainbow.
The shadows of the figures in the foreground point to the right but should point to the center of the rainbow circle. The sky is also no brighter below the bow. Apparently, Pintoricchio painted the sky first and then added one of fine art's many inserted rainbows.

Despite these errors, this painting is still a meteorological tour de force. Pintoricchio had disturbed the atmosphere and it reacted by yielding a pearl.

Pintoricchio was assisted by the young Raphael, who contributed to the murals in the Piccolomini Library before heading out on his own. Wherever he went, Raphael learned like a sponge, absorbing the techniques of other Renaissance masters and making them his own.

He was apparently never plagued by the doubts and hesitations that constantly haunted Leonardo. His output was prodigious; what might he not have accomplished had he lived past 37?

Fig. 6-21. Raphael. Madonna of Foligno. 1511. Pinacoteca, Vatican.

Raphael arrived in Florence in 1504, saw the works of Leonardo, and began to paint clouds with indistinct outlines. In 1509 he went to Rome. Soon thereafter his skies began to grow a bit hazier. Then, perhaps in 1511, he was commissioned by Sigismondo de' Conti, monsignor of Pope Julius II to paint the Madonna of Foligno (Fig. 6-21), a votive picture to commemorate the miraculous incident in which de' Conti's house was struck by lightning or by a meteorite yet not harmed.

The Madonna of Foligno shows either a small shooting star or comet about to strike one of the larger houses in the town of Foligno while divine protection appears in the sky above. The Virgin and Child are seated on a throne of unconvincing cotton puff cumulus. High in the sky the cloud puffs have been miraculously transubstantiated into a web of gray angels.

In 1511, the cloud-angel was still a relatively young creature. Clouds had been associated with divine figures since at least Roman times. Most often they served as seats or footstools. Sometimes the clouds would hide part or most of the figures. In all these cases the exposed portions of the divine figures were portrayed as solid bodies. It was only around 1470 that the divine figures emerging from the clouds were themselves composed of clouds. The Coronation of the Virgin (Pinacoteca, Siena), attributed to Francesco di Giorgio, wove a web of nebular angels that is barely distinguishable from the misty cloud.

In the Coronation of the Virgin, atmospheric visibility is severely reduced in the cloud near the top, while visibility below the cloud remained at high Renaissance levels. The idea of placing two regions of different visibility in the same work to distinguish the divine from the secular or the hero from the masses was one that would thenceforth be utilized by many artists. The technique became especially popular and was brought to perfection in the seventeenth century under the care of masters including Murillo and Rembrandt (see Chapter 7).

The Madonna of Foligno also contains two regions of different visibility. Obscuration reigns in the sky behind the Virgin and Child, but visibility is high on the earth below.
Sky and earth in the *Madonna of Foligno* are linked by a golden miniaturized rainbow. The bow appears to support some unrealistic cumulus puffs that serve as seat and footstool to the Madonna, for their weight squashes the bow as if it were a metal hoop. Raphael also did not make the sky below this material bow brighter.

The subtlest error in Raphael's bow results from a fundamental misconception. Just under the Virgin's left foot, the golden bow emerges from behind the base of a cloud puff to illuminate the nearby sky. Raphael apparently conceived of the rainbow as a self-illuminating phenomenon and therefore made it a luminescent rainbow. However, rainbows are merely reflected and refracted sunlight. Therefore, at precisely the point where Raphael's bow illuminates the sky, the cloud should have blocked the sunlight and created a gap in the bow.

![Image](https://via.placeholder.com/150)

Fig. 6-22. Matthias Grünewald. *Madonna in the Garden, Altarpiece of Our Lady of the Snows*. c. 1517-1519. Church, Stuppach.

A few years later, around 1518, Matthias Grünewald included a new rainbow observation in his *Madonna in the Garden* of the Altarpiece of *Our Lady of the Snows* (Fig. 6-22). A few segments of a faint secondary rainbow can be seen outside the primary bow, the first example of double rainbow in which the primary bow is more intense. The Madonna is seated under a miniaturized and striped rainbow that doubles as a halo. A golden light surrounding the Madonna's head is largely confined to the part of the sky under the bow. It is questionable that Grünewald was doing this as a result of an actual observation, for the sky is considerably brighter precisely where it should be darkest - the zone between the two bows.

Artists have insisted on waging war with the rainbow and have usually come away defeated. There are several reasons rainbows have proven so difficult to paint accurately. First, rainbows conform to a set of rather rigid specifications. Clouds, by contrast, can assume almost any shape so an artist has some justification for whatever clouds he may splotch on the canvas. But the primary rainbow always appears 42º from your shadow and the red is always on the outside. It is always about 2º wide and the sky below it is always brighter than above it. When the secondary bow appears it is always 9º outside the primary, is always broader, almost always fainter, and its color sequence is always reversed.

Before the invention of photography the artist did not have an adequate opportunity to carefully observe and precisely record all the rainbows' features. In places like Hawaii, where showers are fixed to the mountains, rainbows may occur often and last for a long time, but few sixteenth century European artists vacationed there. Since rainbows in Europe are not only fleeting apparitions but rare events as well, appearing only a few times a year, European painters would have had little opportunity to amass a detailed catalog of their properties even if they had been constantly on the lookout.

Therefore European artists seldom got a good look at rainbows. Instead, they had to take quickly formed impressions back to their studios and then paint from a memory burdened with preconceptions. At that time, artists did not exhibit the antipathy toward science and technology that became so
common among more recent generations of their brethren. Nevertheless, they remained uninformed about rainbows because there were few accurate descriptions available until the time of Descartes. Furthermore, artists were not often privy to the latest scientific discoveries. As a result, the preconceptions they relied on were seldom scientific or objective and, as with both Memling and Raphael, the rainbows were doomed to contain errors. After all, who could possibly imagine that anything appearing only a short distance away must be treated as if it were located at infinity?

So artists continued unwittingly down the path of error, groping towards knowledge and beauty at a snail's pace. Their errors usually proved to be costly, for the beauty of rainbows cannot be separated from the laws that shape them. Those errors transformed most painted rainbows into the graffiti of the sky.

One of the ugliest rainbows appeared in Dosso Dossi's *Jupiter and Mercury* (c. 1528, Kunsthistorisches Museum, Vienna). Fortunately, even this unimaginably broad, discolored and ugly bow does have a redeeming feature - Dossi did render the sky distinctly brighter inside the bow, and was perhaps the first artist to do so.

The most convincing of the early bows appears in the *Deluge* of a lesser-known artist named Jan van Amstel. The appearance of a rainbow is appropriate for.

13. I do set my bow in the cloud, and it shall be for a token of a covenant between me and the earth.
14. And it shall come to pass, when I bring a cloud over the earth, that the bow shall be seen in the cloud:
   King James Bible, Genesis, Ch. 9.

This passage is worth pondering. Although it mistakenly places the rainbow in the cloud it establishes the bow as a symbol of good or hope. In many cultures the rainbow has been associated with evil. There are several reasons for this. Alistair Fraser has suggested that rainbows symbolize the fleeting nature of life because they are gone so quickly. But rainbows are also often accompanied by violent, thundery weather. Since thunderstorms are usually storms of the afternoon, most rainbows appear in the east (opposite the setting sun). Outside the tropics, thunderstorms move toward the east so that rainbows are usually seen after the worst is over - a sign of better things to come. But in the tropics, where many of the pessimistic rainbow myths originate, storms come from the east so that an afternoon rainbow must be construed as a warning of imminent danger, destruction and possibly death.

Amstel's *Deluge* is a huge painting and the primary bow triumphantly crowns it. There are several problems with the bow. Its colors are somewhat dull and the sky below the bow is not brighter. The bow is even blocked in places by rain streaks, a likely error since illuminated raindrops are what make a bow. But the storm that produced this bow is quite real. The underside of the cloud is very dark. White cloud fragments called scud can be seen near the edge of the cloud on the left where the sky is brighter, while caverns of light have penetrated from the far side of the storm.

The atmosphere sports a host of other optical phenomena, which artists of this time began noticing. The painting of the spectacular halo display seen in the sky above Stockholm on 21 April 1535 was described in Chapter 3. Otherwise, artists ignored atmospheric halos but did pay somewhat more attention to coronas.

Albrecht Dürer, who treated the landscape with more freedom in his watercolor sketches than in his formal paintings, painted a huge corona around the sun in the *Nativity* from the *Paumgartner Altarpiece* (c. 1502, Alte Pinakothek, Munich). This corona appears in a cloudless part of the sky and so must be relegated to the realm of the solar and heavenly aureoles for which there was already a
hallowed tradition. More convincing coronas had to wait until another German Albrecht began to paint the sky.

Albrecht Altdorfer was one of the great sky painters. He was certainly an anomaly in his own times. Although Leonardo da Vinci and Albrecht Dürer had excluded people from their landscape drawings or watercolor sketches, Altdorfer was the first to omit people from a painting. His *Landscape Near Regensburg* (c. 1522-25, Alte Pinakothek) also contains the first convincing forest - a mixed forest of evergreen and deciduous trees complete with undergrowth - giving the appearance of a continuum rather than an arboreal cluster of individual lollipops. In this and in some of his other major works, Altdorfer succeeded in transforming the sky into a temple of wonders as few others have.

The *Battle of Alexander* (Fig. 6-23) is the culmination of Altdorfer's sky art. It may not contain the most beautiful of his skies - that honor may go to *Susanna at the Bath* (1526, Alte Pinakothek) with its field of swirling flecks and cells of cirrocumulus floating in crystalline, deep blue polar air. But the *Battle of Alexander* has the cirrocumulus and more.

The ostensible theme of the painting is the victory of Alexander's troops over the far larger army of Darius at Arbela on the Issus River in 333 BC. Two armies have flowed together like rivers. Each contains hundreds of antlike soldiers locked in mortal but anonymous combat, a possible reflection of the peasant
uprisings that had just been ruthlessly suppressed throughout Germany.

_The Battle of Alexander_ alludes to a grander theme, the first circumnavigation of the earth by the survivors of Magellan's crew. It offers a vantage point that has been termed cosmic but basically represents an extrapolation of a mountaintop view. Its perspective is thus one that the naturalist Altdorfer, who lived in Regensburg about 100 miles from the Austrian Alps, surely experienced.

In the distance of _The Battle_, a river meanders lethargically on its way to the bay before dispersing into the multiple channels of a classically braided delta. Beyond the bay alpine mountain ranges are seen from a bird's eye view that only Leonardo, also a mountaineer, had attained. The vantage point is so elevated that the armies and the city behind it are dwarfed by the landscape background. The entire background appears blue as a result of its great distance. Even the earth's curvature, so recently established by Magellan's circumnavigation, can be discerned.

Then there is the sky! It is just before sunset at the end of the battle when Darius and the sun are fleeing. At the far right, golden crepuscular rays emanate from the setting sun and pass through a long cavern in cumulus. The cavern's ringed walls are alternately golden where directly illuminated and orange elsewhere. The spreading tops of the cumulus break up into a field of cirrocumulus that resembles the underside of an anvil. The field of cirrocumulus extends to the left where it is responsible for the corona around the crescent moon.

The cumulus no longer consist of the well separated, individual elements of fifteenth century paintings, but form an impenetrable wall at the horizon that defines our earthbound limits and places the entire scene in the eye of a storm. Altdorfer was probably the first northern painter to emphasize entire fields of clouds rather than randomly spaced, isolated cloud elements, just as he depicted forest groves rather than widely separated lollipop trees. This approach made it natural for him to treat cirrocumulus, for these often consist of organized ranks and rows.

The crepuscular rays, formerly reserved exclusively for religious scenes, now appear in a secular context, and Altdorfer was careful to show that they emanate from the sun. Crepuscular rays are sunbeams that have been illuminated by aerosol particles and, to a lesser extent, air molecules. They never emerge from the sun in perfectly clear skies and almost all artists have noted this well. They form when sunlight passes by the edges or through the gaps of a dark cloud or the canopy of leaves in a dense forest and can even be seen in a darkened room when the shade is slightly raised. When the sun is high in the sky, crepuscular rays appear just beyond the fringes of opaque clouds (usually cumulus) that barely block the sun and are also seen in small openings of an almost complete cloud cover. Most commonly, they are seen in the general direction of the sun when the sun is low in the sky (they are translated as twilight rays) and the sunbeams have managed to pass through gaps or low points in a wall of clouds. Sometimes at sunset or dawn, tall mountains can cast large enough shadows to cause crepuscular rays.

Since all crepuscular rays emanate from the sun, they can be used to pinpoint the sun when it is hidden by clouds or when it is below the horizon (Fig. 6-24).

![Fig. 6-24. Crepuscular rays over New Brunswick, NJ.](image-url)
Like sunbeams, all crepuscular rays are actually parallel. Their apparent divergence is simply a result of perspective (Fig. 6-25).

Fig. 6-25. Crepuscular rays are parallel sunbeams that appear to widen because of perspective.

Altdorfer’s crepuscular rays are short, pencil-thin lines that followed a long, unsatisfying artistic tradition. More often, crepuscular rays are rather broad, spreading beams of light. Perhaps one year before Altdorfer painted the Battle of Alexander, Jan van Scorel became the first artist to show convincing crepuscular rays in his Christ Preaching on the Sea of Galilee (Fig. 6-26). Although the view is not topographic, Scorel may have seen such rays during his pilgrimage to the Holy Land in 1520.

Fig. 6-26. Jan van Scorel. Christ Preaching on the Sea of Galilee. c. 1528. Museum of Fine Arts, Boston, MA.

Altdorfer painted coronas around the moon on several occasions. The corona in The Birth of Christ (Gemäldegalerie, Staatliche Museen, Berlin-Dahlem) is a blazing apparition that rings an enormous moon. The corona gives the impression of being a divine rather than a naturalistic presence, but properly resides in patch of altocumulus. The humbler and more secular ringed corona of the Battle of Alexander also resides in a field of altocumulus or cirrocumulus and circles the crescent moon.

Coronas and their irregularly shaped cousins, iridescent clouds, are the opals of the sky. They are produced by diffraction of light waves that pass through thin water droplet clouds such as altocumulus, cirrocumulus, or altostratus. On rare occasion they form in cirrostratus or cirrus that consist of tiny ice crystals too small to produce halos.

The corona in Fig. 6-27 appeared abruptly when the area of tiny translucent cells approached the sun. Within a minute, this patch drifted away from the sun and was replaced by the thicker part of the altocumulus. The corona then promptly disappeared.

Fig. 6-27. Corona over Manhattan.

Most coronas are rather pedestrian affairs that consist of a small circular aureole immediately around the sun or moon. On occasion the corona can turn spectacular. Then the almost colorless aureole is surrounded by circular rings of colors a few degrees in radius. Most coronas are far smaller than halos, but on occasion, irregular segments or patches of coronas called iridescent clouds can occur more than 30° from the sun! Artists have frequently depicted coronas but I do not know
of a single painting in which cloud iridescence has been represented.

Coronas are easier to see around the moon because there is less glare but lunar coronas are not so brilliantly colored. Since the most exquisite coronas form near the sun, precautions must be taken before viewing them. It is almost always necessary to stand in the shade of some solid object such as a building, telephone pole, or tree in order to block out the sun's direct rays. Occasionally a lower, thicker cloud will momentarily shade the sun and then the iridescence of the surrounding higher clouds will appear all the more glorious.

Diffraction is a phenomenon exhibited only by waves. Ordinarily, when sunlight passes by a solid object of finite size it seems to leave a well defined shadow zone with a sharp edge. It was partly on the basis of this observation that Newton mistakenly rejected the idea that light consists of waves. But Francesco Grimaldi had performed experiments, published posthumously in 1665, demonstrating light rays do bend slightly into the shadow zone and that they do produce undulations both of light intensity and of color. Newton, who later repeated some of these experiments for himself, somehow failed to make the link with a wave theory of light and the authority of his name helped lay the theory to rest.

More than a century passed before Thomas Young attacked the problem of diffraction again. In 1801-1802, he demonstrated that the undulations of light intensity and color at the edge of the shadow zone become larger and far more pronounced only when the objects obstructing the light are microscopic.

Diffraction can be envisioned easily with water waves, which represent alternate elevations and depressions of the water surface. Ocean waves are diffracted when they pass through a gap in a breakwater. If the waves continued to travel in a straight line after they passed the gap, they would produce abrupt discontinuities in the elevation of the water surface (Fig. 6-28). Since nature cannot tolerate such discontinuities, the waves are forced to diffract or spread in all directions.

Diffraction diverts wave energy from some directions and focuses it in others. Thus there are directions where the water surface is not disturbed at all, while in other directions the waves are amplified. These directions depend solely on the ratio of the wavelength to the size of the gap in the breakwater.

Light waves produce similar diffraction patterns. When a cloud droplet blocks sunlight it produces a diffraction pattern that resembles the one produced when ocean waves bend into the shadow zone of relatively quiet waters behind a narrow breakwater. Thus, when light strikes a cloud droplet it will be dark in certain directions and bright in others near the edge of the shadow zone. The preferred directions are determined by the ratio of the size of the cloud droplets to the wavelength of the light. The smaller this ratio, the larger the resulting rings of light. Thus smaller drops and longer waves produce wider rings.

Coronas are colored because sunlight covers all wavelengths of the visible spectrum. Each wavelength has its own diffraction pattern around the cloud droplets. Shorter light waves are diffracted by smaller angles. Thus diffraction segregates the colors into separate rings. The rings of blue light (shorter waves) appear closer to the sun or moon than the rings of red light. If, for instance the cloud droplets are 20 micrometers in diameter then the blue inner portion of the aureole will appear about 1.5° from the sun while the red outer portion

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**Fig. 6-28. Waves passing through a breakwater. a: without, and, b: with diffraction.**

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will appear about 2.4º from the sun. The first two blue rings will appear about 2.7 and 3.9º from the sun while the first two rings of blue light will appear 4.3 and 6.3º from the sun. Droplets with twice the diameter produce coronas only half as large. Coronas thus provide a way to determine the size of droplets in a cloud without flying into the cloud and without a microscope.

A corona will form only when the cloud consists of tiny droplets that are reasonably uniform in size. If the cloud has a wide range of droplet sizes then each droplet will produce a different diffraction pattern and the light emerging from the cloud will be incoherent. The need for a cloud to have almost constant size droplets makes it far more difficult to produce a bright corona than a bright rainbow, for the angles of the primary rainbow's colors are almost independent of the size of the drops. Coronas are therefore produced most easily by thin clouds such as altocumulus or cirrocumulus. Mountain wave clouds and other thin, smooth wave or cellular clouds come closest to satisfying these stringent conditions and this is why they are so often beautifully iridescent.

Altocumulus cloud elements tend to be thinner and consist of smaller, more uniform droplets near their edges. On rare occasion there is a gradual change of droplet size from one part of a cloud to another, so that the corona may become elongated into an elliptical shape. More often the gradient of droplet sizes from the edge to the center of a cloud is uneven, whereupon the corona breaks up into iridescent patches of color.

Jacopo Robusti, called Tintoretto, painted an almost elliptical corona in St. George and the Dragon (Fig. 6-29). This corona emanates from the divine figure who is coaching St. George. It is elliptical only because Tintoretto was mistakenly trying to represent it in perspective. The sky is also filled with the wrong clouds for a corona. Lumpy cumulus may have iridescent fringes but can never produce well defined coronas. Nevertheless, Tintoretto needed this divine light, for the world around him was growing darker and colder.

Twilight and The Little Ice Age

We always kiss in the shadows. And many shadows had come to darken the ripened Renaissance spirit. The Reformation and the invasions of the 1520's left Italians feeling a profound sense of decline. In response they abandoned the purer, sunlit search for truth, and replaced it with the pursuit of beauty, pleasure and pastoral joy under twilight skies. A sense of sin then returned full force to the human scene and did battle to restrain our 'human' side. The forces of chastity were aided greatly in this effort by the fear of syphilis, which had reached epidemic proportions through Europe shortly after Columbus returned from America.

The lost sense of innocence was also felt north of the Alps. Waves of puritanism and brutal tyranny swept over northern Europe in the wake of the Reformation. Simultaneously,
and for completely unrelated reasons, the physical climate north of the Alps began to deteriorate. The Little Ice Age cast one more damper on the spirit of liberalism and license. It is not sensible to cavort naked in winter.

Shortly before 1500, Francesco Vecellio, arrived in Venice with his brother, Tiziano or Titian. Francesco apparently made little mark in the world of art but the precocious Titian more than fulfilled any early promise. He would soon show the world how, when, and where to love.

The brothers were born and grew up in the small village of Pieve di Cadore, nestled amid deep alpine lakes in the towering Dolomites. Flat, tidal, cosmopolitan Venice served as home to both for most of their adult lives (Francesco quietly and faithfully assisted Titian until his death in 1559) but the brothers never lost spiritual contact with their rugged alpine birthplace and often returned there.

Titian began as an apprentice to the mosaicist, Zuccato, but then in quick succession worked under Gentile Bellini, Giovanni Bellini and finally Giorgione. Giovanni may have taught Titian the many faces and moods of clouds while Giorgione probably brought Titian's artistic attention to matters of profane love. Titian was so greatly influenced by Giorgione that their themes and styles around 1508-1510 are almost indistinguishable. It is still not known whether such works as the Fête Champêtre (c. 1510, Gemäldegalerie, Dresden) and the Sleeping Venus (c. 1510, Louvre) are by Titian, by Giorgione, or whether they are collaborative efforts. But Giorgione died young in the plague of 1510 and Titian soon became the undisputed master of Venetian painting.

The Bacchus and Ariadne (Fig. 6-30) reveals that Titian was already an accomplished sky painter. Ariadne, deserted first by Theseus and then by Bacchus is walking despondently along the beach. The painting captures the moment Bacchus returns to her after conquering India and confers on her the gift of immortality. She will become the constellation Corona or the Cnossian Crown, seen in the sky and painted with utter disregard for astronomical veracity.

![Fig. 6-30. Titian. Bacchus and Ariadne. 1520-1523. National Gallery, London.](image)

The dramatic setting and the poses of the characters in the Bacchus and Ariadne owe much to Raphael but the sky is all Titian. It is the deep blue and purple sky of dusk, the time when stars reappear and passions reawaken. As Leonardo had observed, dusk or twilight is also the time that the Earth is dark and only the highest cloud tops project upward enough to receive direct sunlight. At the upper left of the Bacchus and Ariadne the topmost fringes of the towering cumulus congestus are touched by sunlight while the bulk of the clouds lie deeply shaded. Titian repeated this setting so often throughout his career that it became one of his trademarks.

Another Titian cloud trademark in the Bacchus and Ariadne is the monochrome and undifferentiated altocumulus. Titian had already painted such clouds several years earlier in his Sacred and Profane Love (c. 1516, Villa Borghese, Rome) and would do so frequently throughout his middle years. In the Bacchus and Ariadne they are represented by several broad, almost horizontal bands while in later works they tend to occupy large areas of the canvas. Since these smooth, ‘filler’ clouds
almost complete lack any fine scale structure they could be painted quite rapidly, and so, were used indiscriminantly by many other notable and time-pressed artists including Veronese, Nicolas Poussin and even Rubens.

The unaesthetic, flattened sheets of altocumulus, ironed into countless canvases in the century beginning with Titian, are truly the most nondescript clouds in the history of art. Nevertheless, there is some meteorological justification for painting them this way. Almost all clouds possess some fine scale structure that may not be visible if the atmospheric conditions are not right. Contrasts of light and color appear markedly reduced both around twilight, when the lighting is feeble and almost everything lies in shadow, and also on hazy days, when visibility is markedly reduced.

During summer, a deep layer of warm, humid air often covers Venice. Cumulus form in this layer during the day and pump great quantities of heat and moisture upward from sea level. This warms and thickens the layer even further. Sometimes the air gets so hazy that it is impossible to distinguish cloud from clear air! Later, this Venetian trademark gained the attentions of Canaletto and Guardi.

Fig. 6-31. Twilight masking structure of altocumulus.

When evening approaches, the warm, humid layer radiates away the heat it accumulated during the day. The largest temperature drops occur both near the ground, where fog results, and at the top of the humid layer, where the altocumulus of twilight forms. The vast majority of altocumulus possesses fine scale structure, but it is masked by thick haze and by the feeble light of deep twilight (Fig. 6-31).

Fig. 6-31 offers any artist who painted such clouds an excuse for his laziness. Twilight had become a favorite setting among the Venetian artists of the sixteenth century and it is startling to contrast the darkness of their paintings with the brightness of early Renaissance paintings. The twilight settings help explain why the century beginning with Titian was the time of the most nondescript clouds in the history of art. Still, the artists who joined in this conspiracy to deface clouds can not be fully exonerated, because in most of their works they kept the atmospheric visibility too high to mask so much of the detailed cloud structure. But neither can they be entirely blamed - they had commissions to fulfil and deadlines to meet.

Veronese’s Marriage at Cana (Fig. 6-32) is one of the more realistic examples of Venetian cumulus and altocumulus. The Marriage takes place at the height of the day in reasonably clean air. Cumulus fill the lower part of the sky while a thin layer of altocumulus covers a large area higher up. The cumulus exhibit very little small scale structure except at their upper fringes.

Fig. 6-32. Veronese. The Marriage at Cana. 1562-1563. Louvre.
Veronese rendered the altocumulus more effectively. They also do not possess much fine scale structure, but this is acceptable because altocumulus are frequently smoother than cumulus. What little structure Veronese did include was taken faithfully from nature. The thinner, more translucent cloud fringes appear whiter than the cores of the cloud elements because they transmit a larger fraction of the incident sunlight. Veronese also was careful to make the sunlit cumulus considerably whiter and brighter than the altocumulus. The sunlit sides of cumulus are far brighter than all altocumulus except those right near the sun, because the more massive cumulus are generally able to reflect a higher percentage of sunlight than the altocumulus can transmit. Monet would later relish this observation enough to repeat it several times.

Oddly enough, some of the most well formed sixteenth century Italian clouds serve as seats or platforms for heavenly figures. Painted clouds had faithfully served divine figures in a variety of capacities since at least Roman times. In Correggio's Jupiter and Io (Fig. 6-33) a dark cumulus plays a new role as a convenient disguise for the philandering king of the gods.

The god-cloud is a remarkable piece of anatomy. Jupiter's face emerges faintly from the almost uniform dark gray to plant a kiss upon Io's lips. At the same time, he firmly holds the ecstatic maiden with a broad hand and fingers composed of cloud. The billowy top of the god-cloud is plainly seen but its base has been hidden or eliminated. After all, it would have been most unbecoming to give Jupiter flat feet!

The humorous image of the cloud-god in Jupiter and Io points to something fundamentally new in painting. Artists were dissolving form right in front of their patrons' eyes. As a result, after about 1520 in Italy and somewhat later north of the Alps it became exceptional for any painter to expose the flat base of cumulus. Look back at Titian's Bacchus and Ariadne. Its swelling cumulus congestus betrays no hint of a flat base nor indeed of any base. The cloud emerges from an unseen source off to the left. Titian designed the Bacchus and Ariadne to hang next to his Bacchanal of the Andrians (c. 1520-23, Prado, Madrid) in a small room of the Duke of Ferrara. When the two works are placed side by side, the cloud fields of each merge, but still there are no bases. Yet no matter how the works are hung we do not miss the cloud base at all. In the heat of passion we all forget our origins.

Thirty years after the Bacchus and Ariadne, Titian began to work for Philip II of Spain, the principal patron of his later years. It appears that the intensely religious Philip wanted two distinct categories of works from Titian. Devotional paintings sufficed for public viewing while erotic, even voyeuristic 'poesies' were directed to his private rooms. The poesies involve romantic or sexual themes taken from Greek and Roman mythology. Even though Titian had Philip in mind when he painted them, the artist apparently was accorded complete freedom so the poesies can be
viewed as his own fantasies. Not surprisingly, they contain some of his most wild and sensually beautiful skies.

One of the poesies involves the Rape of Europa (Fig. 6-34). Titian began this in 1559 and did not complete it until 1562 when he was almost 75. Rubens made a copy of it in the winter of 1628-9 in Madrid and called it "the first painting in the world". According to the myth, Jupiter spotted Europa, daughter of King Agenor, playing on the beach with her Tyrian maidens, and desired her instantly. Even as king of the gods, however, he needed some ruse to effect his conquest. He had his son, Mercury, drive Agenor's cattle from their mountain pastures down to the beach. He then assumed the form of a bull whose beauty and gentleness made him stand out from the rest of the herd. In this form he enticed the princess onto his back. Then he immediately plunged into the waters and swam away with her to the 'beached mountainside of Crete' where he revealed himself and had his will of her.

![The Rape of Europa](image)

Fig. 6-34. Titian. The Rape of Europa. 1559-1562. Isabella Stewart Gardner Museum, Boston.

Titian chose to paint the moment after the abduction, when the bull is surging through the waters. Europa holds the bull with one hand following Ovid's text, but with the other she clutches the part of her gown that the wind has torn from her body. She looks back at her playmates who stand helplessly on the beach. Already the bull has covered a considerable distance, for the shoreline is viewed from afar. But something is wrong with the perspective. The viewer is placed at the level of the bull's shoulder, barely two feet above the water, yet the distant shore and the mountainous background scenery appear as if viewed from a great height. This inconsistency did not bother Titian one bit, for the work is a poesy and a feeling of reckless abandon is better portrayed from the air than from sea.
level. Titian was transporting all of us to a dreamland in the sky.

And what a sky it is! The clearings are deep blue while all the clouds have been set ablaze by the fiery colors of dawn or dusk. The clouds above are confined to a rather thin layer and, appropriately for dawn or dusk, are either stratocumulus or altocumulus. Toward the horizon the cloud forms grow indistinct and grade imperceptibly into an amorphous mist that hugs the distant earth. There, earth, sea and sky almost blend in such a whirl of colors the elements can scarcely be distinguished. Titian's *Rape of Europa* is the youthful dream of an old man who still loves life robustly.

El Greco is known primarily as a visionary who painted grossly elongated figures. He did few landscapes but his unique View of Toledo (Fig. 6-35) is one of the world's best known paintings. In it he successfully integrated the Byzantine or Gothic sense of perspective of his youth with the more modern viewpoint.

The city is perched like a medieval fortress atop gullied badlands in the semiarid Spanish countryside. The landscape has a piled up, Gothic appearance because it is viewed from an invisible hill in the foreground. The unmistakable impression of grandeur and monumentality is enhanced by a curved horizon line that suggests we are viewing the earth from a great height. Surprisingly, careful inspection reveals that the vertical relief is quite modest.

Neither the twilight dreams and reveries nor the misty heavens of Italian painters suited Domenikos Theotokopoulos. El Greco had his own austere vision with its own uniquely distorted perspective to bestow upon Spain. In 1568, El Greco came to Venice from his birthplace in Crete as an established painter trained in the Byzantine icon tradition. He apparently spent a brief time in Titian's workshop and later moved to Rome before trying his luck in Spain, where competition among painters was not so intense.

Stark lighting contrasts redouble the impact of the *View of Toledo*. The earth's surface, covered by a bright green mat of vegetation in the foreground, contrasts sharply with the dark, almost lifeless brown of the distant defoliated hillsides while the city's walls and buildings are various shades of gray.
The almost infinite visibility only heightens the painting's sense of monumentality. This seems to contradict Leonardo's observation that objects appear larger when seen through a fog. El Greco achieved the same effect with stark lighting contrasts that require high atmospheric visibility. Sunlight strikes this landscape with an unrelieved, almost lunar glare wherever it is able to pierce the dense mat of cumulus clouds. And wherever the light falls, it ferrets the features out of a gloomy anonymity.

The drama on earth takes place under an even more morose sky. El Greco has elongated the cumulus clouds just as he did most of his human figures. He then gave these clouds the most exaggerated range of lighting - from bright white to pitch black - ever seen in a painted sky. In the real world such extreme lighting contrasts can only be produced in a sky of high visibility when sunlight strikes parts of towering cumulus or cumulonimbus but leaves other parts deeply shaded (Fig. 6-36). El Greco bestowed extreme reflecting and shading properties upon his modestly sized cumulus and thereby made them appear as monumental as the features of the landscape below. The starkly lit and shaded cumulus are mere impostors - although they may seem like storm clouds no rain will fall from them, for they lack the form and massiveness of cumulonimbus.

I believe the View of Toledo is one of the most eloquent indictments of the Inquisition. A few stick figures have inconspicuous fun swimming in the foreground, but within the city walls not a soul would dare appear to challenge the authority of the Grand Inquisitor. El Greco had no need to resort to blood and gore to convey the dark mood of fear that hovered over Spain. The silence of total desolation within the cities of mankind is enough.

Spain's attempt to impose her intolerant beliefs upon Protestant Europe met with less success than her efforts at home or in the New World, but she still managed to inflict a bitter portion of misery and travail on many innocent people in the Old World.

Philip II of Spain became sovereign of the Netherlands in 1555. At his accession the people were still overwhelmingly Catholic but their brand of religion was far more liberal and enlightened than the Spanish variety. Philip wasted little time in his attempt to bring the Inquisition to the Low Countries and root out heresy forever. Facing growing resentment and resistance to his plans, in 1565 he issued the following blunt directive,

As to the Inquisition, my will is that it be enforced....Let all condemned prisoners be put to death, and suffer them no longer to escape through the neglect, weakness, and bad faith of the judges. If any are too timid to execute the edicts, I will replace them by men who have more zeal.

quoted from Will Durant, The Age of Reason Begins. p 441.

Philip's edict backfired by transforming a once clandestine opposition movement into a Protestant cause celebre in the struggle for independence from hated Spain. In 1567, Alva, the Duke of Alba, arrived in Brussels to execute his king's orders to cleanse the Netherlands of heresy. This ardent butcher served a bloody term and, before he retired to Spain in 1573, managed to initiate a war that dragged on until the Peace of Westphalia in 1648!

The brief painting career of Pieter Bruegel the Elder was confined to the years of growing troubles between Philip's accession and Alva's retirement. There are many suggestions that Bruegel's art contains cryptic allusions to the politics of the day, but the overriding message in his works is that of a chronicler of almost incredible visual range and acuity.

The Tower of Babel (1565, Kunsthistorisches Museum, Vienna) may foretell the impossibility of the Spanish dream...
of total dominance over the tiny Netherlands, but H. Arthur Klein has left no doubt that it is an invaluable guidepost to Flemish technology then used in the port cities of the Netherlands. Likewise, in the Blind Leading the Blind (1568, Gallerie Nazionale di Capodimonte, Naples) it can be said that Bruegel is satirizing the blindness of the Spanish rulers, but Dr. Anthony Torrilhon, a physician, has identified a different type of blindness in each of the five men whose faces can be seen - pemphigus, atrophy of the eyeball due to glaucoma, corneal leucoma, amaurosis and enucleation.

Bruegel's remarkable powers of observation reached the sky. In the Tower of Babel, he employed a lazy altocumulus to show how high the tower was getting. Bruegel also cleared the haze that had drifted in from Italy and revived the flat-based cumulus. Then the winter of 1564-65 struck Europe and Breugel became its chronicler.

The winter of 1564-5, as Hubert Lamb noted in Climate, History and the Modern World, was the coldest since the 1430's and "the first of the great winters of the next two hundred years". Bruegel's Hunters in the Snow (Fig. 6-37) served as its baptismal painting.

![Fig. 6-37. Pieter Bruegel the Elder. Hunters in the Snow. 1565. Kunsthistorisches Museum, Vienna.](image)

Bruegel showed that snow covered every bit of exposed land, right down to the small rocks and rubble that protrude from the frozen stream in the right foreground, but he also showed that all the frozen waterways were bare. This is a strong meteorological statement, for it implies the waters were not frozen until after the snowstorm and therefore that mild weather had reigned prior to the storm. Thus, the Hunters in the Snow may represent a pictorial document of the very snowstorm that ushered in the Little Ice Age.

The Little Ice Age is often defined as the period from roughly 1550 to 1850, when temperatures in Europe and North America were about 2º F cooler than today. Its cause is not certain although the almost complete absence of sunspots during the 1600's may indicate that the sun's output diminished slightly. The Little Ice Age was a period marked by some notorious winters, and by significant advances of North Atlantic sea ice and of glaciers in Greenland and the Alps. This minor climatic perturbation had some surprisingly profound effects on European civilization.

Warm conditions from Europe to North America characterized the period preceding the Little Ice Age, from about 800 to 1200 AD. The warmer and less stormy Atlantic weather encouraged exploration. During this time the Vikings settled on Iceland, discovered and colonized Greenland and even reached North
America. The Viking sagas record two settlements on North America shortly after the year 1000. One of these locations, L’Anse aux Meadows, was rediscovered in 1961 in northern Newfoundland and a second presumably was located further south. The American settlements were abandoned because of the Vikings’ own murderous behavior and because of their troubles with the ‘Skraelings’, most likely an eskimo people. The Vikings then returned to their homes in Greenland.

The climate of southern Greenland was much warmer than now, but it began to deteriorate shortly before 1200. From this time, reports of Atlantic sea ice became much more common and the voyage between Iceland and Greenland became increasingly hazardous. Eventually the people on Greenland lost contact with Iceland and Europe and were abandoned to an icy fate. Failing to adapt like the Eskimos, the Greenlanders finally succumbed to the harsher conditions about the time of Columbus. From their skeletal remains we have a pathetic record of a people literally shrinking away. The average height of grown men in Greenland decreased from about 5’ 10” around 1000 AD to 5’ 5” around 1450 AD.

During the period of medieval warmth, greatly increased reports of storm floods along the North Sea and English Channel coasts between 1000 and 1300 AD suggest a fraction of the polar icecaps melted and raised sea level slightly. In Europe the medieval warmth lasted until shortly after 1300 when a series of cool, wet summers caused crop failures that weakened the populace and set them up for the Black Death. After 1300, the maximum possible altitude to raise crops also decreased so that much elevated land routinely cultivated in the 1200’s thereafter became too high to support crops.

Nevertheless, the climatic deterioration was not continuous. The climate from about 1490 to 1560, although somewhat erratic, was rather warm in Europe and probably set the stage for the dramatic winter of 1564-5. After that, crop shortfalls or failures and famine once again became familiar visitors throughout Europe, and Alpine and Scandanavian glaciers advanced down the valleys to give the Little Ice Age its name.

The coldest and worst years of the Little Ice Age came in the decade of the 1690’s. Temperatures averaged well below normal in every season, but the gravest damage was done during the shortened and stunted growing seasons. In the highlands, snow remained on the ground so long into the spring that planting had to be delayed, and frost returned earlier in the fall to plague the harvests. Many farms were abandoned. Famine grew so widespread and severe that the population of northern Europe may have decreased by over 25% The spread of sea ice and colder waters drove entire fish populations well south of their normal grounds. In 1695, Iceland was completely icebound for many months and suffered greatly from starvation.

For the most part, Bruegel shows the lighter side of the snow. W. J. Burroughs has observed that Bruegel painted all of his snow scenes between 1565 and 1567, while the memory of the severe winter was fresh in his mind. These works cover the range of emotions of cold weather. They include the Winter Landscape with Bird Snare (1565, Musées Royaux des Beaux-Arts, Brussels) with its hazy, overcast orange sky and orange ice that served many later artists as the archetypal European snow scene, the Massacre of the Innocents (c. 1567, Kunsthistorisches Museum, Vienna) with a green overcast resembling the Hunters in the Snow, the Census at Bethlehem (1566, Musées Royaux des Beaux-Arts, Brussels) with its pale blue clear sky, and the Adoration of the Magi in the Snow (1567) (Fig. 6-38). Snow also covers the higher elevations in the Dark Day (1565, Kunsthistorisches Museum, Vienna).

The Adoration is Bruegel's only painting of a snowstorm in progress. The falling snowflakes are represented by white dots that
cover the entire canvas. The sky is a featureless light gray and visibility has been reduced by the snow to only a few hundred feet, judging from the indistinct church and trees a mere block away. Prior to 1565, Bruegel had always painted skies with high visibility (except where fires raged) but apparently the weather of that year (or the explosive political situation) sensitized him to the obscuring powers of the air. Thereafter, a number of his works contain hazy and even discolored skies, and in all of these there are no flat-based rows of cumulus he had previously shown some fondness for.

Despite the onset of the Little Ice Age, summer still returned every year. Bruegel showed this in the Harvesters (1565, Metropolitan Museum of Art, New York), where some of the peasants are utterly fagged out by the heat. Visibility is somewhat reduced by haze, and it is not possible to tell if it is clear or overcast.

Lucas van Valckenborch also showed the snows of winter and the return of warm weather. Valckenborch is one of the lesser known Flemish artists but was an outstanding sky painter who accurately represented weather in every season. His Winter Games on the Scheldt at Antwerp (Fig. 6-39) is a topographically accurate view of the city from the western bank of the ice-covered river and seen from the SSW late on a winter afternoon. It is also a meteorologically accurate view of a departing winter storm. The visibility is quite high, as is typical after winter snowstorms. The rather featureless altocumulus represents a torn membrane of altostratus often seen at the extreme western edge of departing winter storms, and particularly during late afternoon. A final brightening touch is added by the broad, parallel crepuscular rays, which penetrate openings in the cloud sheet on the far right.

Fig. 6-38. Pieter Bruegel. The Adoration of the Magi in the Snow. 1567. Oskar Reinhart Collection, Winterhur.

Fig. 6-39. Lucas van Valckenborch. Winter Games on the Scheldt at Antwerp. 1590. Frankfurt Stadelsches Institut.
Valckenborch was also fascinated by spring and summer storms, which he recorded with an accuracy not often encountered until the 19th century. The Spring Landscape (Fig. 6-40) shows a flat-based towering cumulus or cumulonimbus capped by a dome. A shower falling from cloud base is located directly beneath the cloud's dome, as is often the case. The cloud's sunlit top and left side is bright white while the rest is a gray-blue. The detailed structure is not apparent, presumably because it is lost in haze. The Spring Landscape is one of the more literal skies of the 1500's and must have been based directly on a storm Valckenborch witnessed.

Fig. 6-40. Lucas van Valckenborch. Spring Landscape. 1586. Kunsthistorisches Museum, Vienna. ***Top is missing here***

Valckenborch witnessed more than his share of storms. His Protestant sympathies forced him for many years to keep on the move, a fate he shared with many of his contemporaries. In those years, the darkness of the forest was welcome to Flemings for it sometimes brought safety.

Artists like David Vinckboons and Gillis van Conixloo may well have used the forested landscape as an allegory of political sanctuary but they also made a meteorological discovery deep in the forest that the Chinese had appreciated for centuries. In Conixloo's Hunters in a Landscape (Fig. 6-41) a narrow path leading into the distance is illuminated by a dim light but covered by an almost black canopy. Dull orange light from the early morning sun weakly works its way through a hazy atmosphere and a tiny opening in the canopy. In such a setting you must look down for meteorological inspiration. And hovering just above the stream to the left of the path is is a veneer of fog, so common in the early morning when the air is cold. A few feet higher along the stream bank the fog thins to a mist that tinges the trees slight blue and blurs the foliage just as eighteenth century French painters would later rediscover. Both had good reasons to hide.

Fig. 6-41. Gillis van Conixloo. Hunters in a Landscape. 1605. Historisches Museum der Pfalz, Speyer *** similar picture***.

Nightfall brought more complete darkness and protection. Painters since Pietro Lorenzetti had occasionally treated nocturnal scenes because many biblical events had transpired at night. Around 1468, an artist known only as the Master of the Munich Taking of Christ (Alte Pinokothek, Munich) may have been the first to allow the moon to illuminate the fringes of altocumulus or cumulus in an otherwise black sky. Moonlit cloud fringes have ever since remained a favorite technique among painters for suggesting the nighttime sky.

Jan Gossaert employed moonlit cloud fringes masterfully in his rendition of the Agony in The Garden (Fig. 6-42) after his return from a trip to Rome in 1509. Gossaert may have borrowed some elements of
composition from Andrea Mantegna's Agony in the Garden (c. 1460, National Gallery, London), but Gossaert's nighttime sky was unique. The bright side of a crescent moon points down to a sun not too far below the horizon. The moon has illuminated the fringes of some alto-cumulus and the distinct outlines of the sizable and active cumulus.

Fig. 6-42. Jan Gossaert. The Agony in the Garden. Dahlem Gallery, Berlin.

While Gossaert was reveling in the clouds of the nighttime sky, Nicolaus Copernicus, working near the stormy Baltic Sea, wished all nocturnal clouds away so that he might see even further into the heavens. Copernicus revived an ancient idea that the sun lay at the center of the solar system, but did so in such a compelling manner (using Occam's Razor) that his ideas could not long be overlooked. Privately he circulated a preliminary manuscript in 1514. At first all Europe could do was yawn. But the idea was now out in the open and it was a time in which authority was being challenged on all fronts.

Calvin and Luther, who were themselves devoted to opposing an entrenched authority, (but replacing it with another) were appalled at the heliocentric hypothesis while the rather tolerant Renaissance Catholic Church winked at it. Around 1530, Luther vehemently rejected Copernicus's ideas as contrary to Scripture - after all, the Bible states that Joshua commanded the Sun not the Earth to stand still. Rebuffed in public, Copernicus put aside his revolutionary book, On the Revolutions of the Celestial Orbs and the work was not formally published until he lay on his deathbed in 1543. It was recorded that he saw the title page, smiled and, within the hour, died.

Needless to say, Copernicus's ideas did not die with him. Overnight there were many others who came forth to carry the heliocentric banner and put the Earth in its proper place in the solar system. The calendar was revised under the direction of Pope Gregory XIII and now bears his name. Johann Kepler inherited the meticulous observations of Tycho Brahe and used them to formulate the heretical notions that 1: the orbits of the planets were not circles but rather ellipses and 2: the planets move faster when they are closer to the sun. He published these first two laws in 1609, and added his third law regarding the orbital periods of the planets a decade later.

In the same year, Galileo Galilei aimed his newly built telescope at the heavens and discovered a new universe beyond the universe visible to the naked eye. This proved more upsetting to authoritarian figures than all the earlier astronomical theories put together. It is always possible to dismiss theories as mere harmless hypotheses but it is difficult to deny the evidence of the eyes. For this reason, a professor of philosophy at the University of Padua refused to look through Galileo's telescope, saying,

There are seven windows given to animals in the domicile of the head.... From this and many other similarities in nature, such as the seven metals, etc., which it were tedious to enumerate, we gather that the number of planets is necessarily seven. Moreover, these [alleged satellites] of Jupiter are invisible to the naked eye, and therefore can exercise no influence on the earth, and
therefore would be useless and therefore do not exist... Now if we increase the number of planets this beautiful system falls to the ground.
quoted from W. T. Jones A History of Western Philosophy. p. 622.

In March, 1610, Galileo rushed his early astronomical discoveries into print in a pamphlet entitled, The Siderial Messenger, and its contents became known all across Europe almost instantly. In it, Galileo announced the existence of the moons of Jupiter, the craters of the moon, the phases of Venus, and a host of new stars spotted all across the sky. He also took a close look at the Milky Way, which had usually been thought of as a continuum of light, and found,

By the aid of the spy glass...all the disputes that have tormented philosophers through so many ages are exploded at once by the irrefragible evidence of our eyes, and we are freed from wordy disputes upon this subject, for the galaxy is nothing else but a mass of innumerable stars planted together in clusters.

And this is the way the German painter, Adam Elsheimer, living in self imposed exile in Rome depicted the Milky Way in the Flight into Egypt (Fig. 6-43).

Fig. 6-43. Adam Elsheimer. The Flight into Egypt. 1609-1610. Alte Pinakothek, Munich.
The Flight into Egypt is probably the most famous of all painted night scenes and is an astronomer's dream come true. It was signed and dated 1609, but its treatment of the Milky Way as a band of stars suggests Elsheimer retouched between March 1610 when the Siderial Messenger first appeared, and December, when he died. The Milky Way stretches from the upper left corner to the exact center of the nocturne and directly above the Holy Family. At the upper right is Ursa Minor, with the Little Dipper and the North Star, Polaris at the tip of its handle. Directly beneath Polaris and therefore due north, the full moon lies just above the horizon and casts its yellowish light on the fringes of the nearby stratocumulus or altocumulus. The moonlight and the nearby clouds are reflected in the still waters.

The mood is peaceful and undisturbed but the Flight Into Egypt is astronomically inconsistent. A full moon always lies directly opposite the sun. When the full moon is in the north the sun must be in the south. But at the latitude of Italy or even Germany, this can only happen at noon. It therefore should be broad daylight. If the full moon had been placed properly in relation to the stars, it might have been possible to determine the time of day and the day of the year. As it is, Elsheimer probably inserted the stars after the picture had been essentially completed and thus, we have no way of telling if it is shortly before sunrise or just after sunset. We know only that it is night.

But this is night with a new source of illumination. The Flight into Egypt derives much of its power from the lighting. Torchlight lifts The Holy Family from the background darkness while a fire blazes on the left and the moon glows on the right. Elsheimer utilized the revolutionary lighting techniques that Caravaggio had recently introduced into Italian painting. A powerful new beacon had pierced the twilight and musty darkness of the 1500's to announce the imminent arrival of a new dawn. Perhaps this alone is enough to make the Flight into Egypt a fitting symbol of the transition from the troubled sixteenth to the enlightened seventeenth century.