



Archetypes of Knowledge

The Relevance of Jung's Psychology of Scientific Discovery for Understanding Contemporary Technoscience

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Abstract

This paper substantiates why Jung's psychology is still highly relevant for understanding science today. I explore how his methods and insights allow us to come to terms with the phenomenon of scientific discovery. After outlining core Jungian concepts and insights concerning science, I will focus on the relationship between alchemy and modern science. Also, I will highlight Jung's understanding of scientific research as a practice of the self, directed at individuation (the integration of various aspects of the self into a coherent whole). Finally, I discuss the role of archetypes in the context of discovery of modern science. Whereas archetypal ideas may function as sources of insight and inspiration, the task for researchers is to come to terms with them, instead of being overwhelmed by them. Besides case studies discussed by Jung himself, I also present more recent examples, taken from molecular life sciences research and climate change research.

Keywords

Carl Gustav Jung – Jungian psychology of science – Jung and science – psychology of science – climate change – Anthropocene – archetypes – collective unconscious – individuation – tertium non datur

Carl Gustav Jung began his psychiatric career at the famous Burghölzli mental hospital near Zürich, where he conducted reaction time experiments to explore unconscious complexes. After his intense collaboration and subsequent break with Freud, he experienced a severe mental crisis, but recovered and continued his astonishing intellectual journey through the history of human inquiry, from

pre-historic times up to the present, focussing on alchemy as a practice of the self. This paper substantiates why Jung's psychology remains highly relevant for understanding contemporary technoscience. I will notably explore how his methods and insights allow us to come to terms with the phenomenon of scientific discovery, focussing on three issues: (a) the relationship between alchemy and science (between archetypal projections and reveries of alchemists and the emphatically rational ego of contemporary research); (b) Jung's understanding of scientific research as a practice of the self, directed at individuation (i.e. the integration of various aspects of the self into a coherent whole); and (c) the decisive role of archetypes and the collective unconscious in the *context of discovery* of modern science. By way of introduction, however, I will first provide an outline of Jung's key insights and intellectual career, focussing on his relationship with science.

1 From Experimental Psychiatry to Alchemy: Jung's Intellectual Itinerary

Jung began his scientific career as an experimental researcher at Burghölzli hospital, where psychiatric patients participated as research subjects in association experiments, designed to map unconscious "complexes" (Jung 1905/1979). Words were presented and subjects were asked to give their immediate associations in response, while Jung measured the response time with a stop watch. The focus was on words that evoked a longer-than-average response time ("complex indicators"). Precision instruments and quantification were important ingredients of his research practice and Jung employed sophisticated devices such as a galvanometer and a *Fünftelsekundenuhr* (a one-fifth second time watch) to measure reaction times as accurately as possible (Jung 1905/1979). His experimental technique and up-to-date equipment is represented quite convincingly in the movie *A Dangerous Method*, released in 2011 and directed by David Cronenberg, casting Michael Fassbender as Jung.

During his collaboration with Freud, Jung developed some core insights, such as his distinction between two forms of thinking, namely imaginative and rational thinking (Jung 1911/1968), one that actually builds on a long tradition. Aristotle, for instance, already distinguishes thinking with the help of mental images (*φαντάσματα*) from rational thinking with the help of words and concepts (*γράμματα*). Whereas imaginative thinking is non-directed, spontaneous and free-floating, rational thinking operates with the help of linguistic, logical and mathematical operators and is therefore more demanding and exhausting. Moreover, whereas imaginative thinking is the older form of thinking (reflect-

ing the spontaneous functioning of the human mind), rational thinking is a more recent acquisition. Important intellectual developments, ranging from the invention of reading and writing via scholasticism up to modern science, have contributed to its current dominance, but logical thinking has never completely replaced or erased its imaginative rival, so that the tension between both types of thinking continues to exist. This also informs Jung's view on science. Whereas science purports to be a rational endeavour, throughout his work Jung gives many telling examples of how primal images (archetypes) continue to play a decisive role, a formative and inspirational role on some occasions, a paralysing and disruptive one on others.

The first theme Jung developed after his breach with Freud was his theory of personality types, notably his distinction between introverts and extraverts (Jung 1921/1971). While *introverts* are solitary, focussed and withdrawn (primarily interested in their inner self), extraverts are communicative, energetic, productive and outgoing (expecting gratification from external reality). Introverts are engrossed in their inner world of thoughts and feelings, extraverts are oriented towards the world of objects and people. Introverts are slow to act, distrustful, keeping their distance, as though objects were something dangerous, while extraverts have a more positive and inviting attitude towards external things. Unknown situations entice them. Jung (1972) elucidates the difference with the help of a story about two friends. When the extravert suggests to visit a castle, the introvert is reluctant to enter. Once inside, however, the extravert soon wants to leave, but the introvert discovers a library with rare manuscripts. His initial shyness vanishes completely, and he refuses to depart. He is fascinated, overpowered even, by the object: absorbed by it. The distinction became a core concept of twentieth-century psychology and the starting point for the Myers-Briggs personality test. The distinction is also relevant for science, where, say, Isaac Newton may count as an introvert (dedicated to solving tedious mathematical problems, e.g. the law of universal gravitation, the calculus), James Watson as an extravert (a vocal, visible scientist with a "passion" for objects: birds, bacteriophages, genes, DNA, etc.: Watson 2000).

Gradually, however, alchemy and archetypes became Jung's most pervasive research themes. Already as a psychiatrist, Jung became interested in correspondences between experiences of hospitalised patients and ancient religious or mythological motifs, giving rise to his core theorem: the collective unconscious, the archaic psychic realm of collective complexes ("archetypes"). This entails a different style of reading compared to classical (Freudian) psychoanalysis. While Freud and his followers approach documents from a psychopathological perspective (regarding authors or characters as pathological cases, so that literary artworks, for instance, become reports of a personal neurosis),

Jung approaches textual materials from a different angle, focussing on the core archetypal ideas at work in them, and this also applies to his analysis of scientific discourse. Jung uses his psychological magnifying glass to detect and explore sudden intrusions of collective unconscious material into scientific practices and publications.

One of his most famous examples is the case of Julius Robert Mayer, an introvert physician who, in 1841, on his way to the Dutch East Indies, was suddenly overwhelmed by what later came to be known as the first law of thermodynamics: the idea that energy can be neither created nor destroyed. Although he himself was convinced of the significance of this breakthrough, his publications proved difficult to read and met with much resistance. He was even committed to a psychiatric institution because of his persistent claim that he had made a highly important discovery which experts refused to acknowledge. For Jung (1916/1958), Mayer's case exemplifies how time-old archetypal ideas may suddenly resurge. On his journey to Batavia, Mayer became obsessed with what, in essence, was an intuitive, archetypal vision, Jung argues, namely the idea of "fire" as an elementary principle, forever transforming and recurring, but without ever being extinguished: the principle of life and change. For Jung, Mayer's vicissitudes were symptomatic of the resistance and suspicion of modern science against the resurgence of pre-modern, archetypal concepts. Rather than seeing Mayer as a neurotic, Jung argued that he drifted into psychopathology precisely *because* he was overwhelmed by the impact of an archetype, whose medium he had become: an idea which had found *him*, which had spoken out to him, rather than the other way around. His mental deterioration was not the cause, but the *effect* of a decisive, creative experience. He became the victim of an idea, to which everything was sacrificed. The challenge in such a case, Jung argues, is to *integrate* the archetypal insight into modern scientific thinking. To achieve this, however, the researcher should first of all become consciously aware of the power of the archetypal content and come to terms with it: a process which Jung refers to as individuation. In other words, the first law of thermodynamics is a *coniunctio oppositorum*, a "marriage" if you like, of modern scientific thinking and an archetypal insight, a disruptive collision at first, which eventually allows science to reach a higher level of comprehension. In other words, for Jung, research practices (from alchemy up to quantum physics) are practices of the self: exercises in self-formation or *individuation*. Instead of mastering his archetypal insight, Mayer was tragically carried away by his eureka-experience: the archetypal idea of an inexhaustible source of energy (fire) at work in nature, an overwhelming experience which destroyed his health and his career. A Jungian analysis might have proven helpful in his case.

A famous example of a scientist who profited from Jungian analysis was Nobel laureate Wolfgang Pauli, a quantum physicist, but also a prolific dreamer (Jung 1944/1968; Lindorff 1995; 2004). Pauli postulated the existence of the neutrino in 1930 and acted as Mephistopheles in the famous Copenhagen version of Goethe's *Faust*, written by Max Delbrück and performed in 1932 (Gamow 1966; Segre 2008). According to Jung, who analysed his dreams, mandalas (archetypes of wholeness) played a crucial role in Pauli's dreamlife to compensate for the disruptive impact of quantum physics on established worldviews. By analysing and visualising his dreams, a process of working-through, Pauli managed to visualise and master archetypal influences, thus maintaining his creativity as a physicist.

In academic circles, Jungian ideas often invoke suspicion, so that his work as a psychologist of science is still in need of rehabilitation (Zwart 2010; 2019). Jung's doubtful reputation is partly due to his interest in questionable topics such as telepathy and flying saucers (of which more will be said soon), but also to the anti-Jung campaign launched by Freud himself (1914/1946) and continued up to this day, framing him as a persona non grata. A Secret Committee of inner circle followers was founded by Freud after their break to ward off the Jungian threat. This negative verdict of Jung's work has obfuscated his significant contributions to understanding technoscience. Even Jacques Lacan, who was not at all a Secret Committee member and ran into conflict with the psychoanalytical establishment himself, tended to discard Jung's views as aberrations. Although unmistakably fascinated by Jung (whom he visited in 1954) he nonetheless stayed in line with the international psychoanalytical movement by formally abusing him, not coincidentally in a paper written in commemoration of Freud's most trusted aid, Ernest Jones. Lacan stages Jung as a "mountain gnostic" dwelling in a "Helvetian refuge" and propagating local "canton secrets" whose "local hereditary characteristics we would be wrong to neglect" (Lacan 1966, p. 700). Such anti-rural puns, meant to appeal to urban readers, miss the mark however, if only because Jung was a researcher of international prominence rather than an unworldly mountain hermit, whose oeuvre proves highly relevant for developing a psychological approach to technoscience.

A telling example of the Jungian approach to technoscience is his book on Unidentified Flying Objects (Jung 1959b). His purpose was not to answer the question (central to most UFO publications) whether flying saucers really exist (although Jung was sceptical about the issue). Rather, he wanted to find out why flying saucers consistently assume a particular (spherical) shape. What caused the worldwide UFO rumour? How to explain that even highly trained professionals (airline pilots, police officers, the military, etc.) continued to report

sightings, especially in the United States, “the land of science fiction” (Jung 1959b, p. 1). Also, he wanted to understand why these enigmatic objects moved like airborne insects, floating smoothly through the air and suddenly pausing, as if these visitors from outer space were insensitive to gravitation. And why did Orson Welles’ broadcasting of *The War of the Worlds* in 1938 (about Martians invading New York) cause such a mass panic? Apparently, humankind *wanted* these cosmic intruders to exist, but why? When Jung himself (after an interview in a popular weekly) was misquoted as being a “saucer believer” (p. ix), this instance of fake news spread like wildfire while nobody wanted to hear his rectification: any news confirming the existence of UFOs was welcome, scepticism was undesirable.

In his analysis, Jung connects UFOs with scientific developments such as satellite technology, space travel and atomic warfare. Satellites were a novelty in the 1950s and public audiences were both fascinated and concerned by the expansion of human technology into the stratosphere. According to saucer believers, the possibility of atomic warfare caused disquiet on distant planets, whose inhabitants were surveying human airports and industrial installations to monitor the irrational behaviour of earthlings (p. 4). Also, humanity was looking towards the sky to dispose itself of its surplus (resulting from overproduction and overpopulation): invading other planets as an alternative for the disasters of global warfare. If we are able to travel to the Moon, or even to other planets, the logical implication is that the same may happen to us: that we ourselves may be invaded as well. Furthermore, the world seemed on the verge of disaster, being split into two incompatible halves (capitalism and communism). Against this backdrop, humanity was hoping for signs from heaven: an intervention from above, a *Deus ex machina* (p. 9). All this concurs with the catastrophe archetype: the idea of an emerging cataclysm and the dawn of a new era. Jung considers UFO sightings as symptomatic for the global psychic distress invoked by the awareness that a “platonic month” (p. xi) is coming to an end, that we are entering a new epoch (the Age of Aquarius). Flying saucers reflect the conviction that, in times of global transition, only interventions from outer space can save us. Flying saucers unleash a “visionary rumour”, Jung argues, because they function as projections of unconscious ideas on an aerial screen. Thus, UFO sightings provide an opportunity for studying how myths are formed *de novo* (p. 14).

2 *Obscurum per obscurius: Alchemy and Science*

Jung has written extensively on alchemy. One of the phrases he uses to distinguish alchemy (the *opus alchymicum*: 1968, p. 33, p. 37, p. 266) from modern science is: *obscurum per obscurius* (“the obscure by the more obscure”), an adage which summarises alchemy’s basic method of explanation (1968, p. 35, p. 227, p. 244; cf. Zwart 2019). Modern science and the spirit of Enlightenment aim to reduce the unknown to the known. What seems complex can be understood by reducing it to something simple and elementary. This is also the aim of quantification. Nothing seems as simple as an integer (1 + 1 + 1 + 1 + 1). Via measurements and calculations, complex processes become predictable. ^{replace 4 periods by 3?}

Alchemy, however, works the other way around. Obscure processes are explained by postulating enigmatic principles or causes that seem even more obscure. Newton’s law of gravitation is of interest here, being a mixture (a *coniunctio oppositorum*, alchemically speaking) of modern science and alchemy. Newton explains the movements of bodies (both in space and on Earth) with the help of a basic formula, consisting of four letters from the alphabet, a highlight for the modern scientific aspiration to capture nature in equations ($F = G m_1 m_2 / r^2$). At the same time, Newton (a modern scientist, but also an alchemist) appeals to an obscure, unintelligible factor: the force of gravitation, which works from a distance (*actio in distans*). Whereas Newton’s formula seems perfectly modern, his explanation of gravity with the help of an obscure, hypothetical force (the gravitational constant: *G*) aligns with the spirit of alchemy (*obscurum per obscurius*) rather than with the spirit of Enlightenment.

Jung extensively studied the transition between alchemy and modern science, starting from the conviction that alchemy was actually a form of transference. Practitioners projected their psychic concerns and desires on the interactions between chemical substances. The obscure forces to which alchemists reverted, where actually unconscious complexes, Jung argues. For instance, the production of a chemical compound in vitro was referred to by alchemists as a “chemical wedding”, indicating that erotic desire (love as a universal force of attraction) was guiding the behaviour of chemical substances. Much like the ancient Greek philosopher Empedocles, alchemists postulated the existence of a universal force (love, $\phi\lambda\iota\alpha$) to explain chemical results. Another example of this association between chemistry and psychology is Goethe’s novel *Wahlverwandtschaften* (“elective affinities”), whose title indicates that both human individuals and chemical substances have an intuitive preference to form bonds with certain individuals (or substances) rather than with others.

Whereas modern science explains biology on the basis of chemistry, alchemists explain chemical reactions on the basis of biology or even psychology (erotic drive). Thus, the obscure (a chemical reaction) was explained with the help of something which was even more obscure ($\phi\iota\lambda\iota\alpha$ as a universal force of nature). And whereas alchemy involved projecting psychic complexes onto the exterior world, modern science insists on “de-psychologising” external reality (1921/1971, p. 10), transforming it into quantifiable objectivity.

Alchemy’s method of explanation (*obscurum per obscurius*) was incompatible with Enlightenment (1968, p. 227),—although a certain level of obscurity is noticeable in every modern reach field, even in Newtonian physics, as we have seen—, so that in modern times alchemy split up in two branches, Jung argues, namely hermetic philosophy (the conceptual branch, represented by authors such as Böhme, Schelling and Hegel) and natural science (modern chemistry: the experimental branch). Notably during important breakthroughs (moments of transition), however, archetypal ideas may suddenly resurge. Modern science and unconscious archetypes are not completely barred from one another. The compartmentalisation or “epistemological rupture” (Bachelard 1938/1970)¹ between modern science and archetypal imagination remains a fluid one (Kirkham 2009). Rather than being barred from archetypal content, the mindset of the alchemist continues to exist beneath the surface of the modern technoscientific engineer (Bachelard 1937/1949, p. 14).

A famous example is the case of Friedrich August Kekulé (1829–1896) of course, who discovered that carbon is tetravalent, so that four electrons are available in the outermost electron shell for bonding. In the case of methane (CH_4) for instance, the tetravalent carbon atom forms a chemical bonding with four hydrogen atoms, resulting in a cross-shaped structure. This insight provides the basic conceptual model to explain more complex (obscure) organic substances. As a modern scientist, Kekulé begins with a relatively simple structure and refrains from developing speculative theories about the forces at work within this elementary model (a task that was relegated to twentieth-century quantum science). The structure of benzene (C_6H_6), however, proved a major challenge. Kekulé discovered the ring shape of the benzene molecule when, during a reverie, he saw the vision of a snake seizing its own tail, an alchemical symbol known as Ouroboros.² The bonding becomes a chemical

1 Although his references to Jung’s work are often fairly general or even incorrect (Huskinson 2013), Gaston Bachelard was evidently inspired by Jung so that many scholars of science, notably in the francophone literature, encounter Jungian concepts via Bachelard. This article is meant as a summons to science scholar to read or reread Jung directly.

2 “I dozed off. Atoms danced before my eyes, contorting and turning like snakes. One of them

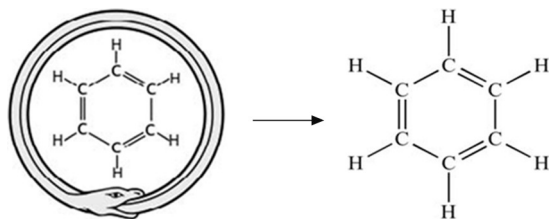


FIGURE 1 ■add caption?

wedding, mimicking a circular structure. As Jung phrases it, the alchemical idea finally reached its scientific goal (1916/1958, p. 179).

The archetypal vision played a maieutic role. An obscure symbol helped to solve a scientific problem, in other words: something obscure (the structure of benzene) was elucidated with the help of something even more obscure (Ouroboros as a symbol of nature as a whole, indicating how everything holds together).

In the case of such an impasse, we are facing an apparently insurmountable obstacle, Jung argues, and there appears to be no way out, no middle way between the either/or of empirical evidence and logical argumentation (as the only two alternatives that seem open to conscious scientific rationality). Indeed: *tertium non datur*, a third option is not given (Jung 1953/1966, p. 76). A solution only becomes possible if we are willing to draw back, which is a regression, strictly speaking, into the interior world of primal images. In Kekulé's case, the third was not given, in the sense of: ready at hand. Rather than being given, it emerged as an (unexpected) *gift*, coming from the unconscious, as the researcher stepped back and descended into the realm of archetypal ideas. When faced with an unsolvable riddle, the human psyche may open-up a third, transcendent option that did not seem to exist before. A *symbol* arises, indicating how the apparently incompatible components of the puzzle can be combined into a convincing whole (1921/1971, p. 105).

The symbol was only a temporary scaffold, however. As soon as the discovery was made, modern science could emancipate again, could shed it off, resulting in a perfectly transparent structure (the version on the right). Kekulé's research profited from the influx of alchemical content, without being trapped or overwhelmed by it. Whilst his reverie temporarily lowered his resistance, eventually he was able to master the intrusion of an unconscious idea. In

took hold of its own tail and whirled derisively before my eyes. I awoke as though struck by lightning (and) spent the rest of the night working out the consequences."

other words, he managed to reconcile the rational and the unconscious on a higher level of comprehension, a process which Jung refers to as individualisation.

This is also relevant for addressing Lacan's criticism of Jung, already briefly discussed above. Lacan's basic concern is that Jung's ideas on symbolism, although congenial perhaps with the views Freud himself elaborated in *The Interpretation of Dreams*, opened the gate to mysticism, in the sense that archetypes such as snakes biting their own tale (i.e. Ouroboros) purport to reconnect the modern psyche with "ancient knowledge" and the concept of a "world-soul" (Lacan 1966, p. 702): obscure ideas from which Enlightenment allegedly emancipated us. In response to Lacan's critique it should be pointed out, however, that Ouroboros basically functions a template, a scaffold, a structure if you will, resurging in nineteenth-century stereochemistry in a way comparable to how, more recently, the archetypal structure of the double helix resurged in modern molecular biology. Indeed, whereas initially modern science seems to negate and annihilate "ancient wisdom", Kekulé's reverie demonstrates that mutual exposure can be an inspirational event, insofar as this dangerous liaison is actively worked-through, so as to reach a higher level of comprehension, and this is exactly what Kekulé managed to achieve.

2.1 *Scientific Research and the Strive for Individuation*

Let me further illustrate the individuation process with the help of a more recent case history: the fascinating case of Maurice Wilkins (1916–2004), a biophysicist who was awarded the Nobel Prize in 1962 as co-discoverer of the structure of DNA (in 1953), together with James Watson and Francis Crick. While conducting X-ray diffraction studies at King's College London, Wilkins was in psychotherapy for many years. His main symptoms were occasional depressions (giving rise to suicidal thoughts) and persistent difficulties with women. Initially, he opted for Freudian analysis, but this soon ended in failure:

I had long been interested in Freud and ... it seemed that Freudian analysis might be useful to me. After a year of daily 8 a.m. visits to a Freudian woman therapist, arranged for me by the official Freudian organisation, I was thrown out because I reported thinking (I thought in accordance to the Freudian rules) 'that women will never get anything out of me' ... After the Freudian debacle, I did try psychoanalysis again ... Having learnt about the unconscious from Freud, I was now interested in Jung's ideas about thinking and feeling, and I found a very helpful analyst whom I was to visit for many years ...

WILKINS 2003/2005, pp. 112–113

As a result of the Jungian approach, which fitted him much better, he developed a strong interest in the interconnections between science and art. Also, his therapy encouraged him to revert to active imagination as a psychic exercise. On one of his self-made drawings, published in his memoirs, we see him at work late at night in his lab, while strange ideas, shaped like grotesque animals, float about: an oneiric self-portrayal in Jungian style. He took art classes, finding painting and drawing satisfying ways to relax after a day in the lab (p. 111). Art functioned as a complementary activity helping him to suture his chronically tormented and inhibited ego, so that, eventually, he significantly contributed to one of the most beautiful examples of a *coniunctio oppositorum* of the rational and the imaginative, the conscious and the unconscious in twentieth century science: the discovery that DNA is shaped like a double helix, an ancient archetypal and artistic form, the spiral staircase of life (Zwart 2015).

X-ray diffraction studies of crystallised DNA enabled researchers at King's College to explore the inner, noumenal structure of DNA as the essence of life. The most famous of all X-ray diffraction images was *Photograph 51* no doubt, taken by Raymond Gosling in 1952 under the supervision of Rosalind Franklin, the "dark lady" of DNA (Maddox 2002). Photograph 51 depicts DNA during its foetal stage of discovery (Zwart 2013). Gosling handed the picture over to Maurice Wilkins, who showed it (without Franklin's knowledge) to James Watson (in a corridor at King's College, London) as a decisive piece of evidence for the helical structure of DNA. At that moment, DNA research was in a deadlock. Was it a double or a triple helix, or something else? Photograph 51 allowed Watson to glance through the keyhole of Franklin's laboratory as it were. It guided the way out of what seemed a dead-end. In the case of an impasse, as we have seen, the solution is a kind of gift (or, in this case, as critics have argued: a theft) in the form of a symbol: the double helix as the modern technoscientific version of a squared circle or circular square, a symbol of holism, of integration and the Self (Jung 1921/1971, p. 460). The story of photograph 51 became the primal scene of molecular biology research, a crucial step on the pathway that led to the discovery of the helical structure of DNA (Zwart 2013; 2015; 2018).

As indicated, in 1952 DNA research had stranded. The usual rational scientific approaches (induction and deduction, in this case: high-tech crystallography and advanced mathematical analysis) refused to yield the desired results. A third option was not given so it seemed (*tertium non datur*). Yet, Watson and Crick did try an alternative route, namely model building (Zwart 2013). Compared to the sophisticated approaches employed at King's, their model-building tools literally "resembled the toys of preschool children", as Watson phrases it (1968/2001, p. 50) and therefore looked quite unimpressive

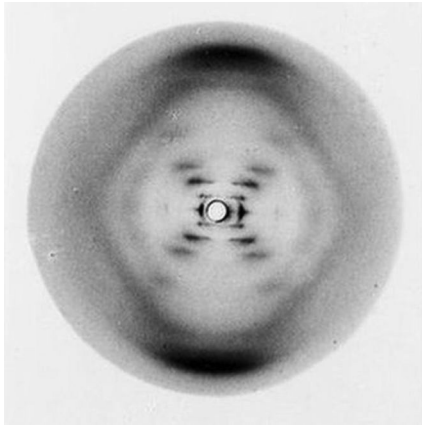


FIGURE 2 Photograph 51

and informal. Disregard for the “tinker-toy-like models” on which their work relied (Watson 1968/2001, p. 69) certainly played a role in their tense relationship with Rosalind Franklin, their rival from King’s College London, who preferred her high-tech crystallographic approach to this playing with toys like mere boys (p. 69). As Gratzner (2000) phrased it, “[many] were shocked by the seeming amateurishness of Watson and Crick’s model-building efforts” (p. xv). Indeed, for Watson and Crick, science “had many elements of playfulness” (McElheny 2004, p. 31). The helical model showed a luscious way out of the impasse.

From a Jungian perspective, however, this should not come as a surprise. In the context of his theory of types, Jung (1921/1971, pp. 105–106) explains how Friedrich Schiller already opted for a third (symbol-creating) function, besides sensation and thinking, namely the playing drive (*Spieltrieb*). In the case of Watson and Crick, modelbuilding became precisely this playful third option between induction (crystallography) and deduction (advanced mathematics), a creative third mode of human activity, resulting in a scientific breakthrough, an epistemological gift: the double helix. Thus, from a Jungian perspective, scientific research is a practice of the self, directed at individuation. Ideally, a union of opposites is achieved, a synthesis of the rational and the imaginative, assembling the various (apparently contradictory) components on a higher level of comprehension, for which the double helix is a perfect, apollonian symbol of numinous quality (1951/1991, p. 180). This symbol performed what Jung refers to as the “transcendent function” (Miller 2004), solving a seemingly unsolvable problem while compensating for the disruptive, fragmentising tendencies of technoscience.

3 Archetypes of Science

Although Jung began his career as a scientist, as we have seen, he became increasingly infected, if you will, by the logic of alchemy, so that an alchemical signature is present in Jung's own method of explanation. The adage *obscurum per obscurius*, one could argue, applies to the Jungian approach as well. The fascination for flying saucers and other psychic pandemics is explained with the help of archetypes, such as the catastrophe archetype. According to Jung, archetypes can be discerned in the myths of ancient cultures, but also in the dreams, drawings and paintings produced by modern patients. They function like *a priori* templates: hard-wired components of our cognitive system, but also basic components of our cultural heritage, our socio-cultural environment. The collective unconscious (the aggregate of archetypes) is both a psychic and a cultural concept, both *nature* and *nurture*. Archetypes are congenital mental structures which are activated by experience and culture. Some archetypes will now be discussed in more detail, starting with the Mother Earth archetype, the aeon (or catastrophe) archetype and the monster archetype.

The Mother Earth archetype conveys the idea of planet Earth as an immense living ("maternal") body in which matter is slowly moving and circulating: a superorganism desiring to bring forth and foster life, an idea which has fallen into disrepute. Modern science disenchants nature and promotes the view that Earth as such is abiotic and inorganic, albeit covered with a film of life: the biosphere. Yet, the Mother Earth idea occasionally resurges, in literature, but also in science. Jules Verne revived the Mother Earth archetype in several of his novels, including *Voyage to the Centre of the Earth* (1864), in which the Earth's centre is a gigantic uterus inside an enormous female body in whose life-preserving liquids Jurassic life forms (that became extinct long ago on the surface of the Earth) are kept perpetually alive (as giant foetuses). Guided by clues provided by an alchemist, the protagonists reach this bizarre site through capillary veins in the crust of the Earth.

This same idea can be encountered in contemporary technoscience, however, where researchers discover extinct and bizarre life forms that managed to survive in dark and isolated places, in deep lakes covered by sheets of ice, or in inaccessible caves (Hazen 2005). A similar idea can be discerned in the work of biologist Lynn Margulis who describes how life on Earth is nourished by (and dependent upon) the presence of a life-sustaining "worldwide superorganism", a microbial *web of life* (Margulis & Sagan, 1986, p. 17). Margulis propounds the idea that Earth is basically a microbial planet while the microbial biosphere is a "communicating and cooperating worldwide superorganism" (p. 17). This same idea was elaborated and updated by Stephan Harding (2006), an ardent

follower of James Lovelock (1979), depicting planet Earth as a sentient, living, suffering, nurturing and nourishing body with a personality of its own. Nature as a whole is presented as a super-being possessing organs and metabolism, a great body, a living being (p. 56). Lovelock conceived his seminal idea while working for NASA on a programme designed to detect life on Mars, realising that life on other planets can be more efficiently detected by considering these planets as a whole. He developed an *Electron Capture Detector* (ECD) for spotting Earth-like organisms, but instead of discovering life on Mars he provided the data on which Rachel Carson based her book *Silent Spring* (1962), showing how DDT pervades the biosphere as a chemical pandemic, poisoning Earth (the catastrophe archetype). Life has radically altered the Earth's atmosphere, turning it into a self-regulating system, maintaining an optimal oxygen level and enveloping the world in a protective ozone shell, thus creating and maintaining the conditions that allow life to flourish. Lovelock experienced his insight as a sudden revelation that abruptly and irrevocably changed his life. Another version is the idea that emerging viral infections indicate that Nature is striking back, suggesting that *we* are the invaders. Mother Earth is mounting an immune response against the human species (Wald 2008). Via viral parasites, its immune system is fighting us off, so that emerging infections are a response to our venturing into primordial places which should have been left undisturbed (the Anthropocene version of the oedipal complex: trespassing punished with a plague).

A final archetypal technoscientific scene is the artificial *in vitro* uterus designed to mimic (as a womb of glass) the primordial "soup" from which life emerged. In 1953, the year of the double helix, Stanley Miller and Harold Urey designed a glass enclosure containing a gas mixture to mimic the atmosphere of prebiotic Earth and exposing it to electric discharges. Soon, a significant part of the methane carbon had converted into amino acids and other biological constituents (De Duve 2002, Hazen 2005): the re-enactment of the primal scene of life in a laboratory setting. The Mother Earth archetype provides the imaginative scaffold. If the components are seen as matter, the archetype is the εἶδος, the form, the idea. What was explicitly addressed in alchemy became latent and dormant in modern science, but under certain circumstances time-old ideas can be reactivated.

The Mother Earth archetype not only conveys a basic image, but also a scenario: we are facing a worldwide ecological crisis, planet Earth has fallen ill: mass extinction as a scenario bridging Mother Earth with the catastrophe archetype, the idea that we are heading for disaster and that we ourselves are the primary causal factor responsible for this (Zwart 2005). Having pervasively and irreversibly changed the conditions for life on Earth, we have entered a

new geological era, the Anthropocene (Crutzen 2002). Similar cataclysm scenarios can be encountered in religious documents, from *Genesis* and the *Book of Revelation* up to millenarian cults (Zwart 2010). In the aftermath of the event, a dramatic and all-encompassing change of life-styles and basic attitudes will occur (Cf. Singer 2002), giving rise to a new era. Whereas the previous epoch (*Pisces*, symbolised by two fishes) was an era of conflict between two incompatible halves (Jung 1951/1991), the dawning era (*Aquarius*) will reflect restored unity (the unification of West and East, technology and nature, science and faith, iconoclastic science and imaginative art, etc.). Geology informs us that previous deluge-like events have been recorded in petrified archives. From a geological perspective, rocks are eloquent and stones can speak. Every layer is a memorial of lost worlds, every stone a Rosetta Stone. The world's crust is a library containing the annals of past catastrophes, of lost worlds inhabited by monsters.

The monster archetype appears in various shapes and formats, ranging from dinosaurs (macro-monsters of the Jurassic past) via human-like monsters (Frankenstein, Dracula) down to (viral or genetically modified) micro-monsters. Combining the monster archetype with the catastrophe archetype gives rise to the prospect of a man-made pandemic, an uncontrollable swarm of invisible entities, impossible to contain. Monsters are *δεινός*: terrible and threatening. In political science, the monster archetype emerges in the unsettling concept of *the masses*, envisioned by Le Bon (1919) and others (Freud 1921/1940). Monsters invoke *fascination* as well, and mass movements may be associated with the idea of a revolutionary cataclysm, cleansing the world, making a new political landscape possible. The “revolt of the masses” incites a particular type of concern: mass phobia, the anxiety caused by the urban human mob, articulated by bourgeois authors such as Mill, Nietzsche, Kierkegaard and Santayana. In the democratic era of urbanised life, the intellectual elite will be outnumbered by a prejudiced, backward majority, acting as an amorphous, violent, irrational crowd, difficult to manage, threatening human culture like a dangerous flood, assuming a machine-like appearance: a fascinating prospect for some, an unsettling idea for others.

According to Jung, to prevent ourselves from succumbing to the power of the archetypes, we should become aware of them, making unconscious mechanisms visible. While modern science disenchants the world with the help of precision equipment, replacing fascinating images and worldviews with formulas, symbols and equations, it nonetheless continues to stir our basic archetypal schemata.

4 The Mandala and the Prophet

A *mandala*, Sanskrit for (sacred) circle, is a spherical-quadratic diagram, a pattern of geometric shapes contained within a circle or square (or “squared circle”), concentrically arranged and radiating from a centre. According to Jung, it is an archetypal symbol for restored unity or wholeness (1968, p. 27; 1959a, p. 356; Zwart 2018). It is a harmonious, symmetric image, gradually constructed, guided by active imagination (1968, p. 96; 1959, p. 356), allegedly containing everything and revealing how everything is related (1959a, p. 357). It may be the ground-plan for a building (garden, temple, monastery, city), such as the Pantheon in Rome: a spherical-quadratic building that contains everything (everything spiritual, for *pan-theon* means “all the gods”).

Mandalas are often used as visual aids in contemplative and meditative exercises (Jung 1959a, p. 356), but may also function as roadmaps for processes of reconciliation and individuation. By realising wholeness, mandalas compensate for the contradictions, conflicts and disorderliness of actual reality (Jung 1968, p. 27; 1959a, p. 388). They enable the transition from disorientation and confusion to order, balance and homeostasis (Jung 1959a, p. 360). The centre has special symbolic relevance and may contain a symbol, a sacred text or a healing substance (*φάρμακον*). A mandala is a *coniunctio oppositorum* (a “union of opposites”) as Jung calls it, for instance: light and darkness, circle and square, the rational and the spiritual, the symbolic and the imaginary. It is a symmetrical arrangement of seemingly disordered, contradictory and irreconcilable elements (1959a, p. 388). As the archetype of cosmic wholeness, it may reflect the shape of an eye or egg. A mandala represents integration as the map or program for a long and difficult journey towards wholeness or individuation, with each layer representing part of it. Although mandalas are prevalent in specific spiritual practices (e.g. Tibetan Buddhism) they can be encountered in all cultural traditions and historical periods.

As to the connection between mandalas and modern science, Jung first of all used mandalas to understand dreams, such as those of Wolfgang Pauli, but there are more mandalas showing up in modern science. One fascinating example is photograph 51 already discussed in the previous section: a helical structure seen from above, conveying the archetypal structure of a mandala, which is no coincidence, for it is a spectrographic rendering of the essence of life, symbolising the commencement (*Anfang*) of a long and complicated journey towards the molecular understanding of life. From a Jungian perspective, the emergence of mandalas in contemporary scientific discourse reflects a holistic turn in contemporary technoscience (Zwart 2018). Whereas in the past the focus was on analysis, on dismantling and breaking down living entities

into basic molecular components, time has now come to put Humpty-Dumpty together again, to develop a systemic holistic perspective, focussing on the living entity as a whole to explore how all these partial objects fit and work together.

A final archetype is referred to by Jung as the archetype of the prophet (Master, wise man, medicine-man), descending from the mountain cave where, after extended spiritual and ascetic exercises, he experienced his moment of enlightenment. A telling case study is Nietzsche's *Thus Spoke Zarathustra*. Nietzsche's personality was overwhelmed by his super-ego, a process for which the hieratic language of his prose is symptomatic (Jung 1959a, p. 39). Succumbing to the archetype (instead of actively coming to terms with it), his project (after a fascinating and promising beginning) dramatically miscarries and derails. Authors should develop a dialectical dialogue with their archetypes, Jung (1998) and Bachelard (1960) argue, but Nietzsche reverts to the position of a medium, possessed by the voice of the Other, carried away by it, resulting in monotony. This is why Nietzsche envied Wagner, Jung argues, and (towards the end of his life) passed such an unfair judgement on him: Wagner succeeded where Nietzsche failed, for his music is an affirmative interaction with the archetypes, a process of working through (Jung 1972, p. 32). While Wagner reached unprecedented depths and became astonishingly productive, Nietzsche's neurotic heroism ended in a cramp (p. 33; Zwart 2012).

In contemporary technoscience, the archetype of the prophet resurges when prominent scientists overstep the constraints of scientific methodology to become vocal advocates of a one-sided ideological truth in the public realm, posing themselves as liberators or saviours, claiming for instance that humans *are* their brains (so that neuropsychology allows us to explain all aspects of human behaviour and experience); or that humans *are* their genomes (thus preaching the creed of genetic determinism, rather than seeing human existence as a dialectical interplay between genes and environment, nature and nurture, receptivity and intervention, etc.); or that environment (nurture) is *everything*; or that humans are fully modifiable, so that drastic enhancement will give rise to a *post-human* future; etc. Such prophets may also proclaim the death of religion and the abolishment of faith by science, apparently unaware of the fact that they are seriously at risk of falling into an archetypal trap, on a planet which, although drastically affected by technoscience, is inhabited by an unprecedented number of religious human beings (more than six billion probably). Whereas an intuitive grasp of the importance of brains, genes, environments, enhancement etc. may function as a source of inspiration, Jung urges us to become aware of the archetypal complexes at work, to remain self-critical, in order to address the challenges at hand on a higher level of comprehension.

For indeed, to be able to face pressing societal issues such as environmental disruption and climate change, we need solid science, but religious perspectives must be involved as well, as a complementary source of knowledge and experience.

This also applies to the idea that, because of climate change and massive environmental disruption, we are heading for disaster: a human-made catastrophe. An archetype is evidently at work here: the catastrophe archetype, the idea (both fascinating and horrifying) of an imminent global cataclysm, closely connected with the awareness that a “platonian month” is coming to an end, that we are entering a new epoch (the Age of Aquarius) and witnessing the dawn of a new era. Whereas the archetype may help us to discern the seriousness of the crises we are facing, we also run the risk of becoming paralysed by global hysteria. We have to be on the alert—not only for disturbing scientific information related to climate change as such. We also have to be attentive to the way human culture tends to respond to this type of information (Zwart 2005). Our interpretations and perceptions tend to be framed and guided by the catastrophe-archetype, a scenario which functions as a scaffold, involving archetypal expectations, images and plots. The point is not that we should try to rid ourselves of archetypal ideas, for human thinking always relies on pre-formatted psychic patterns to interpret and interact with our informational environment in an effective manner. The important thing is to be aware of how these archetypal narratives work. They focus our intentionality and crave for confirmation so that we, while processing or communicating scientific input, remain susceptible to the frameworks they entail. For instance: climate change and the dawning of the new age allows us to play the role of heroic prophets (as happens in climate change cinema, for instance, where the scale and pace of the process tends to be dramatically amplified so that only heroes can save us), while future generations have evidently taken the role of a divine judge, acting as a secular substitute, who will one day condemn us for our irresponsible behaviour. Again, it is only by actively coming to terms with the archetypes involved that we can effectively address the crisis.

Something similar applies to climate scepticism: the denial pole of the climate debate. The archetype at work here is the disconcerting idea that climate change is used as an opportunity to endorse the prospect of a hyper-powerful state, able and willing to intervene in the daily lives of citizens and to sacrifice human liberty to prevent environmental calamities, in other words: the image of a totalitarian, Big Brother-type super-state, using the environmental crisis as an opportunity to legitimately interfere with individual autonomy and to control human behaviour, i.e. the metropolis (= mother-city) archetype,

the politico-economical version of the Mother archetype. The basic concern driving climate change denial is that, on behalf of the environment, human freedom and agency will be sacrificed to the higher goal of collective survival. Both archetypes mutually provoke and amplify each other. In short, in order to develop a convincing and viable global effort to address the disruptive environmental crisis, a Jungian psychological approach is indispensable.

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