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# Chemistry in Literature and Art with Special Attention to Goethe

## Introduction

Widely considered to be the Shakespeare of German literature, Johann Wolfgang von Goethe (1749-1832) is perhaps the best-known German poet, playwright, novelist, and natural philosopher of the German Romantic period. His most famous novel, *Elective Affinities*, and his most famous play, *Faust*, are considered classics; they have had significant effect on German culture.

Goethe was a strong advocate for inquiry-based science and encouraged scientists actively to look for connections between what they learned from their scientific studies and what they know from their daily lives. Some of Goethe's works combined science with literature to demonstrate fundamental analogies between scientific and human phenomena. Goethe tried to bridge the gap between humanities and science. In this effect, perhaps his most notable contribution is his use of chemical principles toward understanding human psychology and social interactions. His work shows the powerful relationship between science and humanity. He encourages scientists to explore this relationship further.

## Biography

Goethe was born in Frankfurt, Germany, to a prosperous family. His father, Johann Kaspar Goethe, was an Imperial Councilor of Frankfurt. Goethe's mother, Katharina Elisabeth Goethe, was the daughter of the mayor of Frankfurt. Goethe had only one sister, Carolina, who survived early childhood. Goethe's father was much interested in the young Goethe's education. His elementary education included science, literature, Greek, Latin, French and Italian. Helped by numerous tutors, Goethe's mother acquainted him with the art of storytelling.

In accord with his father's wishes, Goethe took this diverse educational background to study law at the University of Leipzig. At the age of sixteen he quickly came to love literature and soon became well-known for his Roccoco-style poems. Goethe became involved in the *Sturm und Drang* literature movement that stressed free expression of strong emotions in literature and art. Although he continued to study law, Goethe attended lectures on chemistry, anatomy, surgery, history and political science. He received his law degree in 1771 and started a law practice in Frankfurt.

In 1774 he published a highly popular short novel, *The Sorrows of Young Werther*, that brought him fame throughout Europe. Because of his fame, Goethe was invited to several European royal courts and was later appointed Privy Councilor of Weimar with a lifetime salary. Thus, Goethe was now free to pursue his intellectual and personal interests. At Weimar he wrote several other works such as *Wilhem Meister's Apprenticeship*, *Egmont Torquasto Tasso*, and *Reineke Fuchs*. In 1806, Goethe married Christiane Vulpius, who had only a minimum education; she never fully realized that her husband was a great figure in the literary and intellectual life of Europe. Goethe continued to be active in biology, chemistry, optometry, geology, and especially literature until his death in March 1832. In addition to his numerous literary works, Goethe published an influential book on the theory of color. (Merriman)

**Scientific Ideology**

Goethe favored an "exploration-centered" view of science. He believed that a good scientist must actively look for connections between science and humanities, rather than to restrict scientific research for proving or disproving a scientific theory or hypothesis. According to Goethe, observed scientific phenomena are not only at the center stage of scientific inquiry, but that, in addition, prior theories established by past scientists should not dominate scientific

progress and ingenuity. Goethe published these views in 1792, in his essay, *"The Experiment as Mediator of Object and Subject"*. His remarks also warn against "human error" in science. He writes:

> "We cannot take great enough care when making inferences based on experiments. We should not try through experiments to directly prove something or to confirm a theory. For at this pass—the transition from experience to judgment, from knowledge to application—lie in wait all our inner enemies: imaginative powers that lift us on their wings into heights while letting us believe we have our feet firmly on the ground, impatience, haste, self-satisfaction, rigidity, thought forms, preconceived opinions, lassitude, frivolity, and fickleness" (Holdrege).

Initially, this view did not sit well with the rigid Newtonian scientific community of the time. This scientific community claimed that science should be theory-driven, and that each experiment should be designed to test a specific hypothesis to produce the most un-biased outcomes based only on scientific data. In response, Goethe argued that narrow theory-driven science leaves the scientist biased and pre-disposed to a certain outcome. He believed that such a restricted method of inquiry limits the scope of science and the knowledge that can be obtained from exclusively scientific experimental observation.

Today, a branch of science that emphasizes learning through broad observation and open experiment is called "inquiry-based" science/learning. This attitude stems from Goethe's work; it encourages students to give attention to a question instead of being told a scientific statement. Students should conduct experiments on their own, rather than simply replicating experiments where the result is already known.

**Goethe's Contemporary: Novalis**

One of Goethe's most passionate younger admirers and accomplished contemporaries was Friedrich Leopold von Hardenberg. Hardenberg was born in 1772 to a prosperous family and, like Goethe, excelled in both literature and science. He later took on the pseudonym Novalis in and wrote such famous works as *Hymnen an die Nacht* (1800) and *Heinrich von Ofterdingen* in (1802). (O'Brien) Although Novalis was known for his romantic and "other-worldly" fiction and poetry, he held the same philosophy regarding scientific methodology as Goethe (Nassar). Like Goethe, he firmly believed in an "exploration-centered" practice of science. He writes, "…if one observes assiduously . . . the outer changes through inner changes and vice versa, then I am certain, one will arrive at true, steady relations and laws" (Nassar). This shows how, like Goethe, Novalis sees value in exploring a scientific concept internally, that is, through connections between subject matter, rather than just externally, based on what can be observed by the senses. To this effect, Novalis wrote the *Allgemeine Brouillon*, an encyclopedia of humanities and science in which he expands on both the scientific and philosophical ideas of his time and attempts to show how all these ideas relate to each other. Novalis believed that to gain true knowledge, it was necessary to look for connections both between different subjects or "parts" being discussed (ie. science, art, philosophy) and between these parts and the unified "system" or whole of knowledge. Thus, he called his encyclopedia a "living scientific organon" or more broadly, an "application of the system to the parts—and the parts to the *system* and the parts to the parts" (Nassar).

## *Wahlverwandtschaften* (Elective Affinities)

Goethe's 'exploration-centered' attitude in scientific pursuits helped him to develop a keener awareness for patterns in both nature and in human society. In 1809, Goethe used prevailing chemical theories to show the analogy between chemistry and complex human relationships. He illustrated male-female interactions in his romantic novel, *Elective Affinities*. The original German title of the novel is *Wahlverwandtschaften.* When translated into English *Wahl* means "choice," and *Verwandtschaften* means "family relatives". The novel uses chemical concepts to describe relationships among choice relatives. The term "elective affinities" was used to describe what we now call a chemical double displacement reaction: AB + C + D = AD + CB. In the *Elective Affinities,* 'AB' represents a married couple and 'C and D' represent blood relatives (uncle and niece).

In his introduction to *Elective Affinities*, Goethe writes:

> "Imagine an *A* intimately united with a *B*, so that no force is able to sunder them; imagine a *C*…related to a *D*; now bring the two couples into contact: *A* will throw itself at *D*, *C* at *B*, without our being able to say which first deserted its partner, which first embraced the other's partner." (Mayer/Bogan).

In the novel, a double displacement reaction illustrates the romantic passion, psychology, and the future of each character. The novel construes the inter-relationships on the one hand, between Eduard and Charlotte, a married couple, and on the other hand, their visiting friend the Captain and his niece, Ottilie. Although Eduard and Charlotte married for love, after meeting their guests, Eduard is irreversibly attracted to the young Ottilie, and Charlotte to the Captain. Goethe explains the resulting romantic tangle in terms of a well-known chemical phenomenon:

> " 'Now then!' Eduard interposed: 'until we see all this with our own eyes, let us look on this formula as a metaphor from which we may extract a lesson we can apply immediately to ourselves. You, Charlotte, represent the *A*, and I represent your *B*; for in

> fact I do depend altogether on you and follow you as *A* follows *B*. [Charlette responds], " 'The *C* is quite obviously the Captain, who for the moment is to some extent drawing me away from you. Now it is only fair that, if you are not to vanish into the limitless air, you must be provided with a *D*, and this *D* is unquestionably the charming little lady Ottilie, whose approaching presence you may no longer resist.' "

'AB' in this case represents a married couple and 'C and D' (niece and uncle) represent blood relations. Goethe's chemical imagery comes to represent powerful human emotions that characterize our daily life. For many readers this suggested that complex human relationships could be represented by chemical equations, and thus understood more clearly. Modern interpreters of Goethe's work disagree whether Goethe intended *Elective Affinities* to be solely a metaphor or if he believed that all human interactions are governed by chemical forces.

**Influence of Goethe's *Elective Affinities* on Modern Thought and Art**

The basic idea of *Elective Affinites* was later adopted by sociologist, Max Weber to describe interactions between social constructs. For example, Weber uses the concept of elective affinities to describe the relationship between cultural phenomena and the rise of capitalism. Weber showed that the shift towards capitalism was not simply an economic change, but also a change driven by cultural "elective affinities," such as the prevalent Protestant work ethic in Northern Europe. Weber implied that the same forces and interactions that influenced Goethe's fictional characters at a personal level could also change socio-cultural systems. (Swatos)

*Elective Affinities* continued to have an impact on art, culture, and intellectual ideas throughout the 19$^{th}$ and 20$^{th}$ centuries. The idea that chemistry could be the underlying pattern for human psychology continues to inspire artists and writers alike. One example of this impact is a 1993 painting by Belgian surrealist painter René Magritte, shown in Figure 1. The painting, also called Elective Affinites, presents a bird cage that, instead of a bird, houses an egg. Magritte explains this work:

> "One night, I woke up in a room in which a cage with a bird sleeping in it had been placed. A magnificent error caused me to see an egg in the cage instead of the vanished bird. I then grasped a new and astonishing poetic secret, for the shock which I experienced had been provoked precisely by the affinity of two objects -- the cage and the egg -- to each other, whereas previously this shock had been caused by my bringing together two objects that were unrelated" ("Rene Margritte").

A double displacement reaction (AB + CD = AD + CB) serves as an analogy for this painting. In this case the bonding occurs between an object and its environment. In the original state, the bird and the cage (represented by "A" and "B" respectively) are in unison, while the egg (represented by "C") is in a different, unknown environment (represented by "D"). The cage and the egg, two completely unrelated objects, are brought together because the bird has left the cage for a new, unknown environment.

Similarly, in 1993 a Tom Stoppards's play, *Arcadia,* mirrored the spirit of *Elective Affinities* in its use of scientific concepts to illuminaye philosophical and psychological phenomena. The play uses the second law of thermodynamics (the universe always increases entropy, that is, the universe goes from order to disorder), to convey the idea that order is futile in the face of certain abysmal chaos. In the play, the characters are able to reflect this idea through their interactions. In the passage, below, the characters discuss the idea that even if humans have free will in their short lives, this does not mitigate that ultimately, disorder will prevail:

"Thomsina: When you stir your rice pudding, Septimus, the spoonful of jam spreads itself round making red trails like the picture of a meteor in my astronomical atlas. But if you stir backward, the jam will not come together again. Indeed, the pudding does not notice and continues to turn pink just as before. Do you think this is odd?
Septimus: No.
Thomsina: Well, I do. You can't stir things apart

Septimus: No more you can, time must needs run backward, and since it will not, we must stir our way onward mixing as we go, disorder out of disorder into disorder until pink is complete, unchanging and unchangeable, and we are done with it forever. This is known as free will of self-determination"

In this quotation, Septimus uses the phrase "disorder out of disorder into disorder" to explain the idea of increasing entropy. Regardless of which way or how Thomsina mixes the pudding, she is unable to "unmix" the jam and reproduce the order that once existed in the spoon of jam she originally possessed before mixing it with the pudding. Septimus projects this physical phenomenon onto a grander scale by relating it to the "free will of self-determination" possessed by humans. Regardless of what actions we take to order our world, disorder is ultimately inevitable. Similar to Goethe's concept of using chemical science to illuminate human behavior and relationships, this play construes not only the physical world, but also its similarity to the internal human world. Goethe was a pioneer in attempting to unify physical science and psychology.

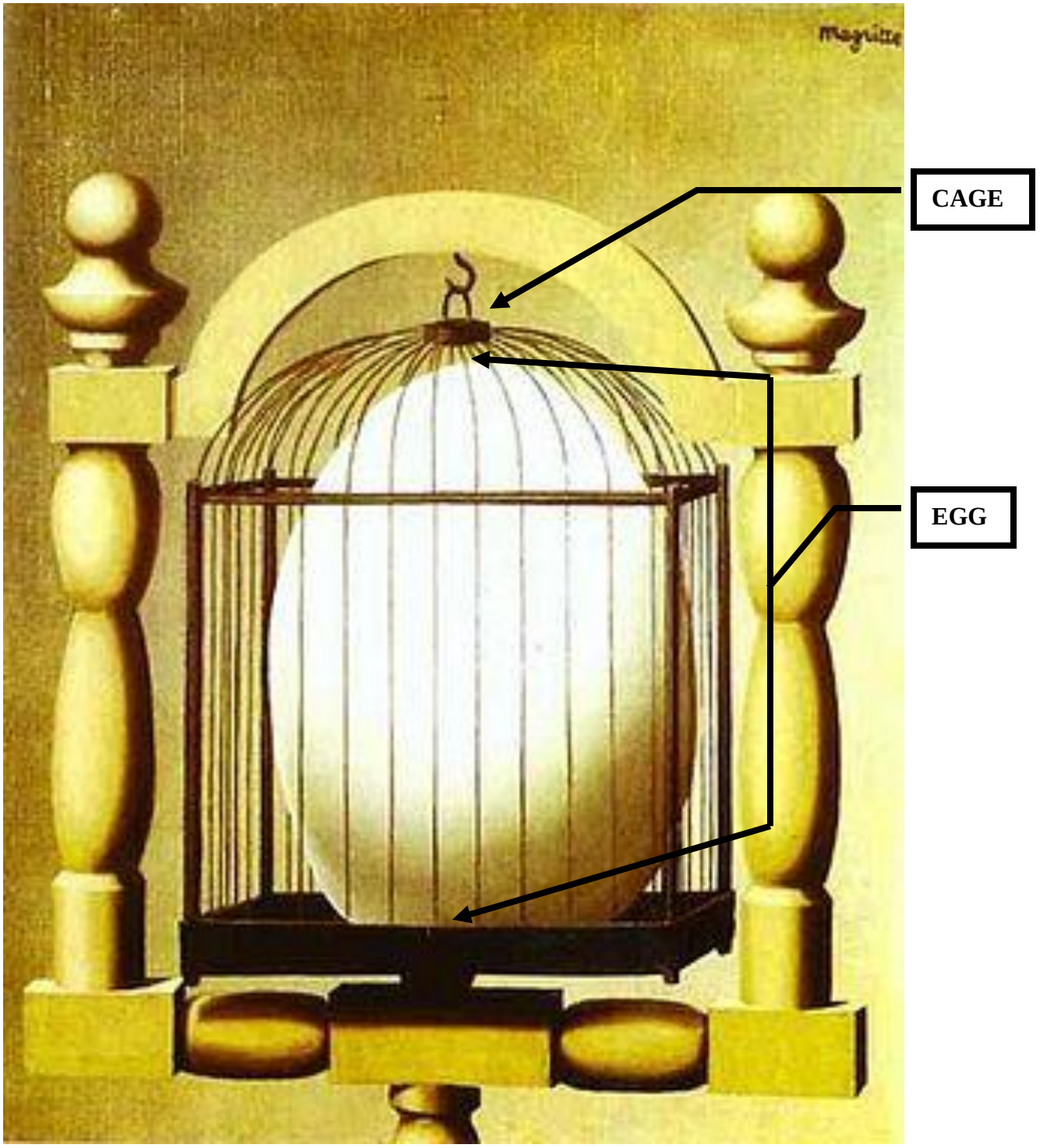


**Figure 1. "Elective Affinities" by Rene Magritte (1993)**

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