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The Scientific Method

Inquire of ancient Wisdom; go, demand
Of mighty Nature, if 'twas ever meant
That we should pry far off yet be unraised;
That we should pore, and dwindle as we pore,
Viewing all objects unremittingly
In disconnection dead and spiritless;
And still dividing, and dividing still,
Break down all grandeur …

(Wordsworth, 1814)

1.1 Introduction

This chapter outlines the achievements and limitations of the scientific method, beginning with a brief discussion of early Systems Thinking (ST) and how it was pushed to the margins of reputable thought by the success of the Scientific Revolution. The Scientific Revolution began in the sixteenth century with Copernicus's heliocentric account of the cosmos and was consolidated in the early seventeenth century with the establishment of the scientific method based upon mechanism and reductionism. Newton's *Principia*, published in 1687, marked its apotheosis. This was a revolution that encompassed remarkable developments in mathematics, physics, astronomy, chemistry and biology. It inspired the agricultural and industrial revolutions of the eighteenth century which transformed the world in which we live. The chapter goes on to discuss some of the limitations of the mode of thought underpinning the Scientific Revolution. Recognition of these limitations, and their consequences for humanity and the environment on which we depend, has led to a positive reassessment of the value of ST as a complementary approach to the traditional scientific method.

Critical Systems Thinking: A Practitioner's Guide, First Edition. Michael C. Jackson.

1.2 Early Systems Thinking

ST has existed for millennia and emerged amongst peoples in all continents.

Indigenous communities, living in close interrelationship with the land and dependent on knowledge sharing for community well-being, produced the first ST. Yunkaporta provided an Aboriginal perspective:

> There are no isolated variables – every element must be considered in relation to the other elements and the context. Areas of knowledge are integrated, not separated. The relationship between the knower and other knowers, places and senior knowledge-keepers is paramount. It facilitates shared memory and sustainable knowledge systems. An observer does not try to be objective, but is integrated within a sentient system that is observing itself. (Yunkaporta, 2019, pp. 169–170)

Many Eastern philosophies evince a systems orientation. The Daoist *I Ching*, with its emphasis on dynamic changes of relationship between interconnected variables, is frequently cited as the oldest systems book. The Greeks introduced systems ideas into the Western tradition of thought. The pre-Socratic philosopher Heraclitus, with his theory of the unity of opposites, is often acknowledged as an influence by later systems thinkers. Aristotle was the first to articulate the systems mantra that 'the whole is more than the sum of its parts'. He went on to reason that the parts only obtain their meaning in terms of the purpose of the whole. For example, the parts of the body make sense because of the way they function to support the existence of the whole organism. Plato anticipated cybernetics, an important strand in contemporary ST, when he drew an analogy between the 'steersman' (*kybernetes*) of a vessel and of the ship of state.

Systems ideas continued to be prominent in later Western thought, for example, in the works of Kant and Hegel and the philosophical traditions of phenomenology and pragmatism. In the twentieth century, however, the influence of the Vienna Circle turned philosophy into a form of logical analysis designed to clear away ambiguity and confusion so that science could make better observations and decide what was and was not the truth. *Language, Truth and Logic* (1936), A.J. Ayer's manifesto of logical positivism, declared that discussions on metaphysical questions – about the nature of reality, existence, consciousness, for example – were nonsensical because they did not lead to hypotheses that were subject to empirical verification. In this tradition, arguments about ethical issues equated to nothing more than shouts of approval or disapproval. At Oxford University, according to Cumhaill and Wiseman (2023), it took four women, inspired by the later work of Wittgenstein, to bring philosophy back to life. Elizabeth Anscombe, Philippa Foot, Mary Midgley and Iris Murdoch were 'metaphysical animals' who saw philosophy as relevant to the whole of human life, not just to humans as calculating machines. Philosophy had to accept humans as part of the natural world, help them navigate their lives together in a particular historical period, suggest alternative ways of going on and re-engage with the language of morality.

It is important to consider why, given its provenance, ST went out of favour and has had so little influence and impact on the development of the modern world.

1.3 The Ascendancy of the Scientific Method

The human mind can engage with the world in a multiplicity of ways. Charles Foster's (2021) exploration of 40,000 years of human consciousness demonstrated this by examining what has been lost as the Upper Palaeolithic period transitioned into the Neolithic and Enlightenment worlds. Neolithic people began the 'divorce proceedings' between humans and nature by learning 'to draw lines'. They started to see themselves as distinct from the natural world and to try to control it. But in seeking to tame nature, they also enslaved themselves. As Foster put it: 'Thoughts as well as sheep were corralled'. People had to stay in settlements throughout the year to respond to the constant demands imposed by husbandry. With larger settlements came politics and hierarchy, and the rich Palaeolithic culture was reduced to the 'priest-curated stories of Stonehenge'. In Foster's account, it was Enlightenment thought that completed the process of estranging us from nature and our humanity by ridding the world of enchantment, conceiving of it as a machine and humans as economic units.

The Enlightenment is closely associated with the Scientific Revolution, which led to significant advances in knowledge in many fields. The success of the Scientific Revolution depended on the efforts of Francis Bacon and Galileo who, in the early years of the seventeenth century, established a well-defined scientific method. First, a phenomenon of interest is identified and studied. Second, a hypothesis is constructed suggesting what causes this phenomenon to occur. Third, predictions are formulated about how the elements involved will behave in the future. Fourth, carefully devised experiments are conducted to test these predictions, and the results of these are measured. The experiments must be clearly described so that they can be repeated by other scientists to check if they get the same outcomes. Finally, the results are analysed, and conclusions are drawn about the veracity of the hypothesis. On this basis, it seemed, the progress of science could be guaranteed.

The philosopher Descartes provided the justification for the notions of mechanism and reductionism upon which the scientific method is based. This relies on a mind–matter dualism whereby an immaterial mind can use rational thought, as exemplified in logic and mathematics, to reach conclusions about the workings of an independent mechanistic universe in which wholes are no more than the sum of their parts. Writing in 1637, Descartes reasoned that, if he wanted to understand the world and the problems it posed, he had

> ... to divide each of the difficulties that I was examining into as many parts as might be possible and necessary in order best to solve it [and] beginning with the simplest objects and easiest to know ... to climb gradually ... as far as the knowledge of the most complex. (Descartes, 1637/1968, pp. 40–41)

Logic is used to build back up from the properties of the parts to an understanding of the whole. In this way, humans can achieve certainty about the nature of reality.

In 1687, in the *Principia*, Newton provided mechanism with its affirmation, setting out his laws of motion and theory of universal gravitation, and uniting terrestrial and celestial mechanics. The universe, set in motion and sustained by God, operated like clockwork. It followed entirely predictable rules that could be fully comprehended by humans. In the eighteenth century, scientists refined and extended Newtonian mechanics and, in 1814, the mathematician Laplace asserted that Newton's laws could in principle be used to predict everything for all time if the current position and velocity of all particles in the universe were known (Mitchell, 2009). In the nineteenth century, the problem of extending Newton's laws of motion to systems involving multiple elements was overcome with developments in statistics and probability theory. In systems of disorganised complexity, because the average behaviour of elements corresponds closely to actual behaviour, it is unnecessary to predict what each element is doing. It became possible to apply Newtonian mechanics to thermal phenomena whether exhibited by solids, liquids or gases. This gave rise to thermodynamics and its fundamental laws of conservation and dissipation of energy. The second of these demonstrates that all isolated systems move from order to disorder as useful energy is lost in the form of friction or heat. Entropy, as a measure of disorder, gradually increases. The universe runs down as useful energy is dissipated.

By the close of the nineteenth century,

> ... scientists had developed two different mathematical tools to model natural phenomena – exact, deterministic equations of motion for simple systems; and the equations of thermodynamics, based on statistical analysis of average quantities, for complex systems. (Capra and Luisi, 2014, p. 104)

Physicists could be forgiven for a degree of hubris in believing that the scientific method, enabled by these tools, could be extended to other fields. It surely would not be long before chemical, biological and even social phenomena would succumb to mechanistic explanations and be seen as nothing but complicated expressions of the laws of physics. Michelson proclaimed, in 1894, that

> … it seems probable that most of the grand underlying principles have been firmly established and that further advances are to be sought chiefly in the rigorous application of these principles to all phenomena which come under our notice. (quoted in Mitchell, 2009, pp. ix–x)

More pithily, Lord Rutherford, a fellow physicist, is reputed to have declared that: 'All science is either physics or stamp collecting'.

The scientific method, underpinning the advances made in the sciences, enabled massive improvements in agricultural yields and industrial productivity. Agricultural societies were rapidly transformed into manufacturing economies through the invention of new machines, methods and processes, as well as through the more efficient harnessing of energy resources. Urbanisation, improvements in the prevention and treatment of infectious diseases, and declining childhood mortality led to population growth and longer life expectancy. Increased industrial productivity made consumer goods plentiful and affordable. The standard of living of the general population gradually increased. A greater range of jobs became available, educational opportunities increased and suffrage was widened. Transportation improved as new roads, canals and railways were built. Shipping lines were opened, increasing international trade. New methods of communication were invented, and the world became a smaller place. It was reasonable to assume that progress would continue. Improvements in science and technology seemed to be leading the way inexorably to richer societies which provided safer, more fulfilling lives for their citizens.

ST did not seem to be necessary. So, what is wrong with the traditional scientific method? In exploring this, we need to consider the opposition it aroused among the 'Romantics', its lack of success in fields such as the life and social sciences and debates about its appropriateness even in the physical sciences.

1.4 Romanticism and Disquiet

The success of the Scientific Revolution ensured that mechanism and reductionism came to dominate Enlightenment thinking. This provoked outrage and opposition from those philosophers, writers and poets who marched together under the banner of 'romanticism'. The Romantics questioned science's reliance on reason alone which, they felt, separated life from art, humankind from nature and individuals from society. The philosopher Immanuel Kant was an important influence. He believed that Newtonian physics could provide universal truths, but this was because it restricted itself to elucidating what the human mind was capable of discerning through the senses. What existed beyond the scope of the senses was beyond science's ken, and Kant provided a warning to those who seek to extend its scope into the biological and human domains. He saw that it was impossible to provide a mechanical account of the vitality, growth and diversity found in nature: 'Are we in a position to say: *Give me matter and I will show you how a caterpillar can be created?*' (Kant, quoted in Mensch, 2013). An organismic approach, going beyond the realm of 'blind efficient causes', seemed essential in the life sciences. When it came to the study of human behaviour, Kant faced a difficulty even more severe than he encountered with nature. According to science, humans are subject to causal determinism, but this undermines the notion of free will, on which the whole of morality depends. To rescue morality, alongside belief in God and immortality, Kant placed human freedom in the realm of the 'noumena' – things capable of being inferred but beyond the reach of scientific knowledge:

> We have in the world beings of but one kind whose causality is teleological, or directed to ends, and which at the same time are beings of such character that the law according to which they have to determine ends for themselves is represented by themselves as unconditional and not dependent on anything in nature, but as necessary in itself. The being of this kind is man, but man regarded as noumenon. (Kant, quoted in Kemp, 1968, pp. 120–121)

Wulf (2022) traced the liberating influence of Kant's thought on the 'magnificent rebels' of the 'Jena Set' of romantic thinkers. To them, imagination rather than reason was the faculty of mind most in need of cultivation. Imagination brought the external world into being. Focussing too much on reason impoverished reality, stripping it of poetry, spirituality and feeling. The polymath Johann Wolfgang von Goethe was the most influential figure in the Jena Set. It has been argued that he developed a 'way of science' completely at odds with what became the mainstream:

> … there is the possibility that there could be a different science of nature, not contradictory but complementary to mainstream science. Both can be true, not because truth is relative, but because they reveal nature in different ways. Thus, whereas mainstream science enables us to discover the causal order in nature, Goethe's way of science enables us to discover the wholeness. (Bortoft, 1996, p. xi)

In Bortoft's view, mainstream science is a 'science of quantity', concerned only with those aspects of phenomena that can be quantified. The scientist seeks to exclude subjective experience. Thus, Newton's physics of light and colour is perfectly intelligible to someone who is colour-blind. Goethe offers an alternative 'science of quality'; his approach pays close attention to how the phenomena under investigation are experienced, addressing those things that cannot easily be measured. While mainstream science fragments the world, Goethe, coming to the study of colour through his interest in art, was interested in what gives rise to colours and how they relate to each other and our emotions. In his later work, as a 'phenomenologist of nature', he argued that to appreciate reality more comprehensively, to make it visible and understand its meaning, requires a consciousness that recognises the 'authentic wholeness' expressed in the reciprocal relationship of parts and wholes. This is difficult to obtain, and the eponymous hero of Goethe's tragic play *Faust* sells his soul to the devil in exchange for a hoped-for moment of transcendence on earth in which he can understand himself, nature and the universe as a harmonious, interconnected whole.

There is no one 'theory' of romanticism, but most commentators agree it possesses two common themes – the promotion of the power of the mind and an organismic worldview (Peckham, 1951). Fichte, Schelling and Novalis, important figures in the Jena Set, illustrated these themes. Fichte's 'ich-philosophy' put the self, as a free being, centre stage. Schelling saw the world as an interconnected whole within which humans and nature were inseparable. Novalis railed against the mechanistic worldview, which was drowning out the 'eternally creative music of the universe' and replacing it with 'the monotonous clatter of a gigantic millwheel'. In his view, a poet can gain a better understanding of the world than a scientist, and science needed to be poeticised.

Romanticism spread from Germany and became a strong current of thought in England, the United States and elsewhere. In England, there was recognition of the dangers posed by mechanistic thinking, especially to an understanding of humanity's 'oneness with nature'. Wordsworth saw such thinking as diminishing human potential and our enjoyment of nature:

> The world is too much with us; late and soon,
> Getting and spending, we lay waste our powers;
> Little we see in Nature that is ours;
> We have given our hearts away, a sordid boon!
> (Wordsworth, 1807, lines 1–4)

In the quotation heading this chapter, he identifies reductionism as the main culprit. As did Coleridge, who borrowed his concept of 'organic form' from the Jena Set. Keats declared, in harmony with Goethe, that Newton 'had destroyed all the Poetry of the rainbow, by reducing it to a prism' (quoted in Wulf, 2022). Blake, in his poem *London* (1794), saw the 'mind-forg'd manacles' of mechanism as giving rise to many of the problems associated with the industrial revolution. In *Jerusalem* (1808), he mourned that 'dark satanic mills' were plaguing England's 'green and pleasant land'. In the United States, Emerson, Thoreau and Whitman championed the romantic project, emphasising nature, transcendentalism and the self. A modern American songwriter who declared, with Whitman, that 'I contain multitudes' echoed the romantic frame of mind when he wrote:

> Yet one place where additional learning does not disentangle the mystery of the subject is music. As a matter of fact, the argument can be made that the more you study music, the less you understand it. Take two people – one studies contrapuntal music theory, the other cries when they hear a sad song. Which of the two really understands music better? (Dylan, 2022, p. 274)

1.5 The Challenge of Complexity

As Kant anticipated, traditional science, successful in astronomy, physics and chemistry, encountered difficulties when it sought to extend its scope to higher levels of complexity as found, for example, in the fields of biology and sociology. At these levels, mechanism and reductionism falter, raising questions about the universality of the scientific method. Complexity makes it difficult to place boundaries around a study and to isolate the key variables impacting what happens. Experiments are difficult to repeat because the phenomena under investigation are constantly changing and cannot be brought into the laboratory. Ethical issues become significant. At the human level, the existence of free will makes prediction difficult if not impossible. Intentions drive behaviour. In general, analysis of the parts alone cannot explain emergent properties, such as life and self-consciousness, which arise from the way the parts are organised. Aristotle's insight that a whole is more than the sum of its parts becomes pertinent. The domain of application of the scientific method is smaller than many thought, as will be apparent from a brief review of the fields of biology, ecology, psychology and sociology.

In biology, there are emergent properties at the level of the organism, such as life itself, viability, adaptation, growth and development, reproduction and regulation. These need to be explained, but that seems impossible in terms of physics and chemistry. Goethe, much influenced by Kant, argued that organisms are driven by 'vital forces' that provide them with their general form and properties as wholes. They are then further shaped by their environments (see Wulf, 2015). A less mystical account became possible with the birth of 'organismic biology' in the first half of the twentieth century. As Capra wrote:

> Vitalists assert that some nonphysical entity, force, or field, must be added to the laws of physics and chemistry to understand life. Organismic biologists maintain that the additional ingredient is the understanding of 'organization', or 'organizing relations'. (Capra, 1996, p. 25)

The best-known organismic biologist, Ludwig von Bertalanffy, argued that the failure of physics in explaining biological systems arises because it only considers systems which are 'closed' to their environments. Closed systems obey the second law of thermodynamics, which presents the universe as a machine that is gradually running down. Von Bertalanffy (1950) asserted that organisms are, by contrast, 'open systems'. They can temporarily defeat the second law of thermodynamics by living off their environments. They import matter and energy, which enables them to exist in a dynamic state, retaining their basic form while increasing their complexity through differentiation and integration. The history of biological science, since von Bertalanffy's time, can be seen as a series of pendulum swings between organismic and reductionist positions, with both seemingly having much to offer.

The most important figure in the early development of ecology, according to Wulf (2015), was Alexander von Humboldt, who was a friend of Goethe and was immersed in the philosophy of Kant. Under the influence of the Jena Set, he was able to

> ... [revolutionize] the way we see the natural world. He found connections everywhere. Nothing, not even the tiniest organism, was looked at on its own. 'In this great chain of causes and effects', Humboldt said 'no single fact can be considered in isolation'. With this insight, he invented the web of life, the concept of nature as we know it today. (Wulf, 2015, p. 5)

Even more remarkable for the time, von Humboldt recognised the connection between human activity – such as deforestation, ruthless irrigation and the 'great masses of steam and gas' – and the state of the natural environment. Based on his thinking, ecology sought from its beginnings to grasp interconnectivity and emergence. It was born by taking a systems approach. Twentieth-century ecology has continued in this vein with the formulation of the concept of an 'ecosystem'. The Gaia hypothesis, which postulates that the Earth itself is a living system, has also gained currency.

The Gestalt psychologists, writing in the early twentieth century, challenged the mechanistic, stimulus-response approach that dominated their field. They emphasised the importance of mind in bringing order to the chaotic reality with which it is confronted. The German word *gestalt*, meaning shape or form, refers to the patterns employed by the mind to make sense of what is perceived. For example, we see patterns of dots before the individual dots themselves. In Koffka's words, it is apparent that 'the whole is something else than the sum of its parts' (quoted in Ramage and Shipp 2009, p. 260).

Auguste Comte, writing in the early nineteenth century, called for a new science of society which he initially called 'social physics'. The scientific method was to be used to seek out general laws governing behaviour in the social world. When that failed to bring the results expected, Spencer and Durkheim took sociology in an 'organismic' direction towards what became the dominant theory: 'structural-functionalism'.

Alternative types of sociology were, however, waiting in the wings and came to the fore in the 1960s and 1970s. 'Interpretive social theory' questions the society-makes-person bias of structural-functionalism. It starts from the study of individual perception and action convinced, by Dilthey's 'hermeneutics' and Schutz's 'phenomenological' approach, of the importance of subjective meaning. The 'sociology of radical change' challenges the conservative bias of structural-functionalism, portraying society as characterised by inequalities that give rise to conflict between different groups which can, in turn, lead to change. It builds on the work of Marx and the Frankfurt School. Marx was concerned, in his early work, with the alienation of 'men' in capitalist society. Later, he argued that the contradictions that exist within capitalism will produce a revolution, led by the exploited working class, and a communist society. The most influential thinker still working in the Frankfurt School tradition is Jurgen Habermas. Whereas Marx based his early critique of capitalist society on alienated labour, Habermas (1979) emphasised the alienation that results from 'distorted communication'. A rational society depends on the existence of 'communicative competence', where citizens can engage in an 'ideal speech situation' to which they can contribute equally with the better argument winning the day. This, in turn, depends on the establishment of certain social conditions. In particular, the 'public sphere' must be re-energised as an arena where democratic discussions can take place and genuine agreements can be reached. For Habermas, the Enlightenment project can be brought to fruition by eradicating distorted communication and promoting communicative competence. He has had to rigorously defend his position against such theorists as Derrida questioning the transparency of language; Foucault emphasising the intertwining of power and knowledge; and Luhmann who, from a systems theoretical perspective, sees society in terms of function systems (economy, politics, law, education, science, mass media, etc.), each constructing the world according to their own self-producing communicative networks (Habermas, 1987). The sociology of radical change was originally focused on class as the primary source of inequality in society but has, over time, come to recognise other forms of disadvantage, developing critiques of inequality based on gender, race and sexual orientation.

1.6 Science and the Scientific Method in the Spotlight

Two revolutionary developments in twentieth-century physics – general relativity and quantum mechanics – have led natural scientists themselves to set aside the Newtonian worldview. According to Rovelli (2016), Newton's *Principia* describes a mechanical universe in which objects travel eternally on precise trajectories, determined by gravity, in geometrically immutable space. In Einstein's theory of general relativity, space-time and matter/energy are inextricably linked. He offered an account of the universe as an organic entity, more interconnected and dynamic than anything previously envisaged. The other revolutionary development, quantum mechanics, describes a world completely at odds with Newton's deterministic vision. Electrons jump from one interaction to another, and it is impossible to be certain when they will reappear. Indeed, they only seem to come into existence when interacting with other systems, for example, measuring instruments. Furthermore, the interactions do not have to be local. Particles are 'entangled' such that a change in one can impact another even across vast distances. Physics, in uncovering greater complexity in the universe, has itself had to embrace a more systemic perspective – highlighting interactions, indeterminacy, relationships and emergence (Rovelli and Jackson, 2022).

These revolutionary developments inevitably provoked reflection on the nature of the scientific method itself. It was obvious that Einstein had not come up with general relativity by following its prescriptions. Rather, the theory seemed to emerge almost fully formed, as a brand-new way of seeing the world, from some incredibly imaginative thought experiments. Popper concluded that the progress of science depends on bold conjectures rather than repeated observations. The latter can have little impact because they must be interpreted in terms of the existing theory (Chalmers, 1982). In a word, they are theory-dependent. Kuhn (1970) developed Popper's argument further in his highly influential account of the structure of Scientific Revolutions. He argued that scientists, during periods of 'normal' science, embrace a single paradigm, exploring its possibilities and finding it hard to see contradictory evidence. As serious anomalies accumulate, however, a period of uncertainty arises. Even then, it requires the appearance of a rival paradigm before scientists begin to abandon their existing theories and view the world in a different way. Science enters a 'revolutionary' phase as the scientific community shifts its thinking. The new paradigm is elevated to dominant status and becomes the basis for a new period of normal science.

The traditional account of science sees progress as cumulative. Kuhn's work suggests something very different. It also points to the impact of external factors. Because, for Kuhn, paradigms are 'incommensurable', each revealing reality to us in a different way, there are no logical grounds for choosing one over another. Fully embracing a new paradigm is akin to a religious conversion. Shifts in paradigm, therefore, do not happen for purely scientific reasons. A scientist may sense that working in a fresh paradigm will enable career advancement. A scientific community might come to believe that embracing the new will bring greater political influence and economic rewards.

The argument that scientific progress is a messy business is confirmed by historical studies showing the influence of other modes of thinking, including the occult, on its development. Alchemy was particularly important. This arcane practice encouraged the search for the philosophers' stone, promoted variously as capable of turning base metal into gold, prolonging life and bringing enlightenment. Newton left behind over a million words on the subject. White's biography painted him as 'the last sorcerer' and came to the unequivocal conclusion that

> ... based upon the evidence available ... the influence of Newton's researches in alchemy was the key to his world-changing discoveries in science. His alchemical work and his science were inextricably linked. (White, 1997, p. 5)

Strathern, charting the history of chemistry, quoted the nineteenth-century German chemist Justus Liebig on the significant role played by alchemy in the search for the elements:

> The finest imagination in the world could not have conceived of a better idea than the philosophers' stone to inspire the minds and faculties of men. Without it, chemistry would not be what it is today. In order to discover that no such thing as the philosophers' stone existed, it was necessary to ransack and analyse every substance known on earth. And in precisely this lay its miraculous influence. (quoted in Strathern, 2014, p. 59)

Today, for all the reasons enumerated, there is much less faith in the scientific method as the sole means of securing knowledge and hardly anyone claims that science is close to understanding everything, even in its favoured domains of physics, cosmology and chemistry. A more modest view of the capability of science prevails. The highly respected physicist, Carlo Rovelli, summarised this when he wrote:

> Science is not a Depository of Truth, it is based on the awareness that *there are no* Depositories of Truth. The best way to learn is to interact with the world while seeking to understand it, readjusting our mental schemes to what we encounter and find ... Every vision is partial. There is no way of

> seeing reality that is not dependent on a perspective – no point of view that is absolute and universal. (Rovelli, 2021, pp. 117 and 166)

There is a further set of issues putting the scientific method under the spotlight. Science and its associated technologies have yielded many undoubted benefits, but its hegemony has also brought unintended consequences. Providing one succinct example, Schumacher wrote:

> Modern man does not experience himself as a part of nature but as an outside force destined to dominate and conquer it. He even talks of a battle with nature, forgetting that if he won the battle, he would find himself on the losing side. (Schumacher, 1973, p. 3)

The scientific, industrial and information revolutions have arguably generated most of the intractable issues that we face today – climate change, environmental and species degradation, pollution, overexploitation of natural resources, food and water shortages, inequality, exclusion, mass migration, the dangers of global recession, the possibility of pandemics, nuclear proliferation, terrorism and the threat posed by artificial intelligence. Furthermore, the scientific method struggles to deal with the problems it has created because they are 'wicked problems' involving many interconnectivities and stakeholders. Increasingly, we are confronted by 'black swan' events (Taleb, 2007) that endanger our well-being and possibly our long-term survival as a species.

1.7 Conclusion

Foster's (2021) attempt to delve into the Upper Palaeolithic mind led him to argue that over-reliance on Descartes's and Newton's thinking has led us to create a world wholly unsuitable to the full expression of our human nature, one where we are cut off from 'constant ecstatic contact with earth, heaven, trees and gods'. He is not alone. Gregg contemplated the benefits and costs of the extensive use of human reason in his book *If Nietzsche Were a Narwhal*:

> Is our exceptional ability to understand and manipulate the physical properties of the universe something that is *inherently* good? … It is the greatest of paradoxes that we should have an exceptional mind that seems hell-bent on destroying itself. (Gregg, 2023, pp. 193 and 206; italics in the original)

McGilchrist (see Spencer, 2022) argued that humans can engage with the world in different ways depending on whether they emphasise left-brain or right-brain thinking. The former prioritises order, control, rationality and precision, picks things apart and tends to prefer the map to the territory. The latter prioritises change, freedom, empathy and reflection, sees the whole and values experience. Over recent centuries, the emissary has become the master and has remade the world 'in the mechanistic image favoured by the left hemisphere'.

Of course, Foster does not advocate a return to an Upper Palaeolithic existence, Gregg the abandonment of human reason, or McGilchrist left-brain lobotomies. Science, in its place, continues to be essential. Rather, the problem is that the Enlightenment had two sides, and we have prioritised one at the expense of the other (Jacob, 2006; Gare, 2008, 2023; Israel, 2010). The first, 'moderate' side promoted the scientific method and rested on the certainty provided by Descartes's philosophy and Newton's confirmation that there was order in the natural world. It sought increased control over nature and, encouraged by the political philosophies of Hobbes and Locke, over people. This side was conservative and emphasised the gradual improvement of existing institutions. The second side, the 'Radical Enlightenment', had its origins in the humanism, scepticism, freedom, relative tolerance and rediscovery of democracy that epitomised the Renaissance. This was the world in which Giordano Bruno promoted 'nature enthusiasm' and republicanism and could contemplate the possibility of life on other worlds. It allowed Montaigne and Shakespeare to flourish.

The Radical Enlightenment was born during the Renaissance, but its time was not long. Montaigne, in his *Essais* (see Bakewell, 2010), ruminated on whether, in some respects, the minds of other animals made them superior to humans. Fifty years later, Descartes was certain that animals were machines and that the screams emanating from the live dogs he dissected were the equivalent of metal screeching. Toulmin (1990) saw the pursuit and embrace of certainty as emanating from the horrors of the Thirty Years' War when apparently irreconcilable religious differences tore the European continent apart. The moderate Enlightenment triumphed.

Although pushed into the background, the Radical Enlightenment was never fully suppressed. For Israel (2010), it was a 'revolution of the mind' that resurfaced in the philosophy of Spinoza (a systems thinker *par excellence*) and, as taken forward by d'Holbach, Diderot, Helvetius and others, assumed a broader social and political significance, promoting greater democracy, challenging existing institutions, favouring greater equality and opposing colonialism. For Gare (2008, 2023), the standard-bearers of the Radical Enlightenment were Kant, Hegel and Schelling. Their emphasis was on the freedom of people to exercise imagination and create their own destinies in societies which they themselves could build. For Schelling, humans were intimately linked with nature, enabling it to be conscious of itself. The inheritors of this mode of thinking, Gare argued, were process philosophers such as the pragmatists and Whitehead. It is the project of the Radical Enlightenment that Habermas wanted to see reinvigorated. Science will continue to play a significant role in creating a better world. However, without ST it becomes blind and can potentially lead the human species to destruction. Science does not define reality. As Cassirer argued, it should be seen as just one symbolic form among several 'autonomous, irreducible modes of world formation' (Skidelsky, 2008). It needs to be complemented with systems approaches that give equal weight to interrelationships, organismic thinking, the imagination, fair and equal societies, and our natural environment.

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