

# Sheldrake's Crystals

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*An exchange of views on morphogenesis leads to the conclusion that testing Sheldrake's ideas about crystallization is useless.*

MARCEL van GENDEREN, BART KOENE, and JAN WILLEM NIENHUYS

Rupert Sheldrake is an unconventional scientist—a biologist by training—who has invented morphogenetic fields. Originally, the word *morphogenetic* meant *influences on the growth of embryos*. One may think of gradient fields of specific signal substances, but the word is actually much older than the idea that signal substances might be involved. In various texts between 1920 and 1960 we find several proposals about the nature of these fields, some of them highly metaphorical.

However, Sheldrake thinks that any kind of natural process that eludes a clear and complete description is partially controlled by such fields, especially when there is some kind of pattern. The basic idea is that such patterns cannot

easily arise naturally, because we don't see how. However, once a pattern is formed, it becomes more and more easy to form again.

Sheldrake thinks that patterns create morphogenetic fields. These fields spread out immediately through the universe without loss in strength. They favor the creation of the same pattern. That is morphic resonance.

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Sheldrake even thinks that the basic laws of physics have been frozen into their present form by morphic resonance. But any generic phenomenon can be considered as a pattern, so the morphic fields amount to an explanation for almost anything that is not explicable in detail.

Testing these ideas is hard, because anything that is precisely predictable is excluded from morphic resonance.

Sheldrake does claim some evidence from phenomena for which any decent explanation seems to be lacking. Typical examples are flocks of birds, blue tits getting the cream out of milk bottles left at the front door, homing pigeons, clairvoyant dogs, solving crossword puzzles, and crystal formation.

### **Morphogenesis and Crystals**

Sheldrake writes in his book *The Presence of the Past* (1988) about crystallization: "It is in fact well known to chemists that newly synthesized compounds are usually difficult to crystal-

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*Marcel van Genderen is board member of the Dutch organization Skepsis. He works in the section Organic Chemistry of Eindhoven University of Technology, where he teaches (among other topics) chemical thermodynamics. Address: Dr. M.H.P. van Genderen, Department of Chemical Engineering and Chemistry, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, Netherlands. E-mail: m.h.p.v.genderen@tue.nl. Bart Koene is a physicist working in the section of Electrochemical Technology of Eindhoven University of Technology. Address: Dr. L. Koene, Department of Chemical Engineering and Chemistry, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, Netherlands. E-mail: l.koene@dds.nl. Jan Willem Nienhuys is a retired teacher of mathematics of Eindhoven University of Technology, a board member of the Dutch organization Skepsis, and editor of its periodical Skepter. He is coauthor of a Dutch encyclopedia of pseudoscience. Address: Dr. J.W. Nienhuys, Dommelseweg 1A, 5581 VA Waalre, Netherlands. E-mail: j.w.nienhuys@tue.nl. Earlier versions of this article appeared in Skepter (Netherlands) and Skeptiker (Germany).*

lize: weeks or even months may elapse before crystals appear in a supersaturated solution. Moreover, generally speaking, compounds become easier to crystallize all over the world the more often they are made" (131).

This has been put to the test—but with a computer, under the assumption that filling the memory of a computer is a process akin to crystallization. One may wonder how many people were impressed by this test. Sheldrake certainly wasn't, and our discussion of the thermodynamics of crystallization below will enable the readers to make up their minds on this.<sup>1</sup>

More recently Sheldrake has proposed that easier crystallization would also imply a rise in melting point. Historically many compounds have shown rises in melting points. This suggested a test to one of the sympathizers of the Dutch skeptics organization Skepsis. In research labs, for instance those of pharmaceutical companies, many new compounds are routinely made.

Why not save some of these in a refrigerator and re-measure their melting points after some time? Doing this with, say, a dozen compounds that were synthesized and crystallized again, and a dozen compounds for which this didn't happen, might settle the issue. We decided to contact Sheldrake and discuss this with him. This article is the outcome of our discussion with Sheldrake.

We discussed several issues, among them practical matters, such as how to determine melting points. What rise in temperatures should be expected? And should the samples be kept as solutions or as crystals?

Why did Sheldrake think that melting points go up? Why not down, for instance? Why to a limit? Why not up without bounds? Why only after a few weeks or years, rather than a few microseconds or several millennia? What does the melting of a compound have to do with the process of crystallization from a solution?

An important part of the discussion centered on the actual historical rises in melting points. This is important because if one wants to interest a research chemist to spend time and energy on something, then one should present some motivation.

We quickly decided that discussing the theoretical issues should precede the planning of an actual test. Sheldrake wasn't inclined to see any experiment as decisive. He was merely interested in exploratory research. In other words, see what happens. He argued that no skeptic has changed his materialistic world views on the basis of some of Sheldrake's experiments, so why should he do otherwise?

The theory question seemed easy. Sheldrake had consulted with a chemist, who pointed out to him that "if morphic resonance leads to a progressive strengthening of the morphic fields of crystals, not only should they crystallize more readily, but also the stronger field of the crystal should mean that the crystal is more stable and that its melting point should rise the more often the compound is crystallized."

Ordinarily chemists think that melting points rise, at least in the literature, because of greater purity. There is no other explanation. Sheldrake thought that this is a circular reasoning, as purity of substances is ascertained by means of melting points.

We disagree, and we told him so. Chemists have many ways to ascertain purity of compounds. For the last forty years, any new compound is put into a nuclear magnetic resonance (NMR) machine. Mass spectrometry is another option, (gas) chromatography too. Element analysis for organic compounds consists of burning a sample very carefully and then measuring the amount of combustion products very precisely. This yields the precise amounts of hydrogen, carbon, and nitrogen in the compound, and by comparing it with the theoretical formula, one can estimate the purity. Chemical companies such as Aldrich have on-line catalogs, and they show for many of their products certificates with reports of such purity analyses.

In fact determination of the melting point is hardly—if at all—used to establish purity. To begin with, you need crystals for that, and that means you already have a quite pure substance. Then, determining a melting point is somewhat cumbersome. The most common technique consists of wiggling a tiny amount of powdery material into a capillary tube (one hopes that hygroscopic material doesn't attract water during this process), and then watching the tube contents through an optical device while the tube is suspended in a fluid bath that is slowly heated. The information from a single melting point is limited to just a single number. At most one can see from such a number that the purity has not improved compared to a previous effort. The other methods give much more information.

### Melting and the Gibbs Energy

What is the chemical theory behind melting points? When chemists describe chemical processes, especially those that proceed without change in temperature and pressure, they often use a theoretical quantity called the Gibbs free energy (named after the famous nineteenth century American theoretical physicist Josiah Willard Gibbs). One may think that chemical reactions and phase transitions try to go in the direction of lower Gibbs functions for the systems involved.

The role of the Gibbs function in chemical processes, not only melting and evaporation but also chemical reactions, was discovered by the famous French physicist and philosopher of science Pierre Duhem at the end of the nineteenth century.

One should keep in mind that the Gibbs free energy is best thought of as a bookkeeping quantity. It contains an energy term and an entropy term, but the entropy term has a minus sign. For example, if we have ice and water in contact at the melting temperature of ice, then the water has a higher heat content (enthalpy) than the ice. But the addition of melting heat increases the entropy, which means that the energy can be distributed in more different ways among the molecules. Microscopically, entropy is a measure for the number of these ways; macroscopically, an increase in entropy is heat added, divided by the temperature.

In fact there is no difference in Gibbs free energy between ice and water at the melting temperature. If no heat is added

to the system, nothing (no freezing, no melting) happens. Only differences in Gibbs free energy make reactions and phase transitions go. Similar remarks apply to a saturated solution in contact with crystals of the dissolved material.

"Nothing happens" is microscopically incorrect. All the time there are water molecules settling into the ice, while others get kicked out. We speak about a dynamic equilibrium: settling down and kicking out occur equally often.

What happens when we add salt to the mixture of water and ice? The salt dissolves, and near the ice surface there are fewer water molecules settling into the ice. The number of ice molecules kicked into the solution doesn't change, so now there is net melting. The dynamic equilibrium can only be established at a lower temperature. Chemists observe that dissolving salt into the water raises the entropy, hence decreases the Gibbs free energy of the fluid, hence creates a difference in Gibbs free energy between ice and fluid, and this "causes" the system to evolve into one with more fluid and less ice. The advantage of using the Gibbs free energy is that one can calculate by how much a given amount of dissolved salt will lower the freezing point, not only for water and salt, but for any compound and any kind of impurity dissolved into a melt.

The result of such a calculation is that the melting temperature goes down—unsurprisingly—in proportion to the concentration of the impurity in the fluid phase.

The decrease is also proportional to the square of the melting temperature of the pure substance in equilibrium with the pure melt (a slightly better approximation is the product of the "pure" melting temperature and the "actual" melting temperature).

However, the decrease is inversely proportional to the melting heat of the substance. That is important to know, because it means that for substances with a small melting heat a little impurity may make a large difference.<sup>2</sup>

Conversely, for a substance with a large melting heat (such as water) enormous amounts of salt are necessary to make the melting temperature go down by an appreciable amount.

If we are dealing with an "impure" crystalline material, we usually have a powder of pure crystals of various



substances. The impurities may, for example, consist of left-over reagents that produced the bulk of the material. The above theory applies to the system consisting of the bulk material covered with a very thin film of impure fluid. Maybe the reader is familiar with the phenomenon that melting ice with salt (and obtaining a cooling effect as well) works better if a bit of water is added to the mixture of ice and salt.

Sheldrake, however, has stated to us that the "Gibbs free energy is not a part of any argument [he] raised," and that it is not particularly relevant. "[T]he morphogenetic field does act as a kind of catalyst." This view corresponds to Sheldrake's view that his morphogenetic fields help probabilistic processes along in some way. On the other hand he stated that if "the Gibbs free energy of a substance is fixed quantity independent of time and predictable in advance," then his hypothesis "does not make sense."

Sheldrake thinks that for many substances there are many slightly different crystal forms possible, each corresponding to a local energy minimum that differs a bit from the others. The morphogenetic field merely helps to choose the best minimum. That means a catalytic action indeed. It would explain quicker and easier crystallization. But Sheldrake also believes that his field somehow makes the crystal stronger in some sense, and thereby protects it a bit against melting, in other words the morphogenetic fields act both as catalyst and as stabilizer. But those two actions are fundamentally different, at least to chemists.

Sheldrake seems to neglect the entropy term in the Gibbs function. In a crystal the entropy is clearly lower than in the fluid. Even so, different crystal forms also differ in the exact amount of freedom of motion of the molecules (that is one of the reasons why the Gibbs function is so hard to compute from theory alone). It is not certain at all that stronger forces between the molecules in a crystal lattice will lower the Gibbs free energy. A tighter packing will lower the entropy, hence raise the Gibbs function.

Nonetheless it seems to us that Sheldrake's hypothesis about melting points is a claim about forces and energies and freedom of motion. For chemists, the Gibbs free energy is what ultimately describes whether the crystal will melt or not at a certain temperature. So implicitly the Gibbs function is involved, but explicitly Sheldrake denies that it plays any role in his thinking. Moreover, explicitly he stated that if the Gibbs function is a fixed quantity, then his hypothesis is out, and implicitly he hypothesizes that the Gibbs free energy of any given crystal can change after it has been formed, merely by having similar crystals produced somewhere in the same or a different lab. From the point of view of chemical thermodynamics, this effect on the stability of crystals means that Sheldrake implicitly supposes that there is an extra term in the Gibbs function. He merely has to tell us what that term is, and then we can study its properties and properly design experiments.

## Crystal Glossary

### **morphogenetic field**

In Sheldrake's view, a kind of influence that is created by any characteristic pattern.

### **morphic resonance**

In Sheldrake's view, the morphogenetic field helps to create or sustain analogous patterns. All forms of memory are in fact examples of morphic resonance of a brain with itself at an earlier time. But a substance, for example cocaine, can also "remember" how to form crystals, and so cocaine can perform better at that task, once cocaine has been crystallized somewhere, sometime. Sheldrake believes that the basic laws of physics have also been created by morphogenetic fields.

### **crystal**

A substance in which the atoms or molecules are ranged in orderly patterns. Often the crystals have characteristic shapes. Examples are ice, many minerals such as diamond or the grains in granite, table salt, and sugar.

### **entropy**

In physics, a measure of disorder in a substance. In thermodynamics one divides any heat loss or gain by the temperature, and one obtains then a quantity that is called the change in entropy. Heat is energy of random motion, entropy is a measure for the evenness of the distribution of this energy, more even meaning higher entropy.

### **Gibbs free energy**

A bookkeeping quantity in physics and chemistry, namely total heat (also called enthalpy) minus the product of total entropy and temperature. One may think of any process such as melting or chemical reactions as driven by differences in Gibbs free energy. In an equilibrium situation (ice and water at 0 degrees Celsius, or salt and a saturated brine) the Gibbs free energy of both components is equal, and nothing (no melting, freezing, dissolving etc.) happens. In other words, the melting point is the temperature where the fluid and solid phase have exactly the same Gibbs free energy.

### **L- and D-forms**

When a carbon atom is bound to four different groups or atoms, one gets a molecule that is not identical with its mirror image, much like a left hand and a right hand. In simple cases one is called L and the other D.

### **amino acids**

In an amino acid a carbon atom is bound to a hydrogen atom, one acid group, one amino group and a third group. So unless the third group is just a hydrogen atom (resulting in glycine), amino acids come in L- and D-forms. Proteins are chains of amino acids. Life on earth almost exclusively uses the L-forms of twenty different amino acids; asparagine, threonine and phenyl alanine are three of them.

### **racemic mixture**

A substance containing equal numbers of two types of molecules that are non-identical mirror images of each other.

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## Concrete Examples

Why should those fields not cause the melting points to go up without bounds? Shelldrake answered that many such processes have natural limits, such as the four-minute mile. We were not impressed by his example. The time for running a mile isn't a natural process, but the result of an athlete wanting to outperform others. Comparing track sports to crystals is merely using yet another anthropomorphic metaphor for crystal formation. As most of humankind still can't run a mile in four minutes, morphic resonance doesn't work too well there! Many natural processes, such as the weather, earthquakes, and animal populations, don't go to any limit but keep varying up and down.

The very first microscopically small crystal will contain on the order of  $10^{15}$  molecules. Why is a million billion learning opportunities not enough? For blue tits and people much less learning suffices for much more complicated behavior! To this Shelldrake had essentially no answer. More important, we asked him if he had any concrete examples of inexplicable historical rises in melting points. Shelldrake gave several examples, taken from catalogues of companies such as Aldrich, Merck, and also from the *CRC Handbook of Chemistry and Physics*, the so-called "Rubber Bible." He spent much effort in obtaining substances from chemical companies and checking the melting points by measuring them himself (actually having an assistant do it for him). We emphasize that he actively acquired data to support his views. However, he never provided any purity data.

He gave one famous substance as example: 18-crown-6 crown ether, first synthesized by Charles J. Pedersen, who reported a melting point of 38 to 39.5 degrees in 1977 (all temperatures are in degrees Celsius). Its melting point is now about 4 degrees more, namely 42–45 degrees. Shelldrake won't believe that this modest four degree rise has anything to do with improved purity after more than ten years. Certainly Pedersen must have done his best to get a pure compound? But chemists spend much of their time in isolating, separating, and purifying substances. In this case absence of any increase would mean that chemistry would not have been able to make any progress after this compound was synthesized for the first time.

His other examples were cocaine and seven amino acids. We didn't think they were good examples. The most serious objection is that many of those melting points are listed with the remark: "with decomposition," i.e., at the so-called melting temperature the stuff starts decomposing: it often turns yellow or brown. Among chemists it is assumed that this type of melting point isn't very reliable. The decomposition products can act as impurities with disastrous effects on the melting point, they may be fluid—creating the illusion of melting—and the judgment that a discoloration is visible is somewhat subjective.

Again, there is no problem here for Shelldrake. Melting and decomposing is the same to him: disruption of the structure.

For example, Shelldrake reported a melting point of 239 degrees for threonine in 1934 and 270 degrees in 1993. However, we found modern melting points of slightly over 239 degrees for the racemic mixture of D- and L-threonine, 256 degrees for D- or L-threonine, excepting Aldrich who mentioned 274 degrees for D-threonine, all with decomposi-

tion. A chemist must conclude that there is something wrong here. Theoretically mirror symmetric molecules (such as these D- and L-compounds) ought to have the same melting points. Generally speaking, any scientist who can discover a basic difference in physical behavior between mirror symmetric situations would achieve instant fame. The indication "decomposition" however, raises a red flag for a chemist.

Shelldrake didn't seem to care much about discrepancies between D- and L-forms. As far as we can tell, he agrees with us that the limiting value of the melting point should be the same for both forms, but D-forms, or their crystals, are usually newer than the L-forms, which are abundant in life on Earth, so it would take some more time until morphic resonance has brought the D-crystals close to their limit melting point. He sees no cause for concern in difference between L- and D-forms. That happens occasionally, he said. It does require explanation, and in fact there are several standard explanations. One is that in the literature melting points are often copied from older sources, rather than remeasured. Data about the "natural" L-forms are often older than those of the newer D-forms. L- and D-forms are made in different ways, so their impurities differ. More specifically, L-compounds can contain certain amounts of the corresponding D-compounds (or vice versa), which tends to lower the melting point. Only an intensive investigation can reveal which explanation applies in a particular case of a specific item in a specific catalog.

Shelldrake gave another example of a compound whose melting point did not go up, namely asparagine: its melting point was 236 degrees in 1936, and it still is. We checked, but again we found in Aldrich an anomalous high melting temperature of 280 degrees for the (synthetic) D-form, and again melting with decomposition for all forms. So we see here the same mystifying anomalous behavior as for threonine.

We have asked Aldrich for an explanation. They mentioned the standard explanation, but for asparagine they took the trouble to remeasure the melting points of their products. They found for L-asparagine 240.5 degrees, and for D-asparagine 274–280 degrees, which rules out the "copied from older data" explanation in this case.

For the moment, we must consider the melting points of asparagine and threonine as puzzles that might have any of several plausible solutions. Whatever these solutions, one cannot very well say that threonine's melting point has gone up, and asparagine's stayed constant.

Shelldrake says that asparagine in some plants serves to transport nitrogen, from the roots to the leaves. Sometimes the sap of the plant is exuded at the leaf tips, the water evaporates, and then the asparagine crystals are left. So crystalline asparagine has been occurring in nature for millions of years, and that explains to him why asparagine melting points don't go up in the literature. He did not proffer an explanation for the high melting point of D-asparagine. His morphic resonance idea predicts a lower melting point for the D-form.

There is only one amino acid that doesn't decompose at the so-called melting point. That is phenylalanine. Here the D- and L-form behave almost exactly the same, and the slight difference can be explained from the purity data which are available in this case.

## Conclusion

Experiments to test these theories are possible, and if anybody wants to do them, we would be willing to cooperate in the design phase. But a null result will not change anybody's mind: *certainly not Sheldrake's and not any chemist's*. Sheldrake does not consider chemical thermodynamics, he states things that seem to us to be in contradiction with each other and also with this century-old and well-tested theory, and he only gave anecdotal support for his conjectures.

We see no possibility to convince a professional chemist that there is something worth their effort and their (and their bosses') time to investigate. For that, one needs an example of a substance with a given purity showing an historic rise in melting point that cannot be explained from a change in purity. Sheldrake has not given even a single such example.

This discussion has had some use for us. We know much

more about the thermodynamics of melting than we knew before this discussion. It was only halfway through our correspondence that it dawned upon us that we were basically discussing the Gibbs free energy.

## Notes

1. See, for example, Francisco J. Varela and Juan C. Letelier, Morphic Resonance in Silicon Chips, *SKEPTICAL INQUIRER* 12 (3) (Spring 1988), p.298-300. Morphic resonance test (Letters), *SKEPTICAL INQUIRER* 13 (1) (Fall 1988), p.100-101. Follow-Up, *SKEPTICAL INQUIRER* 13 (2) (Winter 1989), p. 203-205. The Varela-Letelier experiment was deemed unacceptable because their computer was controlled by a clock, but the students Warner, McNelis, and Losh built a clockless computer that, when properly cooled, gave the same results (private communication).

2. For the cognoscenti (most of whom probably had to memorize this very formula during their studies) we mention that the concentration must be given in mol per mol, and then the proportionality constant happens to be the universal gas constant  $R$ , times a correction factor close to 1, to account for non-ideal behavior. □

# Are Melting Points Constant?

RUPERT SHELDRAKE

(Reply to the article by Van Genderen, Koene, and Nienhuys)

Like van Genderen, Koene, and Nienhuys (subsequently GKN) I am a skeptic, but of a different kind. I think it is important to question fundamental assumptions that are usually taken for granted. In particular, I am skeptical about the idea that the "laws of nature" are constant. This theory was built into the foundations of modern science in the seventeenth century, and was originally based on theology. The laws of nature were created by God and shared in God's nature: they were changeless, universal, and omnipotent.

Until the Big Bang cosmology became orthodox in the 1960s, there seemed no reason to challenge this belief. But we now have a radically evolutionary cosmology. In this context, does it make sense to say that all the laws of nature were fixed at the Big Bang, like a cosmic Napoleonic code? Or to claim that they existed before the Big Bang? There can be no experimental evidence for such a claim. This is clearly a meta-

physical assertion. Evolutionary cosmology raises the possibility that the laws of nature may themselves evolve.

We can even question the concept of natural "laws." This is a very anthropocentric notion, since only humans have laws. As the English writer C.S. Lewis once said, "To say that a stone falls to earth because it is obeying a law makes it a man and even a citizen." Perhaps the regularities of nature are more like habits than laws. Habits imply a kind of unconscious memory. In my hypothesis of formative causation, I suggest that self-organizing systems, including molecules, crystals, cells, organisms and animal societies, are organized by morphic fields which contain an inherent memory given by the process I call morphic resonance. I give a detailed account of this hypothesis in my book *The Presence of the Past*.

According to this hypothesis, the first time a new chemical substance crystallizes in the history of the universe, there

will be no pre-existing morphic field for this compound. But once the chemical has crystallized, subsequent attempts to crystallize it in other places will be influenced by morphic resonance from the first crystals. As the compound is crystallized repeatedly there will be a cumulative effect. It should therefore, on average, become easier to crystallize that chemical.

The morphic field of the crystal works, I suggest, by patterning the crystallization process toward one of the many possible minimum-energy structures that the compound is capable of taking up. Morphic resonance from past crystals should strengthen the morphic field, and hence not only make the compound easier to crystallize, but also more resistant to disruption. Therefore a higher temperature would be necessary to break it up. Thus the melting point would be expected to rise.

According to the hypothesis of morphic resonance, compounds that have crystallized in nature for millions of