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Head in the Clouds

We see the stars by night. We see the clouds by day. Yet there are a number of beautiful exceptions to this simple divide. When the sun sets and the sun rises, its light is reflected by Venus as she makes her night entry as the brilliant Evening Star and bids farewell as the Morning Star. On nights when there is a full moon and thin, broken clouds slip silently across black skies, for brief moments we see their ghostly presence as they glide over the cold, clear lunar light.

Perhaps most ethereal of all are *noctilucent clouds*. Literally translated these are 'night shining' clouds. They are made of wisps of ice crystals that form 50 miles high. They might be seen during the summer months in the higher latitudes, between 50 degrees and 70 degrees both north and south of the Equator. When the sun has set below the horizon and we are in the shadow of evening, the very highest clouds remain in sunlight for a short while longer. If conditions are right, these *mesospheric clouds* reflect the light and appear in dusky north-western skies as luminescent streams of blue and white light.

In this chapter, we are still looking up at the sky, but it's now daylight and our sights are lower. We have come down to earth, almost. We have left the cold, star-studded black of expanding space and have fallen into Earth's outermost layer – the gaseous atmosphere.

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The sky and clouds have always held a deep fascination for writers, poets and artists. In a short essay reproduced in Edward Cook's and

Alexander Wedderburn's edited book, *The Works of John Ruskin*, the art critic and polymath, Ruskin wrote that the atmosphere is 'Sometimes gentle, sometimes capricious, sometimes awful, never the same for two moments together; almost human in its passions, almost spiritual in its tenderness, almost divine in its infinity.'[1]

When Virginia Woolf was experiencing a nervous breakdown, she wrote an essay, 'On Being Ill', in which she valued the opportunities that being unwell gave her, including the chance to reflect on things both big and small. The essay was originally published in 1926. Here she is writing about looking up at the clouds and the sky:

> The first impression of that extraordinary spectacle is strangely overcoming … this incessant making up of shapes and casting them down, this buffeting of clouds together, and drawing vast trains of ships and waggons from North to South. … One should not let this gigantic cinema play perpetually to an empty house. But watch a little longer and another emotion drowns the stirrings of civic ardour. Divinely beautiful it is also divinely heartless.[2]

At first her reactions to clouds are similar to those of other poets and prose writers. She sees shapes in the ever-shifting cloudscape. However, she then goes on to ask more serious questions about the human condition and nature's indifference to our being. Although clouds in themselves can offer no consolation, they can inspire our imaginations. It is in the creative response to nature that we find meaning, freedom and contentment. In this, Woolf is following in the footsteps of William Wordsworth, Samuel Taylor Coleridge and Thomas de Quincy. It was Woolf's image of the sky as a giant cinema that inspired the poet Alice Oswald and her co-editor, Paul Keegan, to publish an anthology of weather-related prose and poems with the title, *Gigantic Cinema: A Weather Anthology*, in which the editors claim their ruling idea was to have no ideas: to dispense with writing 'about' weather, 'writing that knows what it's talking about', in favour of 'writing that is "like" weather', nebulous, shifting, surreal.[3]

It is the air that surrounds our planet that makes life possible. It is held there by Earth's gravity. Yet, relatively speaking, this life-giving layer is as thin as it is precious. Ninety per cent of the atmosphere lies below 52,000 feet, just ten miles above the ground. Above this height, the air gets thinner and thinner. When you reach around 300,000 feet, almost 60 miles up, the atmosphere ends and space begins.

It is just under 4,000 miles from the centre of the Earth to its surface. A further 60 miles and you have reached the very top of the atmosphere. This thin skin of gas is a mere 1.5 per cent of the radius of the Earth from its centre to the edge of space but it's vital for our existence and we need to look after it.

We learn at school that air is made up of 78 per cent nitrogen, 21 per cent oxygen and one per cent argon. A few other gases occur but in very small amounts. In 1900, levels of carbon dioxide in the atmosphere measured below 300 parts per million or 0.03 per cent by volume. Present-day levels have risen sharply, approaching 420 parts per million in 2023. As we burn more fossil fuels, we pump more carbon dioxide into the atmosphere and, because it is a 'greenhouse' gas, any increase also means an increase in atmospheric heat retention, a rise in global heating and ultimately climate change. If we don't care for the air, the air won't care for us.

The air also contains water molecules in the form of a gas known as water vapour, also a greenhouse gas. The amount of water vapour in the atmosphere varies depending on temperature and height. At sea level, on average, there is about one per cent of water vapour present. As temperatures rise, so the air can hold more water. For example, if the temperature of the air is 30 °C at sea level it can hold up to four per cent water vapour by volume. Conversely, on very cold days, below freezing, these levels can drop to well below one per cent.

Water vapour gets into the air through evaporation as the sun shines on rivers, lakes and oceans, and beams down on damp soil, melting snow and slushy ice. When animals respire and plants transpire, they breathe moisture into the atmosphere. These processes mark the beginning of the *water cycle*. Clouds form when water vapour (a gas) cools and condenses to form water droplets (a liquid). However, these droplets are so small they stay aloft. Before they can become rain, the water droplets must grow. As they gain more water, they become larger and heavier. They can no longer float around in the sky as clouds. They fall to Earth. It begins to rain and, to quote the poet Shelley, 'bring fresh showers for the thirsting flowers'. The water is returned to the rivers, lakes and oceans. The cycle is complete, ready to begin all over again. It was in his poem, 'The Cloud', published in 1820, that Percy Bysshe Shelley offered his own take on the water cycle:[4]

I am the daughter of Earth and Water,
And the nursling of the Sky;
I pass through the pores of the ocean and shores;
I change, but I cannot die.
For after the rain when with never a stain
The pavilion of Heaven is bare,
And the winds and sunbeams with their convex gleams
Build up the blue dome of air,
I silently laugh at my own cenotaph,
And out of the caverns of rain,
Like a child from the womb, like a ghost from the tomb,
I arise and unbuild it again.

Water vapour, then, is critical for the formation of clouds; and clouds, their types and behaviour are the main interest of this chapter.

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We first met John Dalton in Chapter 1. He is remembered and celebrated first and foremost as the father of atomic chemistry and we shall meet him again in Chapter 15.[5] As well as chemistry, Dalton also made significant contributions to the new science of meteorology. For over 50 years he took daily readings of the weather, measuring the temperature, air pressure, rainfall, wind speed and direction. His very last reading was taken on 26 July 1844. He reported: '60, 71, 30.18, SW 1, Little Rain.' Translated, this tells us that on this day, there was an outside temperature of 60 °F, an inside temperature of 71 °F, an air pressure of 30.18 inches of mercury, a south-westerly wind and, of course, a 'little rain'. Dalton died the very next day, aged 77. His final weather report appeared posthumously in the *Manchester Guardian*. In honour of a remarkable life, Manchester Corporation organised a mile-long funeral procession which was attended by 40,000 mourners.[6,7]

Amongst his many meteorological observations, Dalton took a particular interest in water vapour and cloud formation. He appreciated that, as moist winds rose, they cooled and, as they cooled, any gaseous water vapour they held condensed to liquid water, and clouds formed. This was particularly evident over the mountains of the Lake District, his home country. He knew that the prevailing winds were westerlies and that they had travelled over the Atlantic Ocean and Irish Sea. They were therefore saturated with water vapour. As the winds rose over the fells, the air chilled. Mists formed and clouds thickened and, more often than not, rain would fall. It was no surprise to Dalton that the wettest parts of the British Isles were the mountains of the west.

Dalton was interested in the weather for its own sake but, more particularly, he was interested in the properties of gases, including air, and the presence of water vapour in the atmosphere. Indeed, it was probably his experiments with gases and water vapour that first gave him the idea of atoms and their relative weights in compounds and molecules. Moreover, although he confirmed and developed the idea of the water cycle, he didn't say much about clouds and their types. Dalton was certainly a child of his age, the Age of Reason. However, the late eighteenth century was still waiting for someone to look at clouds specifically, observe them carefully, collect good facts,and then see if any patterns or laws might emerge.

Up until the eighteenth century, clouds either did not interest scientists, or, if they did wonder about them, their fleeting, morphing appearance, high above and beyond reach, didn't seem to offer a promising subject for careful study. Clouds were described as 'ornaments of the sky' and to study them, to quote Luke Howard, might 'be deemed a useless pursuit of shadows, an attempt to define forms which, being the sport of winds, must be ever varying, and therefore not to be defined'[8]. In an essay, Rhodri Lewis notes that Shakespeare was also drawn to 'inconstant clouds' and their metaphorical potential. Lewis saw them as possessing 'a particular kind of mutability, one closely tied up with the transformative power of the poetic-artistic imagination'.[9]

Even the Latin word for cloud, *nebulosus*, has given us the English adjective 'nebulous', which describes things seen as vague, foggy, cloudy and not clearly defined. However, at the turn of the nineteenth century, ways of thinking about clouds were about to change, and with that change came the prospect of meteorology becoming a sharper and, ironically, less nebulous science.

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Luke Howard was born in London in 1772. Like Dalton, he was a Quaker.[10] His interest in the weather developed when he was a child. In his mid-teens, he set up a weather station in the garden of the family home in Stamford Hill, London. After leaving school in Oxfordshire, he was apprenticed to a pharmacist in Stockport, Cheshire, before eventually establishing his own pharmacy in Fleet

Street, London in 1794. He was aged 21. His return to the capital also gave him the opportunity to attend public lectures on science. It was at these lectures that Howard got to know William Allen. He was a Quaker, pacifist and, like Howard, a supporter of the anti-slavery movement. Allen was also a successful pharmacist with premises in Plough Court, Lombard Street in London.

In 1796, Allen and Howard, along with other Quakers, founded the Askesian Society. This was a debating and self-improvement club to encourage research and education. Members met weekly and presented papers. In 1798, Allen and Howard went into partnership and opened a new pharmaceutical company based in Plaistow, East London.

It was not long after this joint venture was established that Howard had a minor accident. He had to take time off work. His active and enquiring mind, though, didn't rest. Being a pharmacist, he had an interest in botany and the medical properties of plants. Using his microscope he decided to take a look at plant pollen. In 1800 he presented a paper to the Linnean Society of London titled, 'Account of a Microscopical Investigation of Several Species of Pollen, with Remarks and Questions on the Structure and Use of that Part of Vegetables'. It was published in the society's transactions a couple of years later.

East London is flat and the skies, at least then, were big and without interruption. There was plenty of opportunity for Howard to indulge in his other scientific passion, meteorology. He was already familiar with John Dalton's book, *Meteorological Observations and Essays*, published in 1793. Howard's work on pollens and his paper presented to the Linnean Society also meant he knew all about the work of the Swedish botanist, Carl Linnaeus. We shall meet Linnaeus again in Chapter 10, but he is the person who developed the modern system, still used today, for classifying and naming plants and animals using Latin as the *lingua franca*. Linnaeus is known as the 'father of modern taxonomy'.

Howard's genius was to combine his interest in the weather, observations of what was going on in the sky, readings of Dalton's work on meteorology, and knowledge and appreciation of Linnaeus's methods of classifying plants and animals. He then applied his understanding to the studies he'd made of clouds. He brought order to their shape-shifting, transient presence. In 1802 he presented a paper to the Askesian Society on the classification of clouds titled as 'On the Modifications of Clouds, and on the Principles of their Production, Suspension and Destruction'. It was subsequently published as an essay in 1803.[11]

By 1807 Howard had branched out on his own as a pharmaceutical manufacturer. He moved his business a mile up the road from Plaistow to Stratford. The company was a success. It supplied chemicals to industry and pharmaceuticals to the retail trade. Howard also supplied ether to John Dalton in Manchester, which the chemist needed for his experiments. The two men began a lifelong correspondence sharing all ideas meteorological. In 1837 Howard published his *Seven Lectures on Meteorology*, with a dedication to John Dalton in recognition of 40 years of friendship.[12]

Like Dalton, Howard kept a daily record of the weather. For 21 years he noted London's temperature, rainfall, air pressure, and wind speed and direction. He realised that urban areas, such as London, maintained a slightly higher temperature than the surrounding countryside, especially at night, and he was one of the first people to develop the idea of an urban heat island. His studies of urban climates resulted in his landmark publication, *The Climate of London* (two volumes published in 1818 and 1820, respectively), for which he was elected a Fellow of the Royal Society in 1821.

Two years later, he was one of the founding members of the Meteorological Society of London. It had something of a fitful existence. It was eventually wound up in 1850 in favour of the newly formed British Meteorological Society, established on 3 April 1850. At its first ordinary meeting on 7 May 1850, Howard, now aged 76, joined and became a member.

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It had been clear to Howard that clouds, far from being 'airy nothings', were subject to the laws of nature. Physics and chemistry, in particular, with their interest in heat and energy, gases and vapours, seemed to offer the best prospects of understanding the weather, in general, and clouds, in particular. Being a good Linnaean, Howard felt that the first thing to do was to classify the clouds into their different types. This was the basis of his famous 1802 paper, 'On the Modifications of Clouds'.

Others were also having a go at trying to bring order to the skies. The French naturalist, Jean-Baptiste Lamarck proposed a cloud classification scheme in 1805.[13] However, he used French nomenclature and, although his types are not dissimilar to some that Howard identified, his list of descriptive terms didn't catch on. With his Linnaean hat on, Howard classified his clouds using Latin nomenclature. Howard's solution to the problem of how to classify short-lived, ever-changing clouds was both appealing and elegant. Very quickly his cloud types and the names he gave them caught on with both scientists and the general public.

Howard said there were three simple cloud types, determined by their appearance. Some clouds had the look of fibres or wisps of hair (*cirrus*), others piled up in heaps (*cumulus*), while some covered the sky in vast layers or sheets (*stratus*). He also argued that each type could change from one to the other; or they could combine, giving rise to intermediate and compound types. This gave him a classification comprising seven types of cloud, the names of which have entered our everyday language. Here are Howard's original descriptions:

> *Cirrus*: parallel, flexuous, or diverging fibres, extensible in any or all directions.
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> *Cumulus*: convex or conical heaps, increasing upwards from a horizontal base.
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> *Stratus*: a widely extended, continuous, horizontal sheet, increasing from below.
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> *Cirro-cumulus*: small, well-defined roundish masses, in close horizontal arrangement.
>
> *Cirro-stratus*: horizontal or slightly inclined masses, attenuated towards a part or the whole of their circumference, bent downward, or undulated, separate, or in groups consisting of small clouds having these characters.
>
> *Cumulo-stratus*: the cirro-stratus blended with the cumulus and either appearing intermixed with the heaps of the latter, or super-adding a widespread structure to its base.
>
> *Cumulo-cirro-stratus* or *Nimbus*: a horizontal sheet, above which the cirrus spreads, while the cumulus enters it laterally and from beneath.

His classification was a landmark achievement in the world of meteorology. It showed that cloud formations were the visible signs