Chemistry and the Science of Transformation in Mary Shelley's *Frankenstein*

Sharon Ruston

Department of English Literature and Creative Writing, Lancaster University, UK

New evidence of a world in constant transformation was presented by chemists of the Romantic period. Chemistry was perhaps the most exciting science at this time, with discoveries being reported almost daily and the tantalizing possibility of more breakthroughs to come. Chemists discovered that air and water were not single elements but could be made to reveal the individual elements of which they were composed. Ice, water, steam, and water vapour were found to be different states of the same element or compound. Joseph Priestley's experiments on "air" identified many different elemental gases within the atmosphere and his work with the air-pump found that the "goodness" of air was vitiated during the breathing process. The new worldview enabled by these breakthroughs recognised the constant transformation of matter from one form into another. These insights reveal the world to be a closed system, where all the elements in the world already exist and cannot be destroyed. Such sentiments could be traced back to Lucretius's materialism, put forward in *De Rerum Natura*, where he argued that nothing dies but everything changes. This "chemical worldview" can be found also in Mary Shelley's novel *Frankenstein*. It is my contention that it is this view of chemical transformation that enables Victor Frankenstein to create the Creature. This essay argues that chemistry is the most important scientific discipline in the novel, refuting the commonly-held belief that Frankenstein is a medical doctor.

When applied to the idea of the self, the new chemical worldview might be likened to the Ship of Theseus, a thought experiment that explores whether humans continue to be the same unique individual through their lifetimes. The Ship of Theseus imagines a ship kept in a museum that eventually has each piece replaced and asks whether, at the end of this process,

the ship can be considered the same ship as it was originally. Similarly, in the Romantic period, biological processes were understood as processes of assimilation and ejection that constantly altered our being. The idea of selfhood as mutable and fluid parallels the rapid movement of political and historical events. This essay offers another instance of the use to which scientific and medical ideas are put in literary texts of the time: radicals such as William Godwin and the Shelleys utilised this new model to argue against the fixity of identity and to encourage a new idea of the human as open, adaptable, and inherently fluid, such as we find now in our contemporary ideas of gender. Sharing some elements of Michel Foucault's "medical gaze" and Laura Mulvey's "male gaze", the chemical worldview emphasises the material and physical elements of the individual while observing from a perspective of authority and control.

Many scholars now agree that in the last quarter of the eighteenth century, identity markers – such as gender and race – came to be thought of as fixed, partly because they were supported by often spurious biological studies that made them seem "essential". Dror Wahrman (2006) has written on how, before this time, one's race and gender was considered mutable, fluid, and changeable. As this shifted, science was used to bolster political claims to find women and black people inferior. Andrea Henderson (1996) demonstrated that there were competing models of selfhood available in the Romantic period, that there were alternatives to the idea of selfhood as deep, unique, and whole. She finds, instead, examples of flat characters, characters that are "dangerously fluid", and changeable, being put forward by writers in the period. In this essay, I wish to define a sense of self asserted by Romantic chemists that is not the fixed identity we have come to expect of the period but a model of self as consistently shifting. Like Henderson, I see this version of selfhood as yet another possibility seen in this specific historical moment of political turmoil and social change, but one that embraces rather than guards against the radical possibilities that the historical moment holds.

In this essay, I will first ascertain Frankenstein's identity as a chemist before exploring what it means to be a chemist in this period. I investigate how chemists of this period viewed the world using the work of Humphry Davy, whom Shelley read and echoed in her novel, among others. Frankenstein's achievement is only possible because he possesses this worldview. I explore the transformations that are witnessed or referred to in the novel, paying particular attention to the most important change, from life to death and death to life. Humans are considered subject to mutability by poets and men of science alike in this period; they change during their lives as well as after death. I consider Shelley's foregrounding of human mutability before focusing specifically on her use of clouds in the novel. The water cycle as a process is used to symbolise the transitory nature of human mood and emotion. Ultimately, the chemist understands that there is a finite quantity of matter in the world, which is continually circulating but not being created anew, and sees the world in flux and movement. Without this understanding, Frankenstein could not have embarked upon the most daring scientific experiment to be imagined.

Victor Frankenstein, the Chemist

Despite popular conceptions of the novel, Victor Frankenstein was never, in fact, a doctor. At university in Ingolstadt he studies natural philosophy and chemistry – he does not take the other courses that you would expect of a trainee physician, surgeon, or apothecary (see Bonner 2000). He attends Professor Waldman's course of lectures on chemistry on alternate days and is impressed by Waldman's declaration that "[c]hemistry is that branch of natural philosophy in which the greatest improvements have been made and may be made" (M. Shelley 1994, 30). The narrative reveals that "[f]rom this day natural philosophy, and particularly chemistry, in the most comprehensive sense of that term, became nearly [his] sole occupation" (M. Shelley 1994, 31). It is in chemistry that Frankenstein distinguishes himself at the university. His ardour

and dedication to chemistry are such that "at the end of two years, [he] made some discoveries in the improvement of some chemical instruments" (M. Shelley 1994, 33). His discovery of the secret of life comes after further studies in physiology and anatomy but he tells us that the latter was not sufficient alone; at the crucial moment chemistry is key. Frankenstein realises that he needs to study the decay of human bodies after death: "examining and analysing all the minutiae, as exemplified in the change from life to death, and death to life" in order to discover the principle of animation (M. Shelley 1994, 34). It was exactly these kinds of transformations from one state to another that fascinated the chemists of the late-eighteenth and early-nineteenth centuries.

At the beginning of the nineteenth century, chemistry was emerging as a distinct discipline even while it argued for its importance to many other disciplines. The most famous chemist of the period was Sir Humphry Davy. On five occasions during the period of composing *Frankenstein*, in late October and early November 1816, Shelley recorded that she was reading what she called "Davy's Chemistry", on one occasion specifically noting that she was reading it with her husband, Percy Shelley (1987, 142-144). In one entry Shelley specifies that it was the "Introduction to Davy's Chemistry" that she read (1987, 142). Laura E. Crouch (1978) persuasively argued that Shelley was referring to Davy's 1802 *Discourse, Introductory to a Course of Lectures on Chemistry*, while Paula R. Feldman and Diana Scott-Kilvert claim this is a reference to Davy's 1812 *Elements of Chemical Philosophy* (M. Shelley 1987, 142, 644). Regardless of which was meant specifically, both texts share a definition of the nature of chemistry that is important to my argument here.

In the first paragraph of the 1802 publication, Davy identifies chemistry as the study of changing states of matter in the natural world:

> Chemistry is that part of the science of nature which is related to those intimate actions of bodies upon each other, by which their appearance are altered, and their individuality destroyed. (1)

In other words, chemistry studies the processes by which material bodies act upon each other in such a way as to effect change. Importantly here, it is appearances that are altered (rather than, say, their true nature) but in these processes the individuality of the body is destroyed; it is no longer what it was before but has been acted upon in some way to create something new. One example of such a process, which I contend is crucial to the novel, is the case of oxygen and hydrogen combining to become water. Equally, the realisation that water could change state without changing its chemical properties – say, from ice to liquid to steam – was the "decisive innovation" of late eighteenth-century chemistry (Golinski 1992, 376). Ice becoming water becoming steam is routinely described as a "transformation" in scientific writings of the time (see, for example, Adams 1794, vol. 1, 136, 268, 270). Lavoisier's decomposition of water into its component parts and its recomposition back into water in 1785 offered a spectacular example of a new idea – that all the elements of the world already existed and that matter was not newly created or destroyed but merely transformed, whether into new compounds by chemical processes, or into new states of matter by physical processes (Golinski 1992, 133).[1] In keeping with the period's use of this language, Robert Kerr's translation of Lavoisier's *Elements of Chemistry* attributed the "transformation of solids into fluids, and of fluids to aëriform elasticity" to caloric (1799, 253). The chemical worldview, therefore, sees movements between states of matter as material transformations.

In the 1802 *Discourse*, Davy goes on to name specific processes that demonstrate his point:

> The phaenomena of combustion, of the solution of different substances in water, of the agencies of fire; the production of rain, hail and snow, and the conversion of dead matter into living matter by vegetable organs, all belong to chemistry[.] (1)

The final item is of particular relevance to *Frankenstein*; Victor's breakthrough comes as a result of studying the transformation of dead matter into living matter. Other of these processes are also alluded to in the novel. It is interesting to note how much Davy ascribes to the scope of "chemistry". Material bodies that change because of the application of heat, water, and fire are mentioned. He speaks of meteorological changes – "the production of rain, hail and snow" – as processes that should be studied and explained by chemistry.

The idea that there is a finite quantity of matter in the world continually circulating but not being created anew can be found in contemporary accounts of the French Revolution (see Ruston 2014). When something is transformed, the elements that comprise it are not lost or added to but reorganized to create something new. Shelley published a short story called "Transformation" in 1830, which featured a swapping of bodies, one handsome and one a "monster", in order to teach the handsome youth the true value of life (1976). In the 1831 "Introduction" to *Frankenstein*, she wrote:

> Invention, it must be humbly admitted, does not consist in creating out of void, but out of chaos; the materials must, in the first place, be afforded. (M. Shelley 1994, 195; see also Ruston 2013, 128)

In other words, nothing comes from nothing (*ex nihilo*). The creature in *Frankenstein* is the best example of this kind of creation: made from many bodies (both human and animal), he is a new being created from materials obtained from elsewhere.

Frankenstein's Chemical Training

Professor Waldman explicitly tells Frankenstein he must not neglect other branches of science while he studies chemistry. If he did he would be but a "sorry chemist", merely a "petty experimentalist" rather than a well-rounded "man of science" (M. Shelley 1994, 31). Waldman advises Frankenstein instead to "apply to every branch of natural philosophy, including mathematics" (M. Shelley 1994, 31). This advice is patently not heeded; by his own account, Frankenstein begins to pursue chemistry almost "exclusively […] for its own sake" (M. Shelley 1994, 32). He speaks of how his application in the science became "ardent and eager"; he "improved rapidly", such that his "proficiency" is much commented upon (M. Shelley 1994, 32). Two years pass in which he is "engaged, heart and soul, in the pursuit of some discoveries, which I hoped to make" (M. Shelley 1994, 32-33). We are not told what these discoveries are, but, at the end of the two years, he has progressed sufficiently to make improvements to some unspecified chemical instruments (M. Shelley 1994, 33).

While there is one reference to the "instruments of life" he gathers in order to create the creature, there are four references specifically to "chemical instruments" in the novel (M. Shelley 1994, 48, 128, 132, 142). It is interesting to look at some of the catalogues of this time to see what Shelley might have meant to include within this term, such as G. Hayden's 1818 *Chemical Apparatus and Instruments*. According to this text, the most "essential Chemical Instruments and Utensils, requisite for carrying on a general Course of Chemical Experiments" included portable furnaces, pocket blowpipes, thermometers, an assortment of glass retorts, gas bottles, crucibles, scales, weights, "a galvanic battery, with apparatus, for the decomposition of water", and many other items (*Chemical Apparatus* 1818, 58). Percy Shelley, according to his friend Thomas Jefferson Hogg, possessed "an electrical machine, an air-pump, the galvanic trough, a solar microscope, and large glass jars and receivers" while a student at Oxford

University (1858, vol. 1, 70). Frankenstein's father had also demonstrated a "few experiments" to him on an "electrical machine" (M. Shelley 1994, 24).

At one point, Frankenstein explains why science had a particular appeal to him. He tells us that he is prepared to ask the "bold question" of where life came from and would not be restrained in his investigation by "cowardice":

> None but those who have experienced [discoveries] can conceive of the enticements of science. In other studies you go as far as others have gone before you, and there is nothing more to know; but in a scientific pursuit there is continual food for discovery and wonder. (M. Shelley 1994, 33)

Science is typified here by novelty and constant change. Frankenstein is most attracted to science because of the possibility of exceeding the successes of those who had gone before him. He uses an interesting metaphor when describing "scientific pursuit" as "continual food for discovery and wonder"; at this time, food was commonly thought of as a process of assimilation (see Ruston 2005a, 143-144, 163-165). The body's ability to convert food and other substances to its own nature was seen as a particular function of the living body. There is also a sense here that the man of science pursues an ever-moving target; the landscape is forever changing with new knowledge and new results emerging constantly. Public figures such as Davy and Jane Marcet made chemistry fashionable and accessible. Scientific discoveries could be couched in language found in *Frankenstein*. For example, when Davy wrote to Samuel Taylor Coleridge of his early experiments with galvanism, he told him: "I have made some important galvanic discoveries which seem to lead to the door of the temple of the mysterious god of Life".[2]

Chemistry was linked with its predecessor alchemy in its efforts not just to analyse material bodies but to effect transformation within them. In the case of the alchemists, there were efforts to transform base metal into gold and to make the mortal immortal. Frankenstein is also clearly attracted to the "grand" dreams and visions of the alchemists. When he hears Waldman's "panegyric upon modern chemistry" he comes to realise that modern chemists, too, "have indeed performed miracles" (M. Shelley 1994, 29, 30). Waldman has the true chemical worldview; he recognises that modern chemists come from ancient alchemists, just as nothing comes from nothing. Among the achievements listed, Waldman names knowledge of "how the blood circulates, and the nature of the air we breathe" (M. Shelley 1994, 30). Both of these are circulatory processes, understood at this time as the assimilation and transformation of food and air into our veins and lungs.

When Waldman describes modern chemists as those who seem merely to "dabble in dirt", he may be echoing Davy, whose *Elements of Agricultural Chemistry* was first published to much acclaim in 1813 (M. Shelley 1994, 30; see Miles 1961). Percy Shelley would write extensive notes from this text in 1820.[3] In this book, Davy gave particular attention to the importance of dead or decaying matter on vegetable life even while he is adamant, as a vitalist, that "Life" has a unique or "peculiar character" (1814, 17). Percy Shelley specifically noted from Davy: "[m]anure is useful & may be converted into organized bodies" (1997, 171 rev.). Frankenstein uses the verb to "dabble" only once elsewhere in the novel when he describes how he "dabbled among the unhallowed damps of the grave" (M. Shelley 1994, 36). The meaning of "dabble" here is to interfere, tamper, or meddle with and the "dirt" that Frankenstein dabbles in is specifically that formed by decaying bodies; as he puts it, "the cause and progress of […] decay" (M. Shelley 1994, 34). Dead or decaying matter is essential to Frankenstein's creation of a living being.

When describing his youth and his haphazard education, Frankenstein tells us that "[t]he natural phenomena that take place every day before our eyes did not escape my examinations. Distillation, and the wonderful effects of steam […] excited my astonishment" and his "utmost wonder was engaged" by the demonstration of an airpump (M. Shelley 1994, 24). The chemical process of distillation had been known since ancient times; it was perhaps best known as the process used to distil alcohol. Mixtures are heated until that with the lower boiling point evaporates and is then cooled and condensed separately. The process depends upon a knowledge of the different states that matter can attain and enacts these changes first from liquid to vapour and then back again to liquid form. Also in this passage, Frankenstein specifically draws attention to one of the many states of water. The "wonderful effects" Frankenstein mentions here, when steam is produced by boiling water, presumably refer to the mechanical power produced by the steam engine, most famously associated with James Watt. The airpump, as featured in Joseph Wright of Derby's painting *An Experiment on a Bird in the Air Pump* (1768), shows how oxygen is crucial to life by pumping air out of a glass cylinder in which an exotic bird is held. The airpump merely removes air, hopefully to reintroduce it at the last possible moment to save the bird from death. In the first two examples, distillation and steam, the change is from one physical state to another; in the third, asphyxiation, it is a chemical change that results in death, as air beomes vitiated. In each of these examples, the components of the world are reorganised to change the state of matter: elements are rearranged, their chemical properties remain intact, but their forms are transformed. There is power in such transformations too: steam is harnessed to create intensely powerful effects. In the case of the airpump, the power of the demonstrator over the experiment's subject is godlike; he decides whether the bird will live or die. Joseph Priestley asserted the potential power that scientific research possessed when he wrote that "the English hierarchy (if there be any thing unsound in its constitution) has equal reason to tremble even at an air pump or an electrical machine"

(1774-1786, vol. 1, xiv). The chemical worldview thus recognises and exerts a political authority.

Frankenstein attends "a course of lectures on natural philosophy" at the desire of his father before he goes to university (M. Shelley 1994, 25). This course, as much as Waldman's bombastic (and hyper-masculine) speech later on, could easily be based on one of Davy's chemistry courses at the Royal Institution. According to Frankenstein, "[t]he professor discoursed with the greatest fluency of potassium and boron, of sulpates and oxyds" (M. Shelley 1994, 25). Sulphates are the salts produced from sulphuric acid and an oxide is a compound of oxygen and another element; both are the result of chemical transformations. Both potassium and boron were first isolated by Davy, in 1807 and 1808 respectively, using the new method of electrochemistry (Davy 1808). In fact, potassium was the first metal to be isolated using these means, and was, in many respects, the achievement that made Davy's name. Electrochemistry had first been used by William Nicholson and Anthony Carlisle, friends of William Godwin, in 1800 to decompose water into its component parts, thus establishing the link between electricity and chemical affinity. The elements and compounds here mentioned reveal a world in flux, as things join and separate, forming new combinations and isolating single identities.

Frankenstein's formative experience watching lightning strike a tree is not viewed as a transformation but as annihilation. He tells Walton that the tree was "utterly destroyed" (M. Shelley 1994, 24). In fact, the chemist John Dalton had argued in his 1808 *A New System of Chemical Philosophy*:

> No new creation or destruction of matter is within the reach of chemical agency. We might as well attempt to introduce a new planet into the solar system, or to annihilate one already in existence, as to create or destroy a particle of hydrogen. (212)

In Dalton's view it is as ridiculous to think that you can destroy something as create it: nothing comes from nothing, everything comes from something. If chemists then had come to believe that everything is continually metamorphosing rather than being newly created or annihilated, the world is a closed system where elements can be rearranged and forms change. The airpump (and particularly Priestley's experiment on air) revealed that air could be vitiated when a mouse was trapped in a glass jar but restored with the introduction of oxygen-producing plants (Golinski 1992, 77-78).[4] This work would eventually lead to our knowledge of photosynthesis, confirmation that animals and plants mutually depend upon each other for life in a closed system, and further evidence for Priestley of a divinely ordained economy in the natural world.

Frankenstein's chemical education often focused upon processes of transformation: the chemist sees the world in flux and recognises the power inherent in tools that can modify and change states of being. The kinds of apparatus and instruments Frankenstein would be expected to possess would enable the cooling and heating processes that cause transformations in matter. The processes named (distillation, the production of steam, extracting air, dabbling in dirt) are means by which material bodies can be transformed.

Life to Death and Death to Life

The most important change witnessed in the novel is of course the movement from death to life, dead matter being revived so that it lives again. In fact, Frankenstein speaks of both "the change from life to death, and death to life" as key to his discovery of the principle of life (M. Shelley 1994, 34). These states of being are discussed in the novel in relation to each other and movement between them is thought possible, not just in one direction – from life to death – but also from death to life.

Frankenstein first realises the secret of life when he notices "how the fine form of man was degraded and wasted; I beheld the corruption of death succeed to the blooming cheek of life; I saw how the worm inherited the wonders of the eye and brain" (M. Shelley 1994, 34). Thus, he witnesses the change from health and happiness to disease and death and then, the converse, how death provides for new life. He also notes that dead bodies provide "food for the worm" (M. Shelley 1994, 34). The dead provide for future life in a cycle of existence. As Davy put it in *Elements of Chemical Philosophy*, "the elements of matter are newly arranged in living organs" (1812, 175).[5] Frankenstein's success is only possible because he sees life and death as merely "ideal bounds" that he can "break through", meaning that they are theoretical or abstract rather than real (M. Shelley 1994, 36). Davy was not the only one to recognise the movement between death and life; it was a common theme in chemistry books of the time. For example, Jean-Antoine Chaptal's *Elements of Chemistry*, translated by William Nicholson in 1791, recognised the "general law of nature which condemns all living beings to renovation, and a continual circulation of decompositions and successive generations" (vol. 1, xviii).[6]

When William dies in the novel, the boundary between life and death seems almost unbearably porous: the night before he had been "blooming and active in health" but now he is "livid and motionless" (M. Shelley 1994, 52). When Frankenstein muses on the fate of humans more generally he comments on the rapidity with which change occurs: "how many brides and youthful lovers have been one day in the bloom of health and hope, and the next a prey for worms and the decay of the tomb!" (M. Shelley 1994, 149). In his (highly Freudian) dream after the creation of the creature, Frankenstein imagines a healthy Elizabeth turn instantaneously into his dead mother, "the grave-worms crawling in the folds of the flannel" (M. Shelley 1994, 39). Improved resuscitation techniques, such as those advocated by the Humane Society, made people reconsider the nature of the boundary between life and death, as did disagreements in the Royal College of Surgeons between surgeons John Abernethy and

William Lawrence about how exactly to define life and death (Ruston 2005b). During the real William's last illness, Percy Shelley wrote that their son had been temporarily brought back to life: "[b]y the skill of the physician he was once reanimated after the process of death had actually commenced, and he lived four days after that time" (1964, vol. 2, 104). It seems that the Shelleys also believed in the porous nature of the boundary between life and death and that it could be traversed in both directions.

The chemist sees the world as made up of elements continually being composed, decomposed, and recomposed into new forms. Individual identity is lost with death as once-living matter is used to provide for new life. This is the key transformation in the novel but it is only part of a general understanding that the world is essentially mutable. Frankenstein's knowledge that dead matter feeds and becomes assimilated into living matter enables his creation of the Creature. His insistence that dead and decaying matter will live again in another form, just as living beings can die, informs and makes possible his greatest scientific achievement.

Mutable Humans

Human life was not considered immune to the changes witnessed in material beings. The natural historian William Smellie, in a section called "On the Transformation of Animals" in his *Philosophy of Natural History*, was very clear that "[a]ll *organized bodies* pass through successive changes" (1790, 305). Humans were no exception to this rule: "in both the animal and vegetable kingdoms, forms are perpetually changing" (Smellie 1790, 307). He represents the natural economy as a closed system where what is given is returned: "[t]he earth is continually bestowing fresh gifts upon us; and her powers would soon be exhausted, if what she perpetually gives were not perpetually restored to her" (Smellie 1790, 308). He is certain, too, that humans are perpetually changing within their lifetime, from youth to old age, both

physically and mentally: “[t]he mind of man undergoes changes as well as his body. The taste, the appetites, and the dispositions, are in perpetual fluctuation” (Smellie 1790, 286-287). There is much evidence that *Frankenstein* takes up Smellie’s ideas and similarly considers humans subject to significant change during their lives.

Percy Shelley’s poem “Mutability” is quoted twice in *Frankenstein* (M. Shelley 1994, 74, 104). It was published in January 1816 in the collection *Alastor; or the Spirit of Solitude* and clearly Mary Shelley felt that there were affinities between the poem and her novel (P. B. Shelley 1989, 456-457). The poem argues that the only constancy is change. Percy Shelley compares humans to the natural world, to the ever-changing clouds in the skies as they endlessly form and reform, making new shapes continually. He compares humans to Aeolian lyres, which are played by the wind. The actions of poisoning and polluting, both mentioned in the poem, alter the constitution of a material being, potentially with fatal consequences. Human moods are described as constantly shifting; the slightest thing can change or destroy a mood irreparably. Percy Shelley concludes that all is in flux and the only thing that will survive is the principle of change. The poem enacts the certainty of uncertainty, with each four-line stanza rounded off with a full stop or other punctuation mark and the final, definite statement: “Nought may endure but Mutability” (P. B. Shelley 1989, 457, l. 16). There are many other examples of this kind of sentiment in Percy Shelley’s poetry. For example, in “Mont Blanc”, written between July 22 and August 29 1816: “All things that move and breathe with toil and sound / Are born and die, revolve, subside and swell” (P. B. Shelley 1989, 540, ll. 95-96). In his 1820 poem “The Cloud”, the eponymous cloud declares “I change, but I cannot die” 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. (P. B. Shelley 2011, 364, ll. 76, 82-84)

Knowledge and use of natural cycles are equally important in *Frankenstein* where there is evidence of a mutual interest in processes of transformation within the natural world. Clouds and the weather provide particularly apt examples of the world continually reforming itself anew and offer both Shelleys a specific example of the new scientific understanding of a natural process that is enacted throughout the wider world. Chemistry recognises the movement and flux in the world through such examples.

Just as Percy Shelley drew attention to the mutable nature of human mood in his poem, there are a number of examples of fluctuating moods in *Frankenstein*. Examples can be drawn from many different characters as well as seen in more philosophical statements such as this from Victor: "[h]ow mutable are our feelings, and how strange is that clinging love we have of life in the excess of misery!" (M. Shelley 1994, 144).[7] He describes a constancy – "that clinging love of life" humans have – in the midst of otherwise inconstant feelings. The landscape in the Orkney Islands is described as having the same constant inconstancy: "[i]t was a monotonous, yet ever-changing scene" (M. Shelley 1994, 136). In such sentiments, we recognise the chemical worldview: the only constant in the world is change.

In the lines before Shelley quotes her husband's poem, Frankenstein laments how humans are "moved by every wind that blows, and a chance word or scene that that word may convey to us" (M. Shelley 1994, 75). He sees humans as mutable and delicate, influenced and changed by the effect others can have upon us. These attitudes give the lie to Frankenstein's final, bombastic speech urging the sailors under Walton to continue northwards should they get the opportunity. Movement is impossible at the end of the novel when Walton's ship is caught in ice.[8] Once in a fluid state as water but now frozen solid, ice becomes deadly. Despite the danger, Frankenstein tells the crew: "[t]his ice is not made of such stuff as your hearts might

be; it is mutable, cannot withstand you, if you say that it shall not" (M. Shelley 1994, 183). This sounds grand and inspiring but is, ultimately, nonsense. In the case of Walton's expedition, ice is potentially fatal, with a character that is immovable and implacable. When Frankenstein tells the sailors that their hearts are less mutable than ice, he is presumably speaking metaphorically, using the heart to symbolise their courage and strength of spirit; in the body, hearts are of course vulnerable to injury and death and a vital organ. Frankenstein presents a false and irresponsible comparison; he tells the crew that if they just decide that they are stronger they will defeat the ice when, of course, this is patently untrue. Walton reveals that listening to Frankenstein has the desired effect; the ice is diminished and comes to seem mutable and possible to overcome, but this transformation is imagined and transitory:

> Even the sailors feel the power of his eloquence; when he speaks, they no longer despair; he rouses their energies, and while they hear his voice they believe these vast mountains of ice are mole-hills which will vanish before the resolutions of man. These feelings are transitory; each day of expectation delayed fills them with fear, and I almost dread a mutiny caused by this despair. (M. Shelley 1994, 181)

The truth is that no amount of courage will defeat the physical threat that the ice imposes and there is nothing the sailors can do but wait to see whether the ice will break and return to its more innocuous liquid state. Frankenstein's speech offers powerful words but the physical composition of the world cannot be changed by them.

Recognition that the world is in constant change, and that the boundaries between different states of matter are merely "ideal" and may be traversed, enables Frankenstein's scientific achievement. The changefulness of human emotions and moods is described metaphorically using changes in the natural world such as in the formation of clouds or of ice. Human life is

recognised as mirroring the wider material world, with feelings being described as fluctuating or transitory and likened to the weather. The chemist sees constancy in change, with individual identity challenged by the recognition that human beings are in constant flux.

Mutable Weather

One aspect of the many changes that water can pass through is the process of atmospheric evaporation, condensation, and precipitation that forms clouds. Weather has long been acknowledged to be an important feature of the novel. The huge dust cloud caused by the eruption of Mount Tambora meant that 1816 was unseasonably cold, dark, and wet (see Wood 2015). Clouds are particularly invoked by both Shelleys to symbolise human mutability and are particularly appropriate for my discussion because they take part in a natural cyclical process as water vapour is drawn from and returns to the earth. They are also archetypal mutable forms, shifting shapes, obscuring and revealing other elements as they change. Thomas H. Ford has written about this characteristic of what he calls "atmospheric Romanticism" where the atmosphere is used metaphorically at the same time as it became more precisely understood scientifically (2017; see also Ford 2018). Clouds are the means by which atmospheric electricity is transmitted and Frankenstein's father informs his son of the process that is at work when he demonstrates the electric kite; he speaks of drawing down "that fluid from the clouds" (M. Shelley 1994, 24). This process is also alluded to in Percy Shelley's "The Cloud". The French chemist Chaptal described the world as being "a vast laboratory" (1791, vol. 1, lxiii). Percy Shelley echoed this in his notes on Davy's *Elements of Agricultural Chemistry* where he called the earth a "laboratory" (1997, 171 rev.). The chemical worldview sees that the atmosphere, once thought of as a homogenous mass of only a single element, is a "true chaos" made up of many gases, which can be measured and analysed (Chaptal 1791, vol. 1, lxiii). In the Romantic period, cloud formations were first identified and named.

Percy Shelley read Luke Howard's essay "On the Modification of Clouds, and on Their Principles of Production, Suspension, and Destruction", which was first published in the *Philosophical Magazine* for 1803. The title makes it clear that Howard was interested in what he called the different aggregations of clouds, even while he identified distinct shapes to which he gave the nomenclature that we still use. He considered clouds able to modify and change their identity from one shape or form to another. Howard's topic was "the various forms of suspended water, or, in other words […] the modifications of cloud" (1803, 16: 97). He identifies "simple", "intermediate", and "compound modifications" in clouds (Howard 1803, 16: 98-99). Among the seven types of cloud listed, there are two "compound modifications", the "cumulo-stratus", and the "cumulo-cirro-stratus", which is "[t]he cirro-stratus blended with the cumulus", otherwise known as the "Nimbus" or "[t]he rain cloud" (Howard 1803, 16: 99). Howard emphasises the ability of clouds to move and change: "in changeable weather [cumulus clouds] partake of the vicissitudes of the atmosphere; sometimes evaporating almost as soon as formed, at others suddenly forming and as quickly passing to the compound modifications" (1803, 16: 101). This knowledge was utilised in Percy Shelley's poem "The Cloud" where, Richard Hamblyn claims, almost all of Howard's cloud categories are presented (2001, 215-217). The poem, following Howard, emphasises the cloud's transformations from one shape and function to another.

Likewise, in *Frankenstein*, and following Howard, it is possible to identify which particular clouds were imagined according to their purpose or other features: such as whether they precede rain (nimbus), appear at night, or are described as "uniform clouds" (stratus), or accompany fine weather (cirro-cumulus).[9] Howard quoted poetry from Virgil's *Georgics* and Robert Bloomfield's *A Farmer's Boy* to illustrate his descriptions of clouds (1803, 16: 102-104). His essay also included a theory of evaporation; he described how water changed state "to assume a new form, called *steam*" in boiling, when its temperature rises above 212 degrees;

and offered a theory of dew or condensation (Howard 1803, 16: 347, 332). The other highly influential writer on clouds at this time, Thomas Forster, also had links to both Godwin and Percy Shelley; at the beginning of his 1813 *Researches About Atmospheric Phaenomena*, he defined a cloud as "a visible aggregate of minute particles of water suspended in the atmosphere", drawing attention to the cloud's distinct identity being comprised of many minute particles aggregated together (1).[10]

Clouds are useful symbols and metaphors because, as they shift in shape, combine, or disappear altogether, they can hide or reveal something behind them. The restlessness of clouds means that they can temporarily obscure. Speaking of Elizabeth's misery at the death of Justine, which, he claims with characteristic narcissism, is not as deep as his own, Frankenstein refers to clouds metaphorically: hers was the "misery of innocence, which, like a cloud that passes over the fair moon, for a while hides but cannot tarnish its brightness" (M. Shelley 1994, 68).[11] Here clouds are notable because they are ephemeral; they only temporarily obscure sight of the moon behind them. Likewise, Frankenstein notes elsewhere that "[t]he stars shone at intervals as the clouds passed from over them" (M. Shelley 1994, 122). This experience is described as a particularly momentous scene of "wondrous solemnity", which "stirred strange thoughts" within him (M. Shelley 1994, 122). When he is in Geneva, Frankenstein tells us that he "passed whole days on the lake alone in a little boat, watching the clouds" (M. Shelley 1994, 124). When he is trying to get rid of the physical remnants of the female creature, Frankenstein uses the momentary cover of a "thick cloud" that hides the light of the moon. Perhaps reflecting the dubious nature of his actions, the sky remains "clouded". Where previously the moon had been clear, now, "everything was obscure" (M. Shelley 1994, 143). In fact, this refreshes rather than depresses Frankenstein's spirits. Later, "[a]midst the wilds of Tartary and Russia", he is literally revived by a cloud: "[o]ften, when all was dry, the heavens cloudless, and I was parched by thirst, a slight cloud would bedim the sky, shed the few drops that revived me, and

vanish" (M. Shelley 1994, 172-173). It is also the case that a "cloudless" sky can make him feel momentarily tranquil (M. Shelley 1994, 129). Elizabeth attributes the beauty of a scene to the movement of the clouds: "[o]bserve how fast we move along, and how the clouds which sometimes obscure, and sometimes rise above the dome of Mont Blanc, render this scene of beauty still more interesting" (M. Shelley 1994, 163). In the 1831 edition of the novel, the child Elizabeth is described as possessing "blue cloudless eyes" while the creature has "watery, clouded eyes" (M. Shelley 2017, 5; 1994, 154). Here, "cloudless" denotes innocence while "clouded" suggests ambiguity at best and, at worst, guilt.

Somewhat conventionally, Frankenstein's melancholy is often described as a cloud that blinds him to other emotions, or, his melancholy is said to descend upon him like a cloud. This mood returns in "fits, and with a devouring blackness overcast the approaching sunshine" (M. Shelley 1994, 124). In his father's words, the murder of William has "cast a gloom over us. But it is this gloom, which appears to have taken so strong a hold of your mind, that I wish to dissipate" (M. Shelley 1994, 125). The word "dissipate" in the novel links the weather, the modulations of emotion, and the idea of the transformation of forms. It is used in the novel to refer to a breeze dissipating the cloud and Walton's hope that "the ice should dissipate and a free passage be opened" (M. Shelley 1994, 76, 182). The word is equally also used to speak of dissipating moods; gloom and melancholy are particular moods that Frankenstein is unable to drive away.[12] The processes that bring about change are brought together in the character of Safie, whose "presence diffused gladness through the cottage, dispelling their sorrow as the sun dissipates the morning mists" (M. Shelley 1994, 93). Dissipation at this time generally means to gradually disperse, diffuse, or dispel but it was also specifically associated with natural phenomena of evaporation, precipitation, and condensation, which are often also metaphorically used to describe humans' fluctuating moods (*OED*).

These examples demonstrate that, as Ford (2017) has argued, the atmosphere can simultaneously work metaphorically and with scientific precision in literary texts. They are further example of the novel's interest in changing states of matter with the cloud providing a particularly malleable metaphor. While representing melancholy or changing and fluctuating mood as a cloud is perhaps a literary convention, in this novel the use of clouds brings together the scientific interest in natural cycles and in water cycles and compounds more generally. Clouds are viewed as an aggregate mass of many distinct components; a new identity is temporarily forged by many tiny particles but this identity will soon shift and change as new clouds form.

Conclusion

Davy's 1802 *Discourse* noted how during the processes studied by chemistry, including meteorological processes, individuality was destroyed. David Hume questioned how humans thought themselves "possest of an invariable and uninterrupted existence thro' the whole course of our lives" when, in fact, we are simply a succession of perceptions (1739-1740, vol. 1, 440). How can selfhood be considered singular, unique, and individual, when we change so much over time? The doctor Sir Thomas Charles Morgan (husband to the novelist Sydney Owenson) mooted the possibility that due to bodily changes we are a new person every forty days. Owing to what he calls assimilation and elimination, there is a "complete revolution of the whole man" (Morgan 1818, 50). The creature in *Frankenstein* becomes a metaphor for the transformations that take place in the material world: he is only possible because Frankenstein understands that death creates life just as life creates death. He is the result of other bodies being adapted, rearranged, and repurposed: something new has been created from elements that had existed previously in other forms. The novel dwells upon processes of transformation – whether chemical or natural – to emphasize the mutable nature of humans and the world in

which we exist and the role of the chemist as the exemplary scientist who observes and traces this flux and movement. Victor Frankenstein's identity as a chemist – not a doctor – is critical to this understanding of the novel.

Notes

[1] The allocation of priority of discovery in this case was contentious; see Miller 2004 and Chang 2012.

[2] Humphry Davy to Samuel Taylor Coleridge, November 26 1800. Davy Letters Project: http://www.davy-letters.org.uk. This will be superseded by *The Collected Letters of Sir Humphry Davy*, edited by Tim Fulford and Sharon Ruston, 4 vols (Oxford: Oxford University Press, 2020).

[3] Shelley wrote eighteen pages of notes from the second (1814) edition of this book. See P. B. Shelley 1997, 155 rev.-172 rev.. For differences between Shelley's notes and Davy's text, which show Shelley's specific interest in and interpretation of the original, see Ruston 2005a, 95-101.

[4] Priestley was awarded the Copley Medal in 1773 for his discovery that vegetables produced oxygen. Shelley noted this process in his notes on Davy's *Elements of Agricultural Chemistry*: see P. B. Shelley 1997, 170 rev.-171 rev..

[5] Davy offers a distinctly vitalist reading of this process: "[t]he laws of dead and living nature appear to be perfectly distinct: material powers are made subservient to the purposes of life, and the elements of matter are newly arranged in living organs; but they are merely the instruments of a superior principle" (1812, 175).

[6] Natural philosophers also drew attention to the cycle of life and death. For example, William Smellie in *The Philosophy of Nature*: "[i]t is a law of Nature, that all organized bodies should be decomposed, and gradually transformed into earth. While undergoing this species of dissolution, their more volatile particles pass into the air, and are diffused through the atmosphere. Thus animals, at least portions of them, are buried in the air, as well as in the earth, or in water. These floating particles soon enter into the composition of organized beings, who are themselves destined to undergo the same revolutions" (1790, 307-308).

[7] Moods are described as fluctuating; see, for example, M. Shelley 1994, 7, 16, 163.

[8] See Wilson 2003. An argument could be made that despite possessing the worldview of a chemist, Frankenstein is, for the most part of the novel, passive and static, while the Creature shows himself best able to adapt to a new climate and new circumstances. When travelling with Clerval in England, Frankenstein comments upon his inability to recover from the shocks he has encountered, likening himself to a tree blasted by lightning; he says that sublime scenes now fail to "communicate elasticity to [his] spirits" as they once had (M. Shelley 1994, 133).

[9] M. Shelley 1994, 55, 173, 68, 122, 75, 74; Howard 1803, 16: 102, 17: 10, 16: 102-103.

[10] See Ruston 2005a, 91-95.

[11] See Jacobus 2012, 11: "[c]louds […] make us think not only about form and vacancy, mobility and change, but also about the peculiar realm of affectivity that we call 'mood'".

[12] Dissipation is part of the process of entropy described in the second law of thermodynamics; while this was discovered later in the nineteenth century it does describe a similarly closed system to that imagined by early nineteenth-century chemists.

Notes on Contributor

Sharon Ruston is Professor of Romanticism at Lancaster University. She is the author of *Shelley and Vitality* (Palgrave Macmillan, 2005; paperback 2012), *Romanticism: An Introduction* (Continuum, 2010), and *Creating Romanticism: Case Studies in the Literature, Science and Medicine of the 1790s* (Palgrave Macmillan, 2013), and the co-editor of *The Collected Letters of Sir Humphry Davy*, 4 vols (Oxford University Press, 2020).

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