

## Origin of life: the chirality problem

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Many important molecules required for life exist in two forms. These two forms are non-superimposable mirror images of each other, i.e.: they are related like our left and right hands. Hence this property is called **chirality**, from the Greek word for hand. The two forms are called **enantiomers** (from the Greek word for opposite) or **optical isomers**, because they rotate plane-polarised light either to the right or to the left.

Whether or not a molecule or crystal is chiral is determined by its *symmetry*. A molecule is *achiral* (non-chiral) if and only if it has an *axis of improper rotation*, that is, an  $n$ -fold rotation (rotation by  $360^\circ/n$ ) followed by a reflection in the plane perpendicular to this axis maps the molecule on to itself. Thus a molecule is chiral if and only if it *lacks* such an axis. Because chiral molecules lack this type of symmetry, they are called **dissymmetric**. They are not necessarily **asymmetric** (i.e. without symmetry), because they can have other types of symmetry.<sup>1</sup> However, all amino acids (except glycine) and many sugars are indeed asymmetric as well as dissymmetric.

### Chirality and life

Nearly all biological polymers must be *homochiral* (all its component monomers having the same handedness. Another term used is optically pure or 100 % optically active) to function. All amino acids in proteins are 'left-handed', while all sugars in DNA and RNA, and in the metabolic pathways, are 'right-handed'.

A 50/50 mixture of left- and right-handed forms is called a **racemate** or **racemic mixture**. Racemic polypeptides could not form the specific shapes required for enzymes, because they would have the side chains sticking out randomly. Also, a wrong-handed amino acid disrupts the stabilizing  $\alpha$ -helix in proteins. DNA could not be stabilised in a helix if even a single wrong-handed monomer were present, so it could not form long chains. This means it could not store much information, so it could not support life.<sup>2</sup>

### Ordinary chemistry produces racemates.

A well-regarded organic chemistry textbook states a universal chemical rule in bold type:

**'Synthesis of chiral compounds from achiral reagents always yields the racemic modification.'** and **'Optically inactive reagents yield optically inactive products.'**<sup>3</sup>

This is a consequence of the Laws of Thermodynamics. The left and right handed forms have identical free energy (G), so the free energy difference ( $\Delta G$ ) is zero. The equilibrium constant for any reaction (K) is the equilibrium ratio of the concentration of products to reactants. The relationship between these quantities at any Kelvin temperature (T) is given by the standard equation:

$$K = \exp(-\Delta G/RT)$$

where R is the universal gas constant (= Avogadro's number x Boltzmann's constant k) = 8.314 J/K.mol.

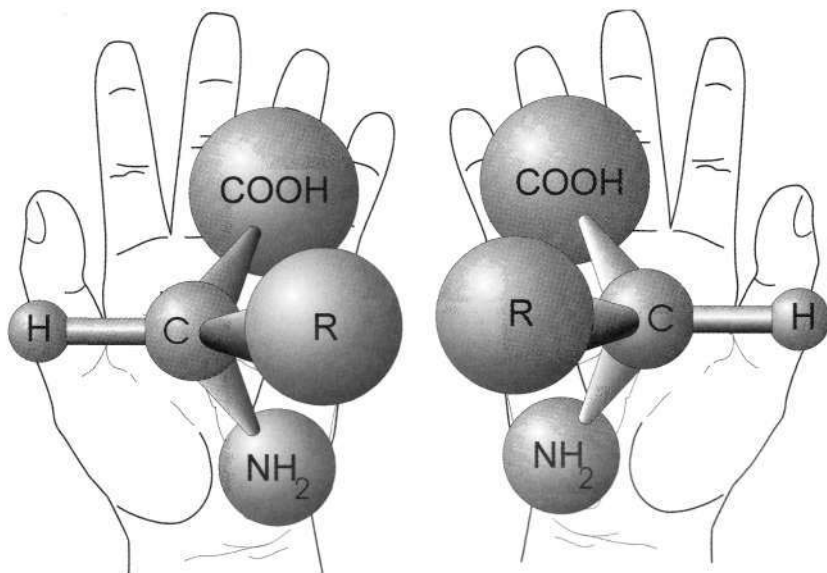
For the reaction of changing left-handed to right-handed amino acids (L  $\rightarrow$  R), or the reverse (R  $\rightarrow$  L),  $\Delta G = 0$ , so  $K = 1$ . That is, the reaction reaches equilibrium when the concentrations of R and L are equal, that is a racemate is produced. This explains the textbook rule above.

### Separating the left hand from the right

To resolve a racemate (i.e. separate the two enantiomers), another homochiral substance must be introduced. The procedure is explained in any organic chemistry textbook. The idea is that right-handed and left-handed substances have identical properties, *except when interacting with other chiral phenomena*. The analogy is that our left and right hands grip an achiral (non-chiral) object like a baseball bat equally, but they fit differently into a chiral object like a left-handed glove. Thus to resolve a racemate, an organic chemist will usually use a ready-made homochiral substance from a living organism. The reaction products of the R and L enantiomers with an exclusively right handed substance R', that is R-R' and L-R' (called **diastereomers**), are not mirror images. So they have different physical properties, e.g. solubility in water, thus they can be separated.

However, this does not solve the mystery of where the optical activity in living organisms came from in the first place. A recent world conference on 'The Origin of Homochirality and Life' made it clear that the origin of this handedness is a complete mystery to evolutionists.<sup>4</sup> The probability of forming one homochiral polymer of N monomers by chance =  $2^{-N}$ . For a small protein of 100 amino acids, this probability =  $2^{-100} = 10^{-30}$ . Note, this is the probability of *any* homochiral polypeptide. The probability of forming *a functional* homochiral polymer is much lower, since a precise amino acid sequence is required in many places. Of course, many homochiral polymers are required for life, so the probabilities must be compounded. Chance is thus not an option.

A further problem is that homochiral biological substances racemize in time. This is the basis of the amino acid racemization dating method. Its main proponent is Jeffrey Bada of the Scripps Institution of Oceanography in La Jolla, California.<sup>5</sup> As a dating method, it is not very



The two enantiomers of a generalised amino acid, where R is any functional group (except H).

reliable, since the racemization rate is strongly dependent on temperature and pH, and depends on the particular amino acid.<sup>6</sup> Racemization is also a big problem during peptide synthesis and hydrolysis.<sup>7</sup> It shows that the tendency of undirected chemistry is towards death, not life.

A tragic reminder of the importance of chirality is thalidomide. In the early 1960s, this drug was prescribed to pregnant women suffering from morning sickness. However, while the left-handed form is a powerful tranquilliser, the right handed form can disrupt fetal development, resulting in severe birth defects. Unfortunately, the synthesis of the drug produced a racemate, as would be expected, and the wrong enantiomer was not removed before the drug was marketed.<sup>8</sup>

In my own undergraduate chemistry education, one of the required experiments demonstrated these concepts. We synthesized the dissymmetric complex ion,  $[\text{Co}(\text{H}_2\text{NC}_2\text{H}_4\text{NH}_2)_3]^{3+}$ ,<sup>9</sup> from achiral reagents, so a racemate was produced. We resolved it by reacting it with a homochiral acid from a plant source, forming diastereomers that could be resolved by fractional crystallisation. When the resultant homochiral crystals were dissolved, and activated charcoal (a catalyst) added, the substance quickly racemized, because a catalyst accelerates approach to equilibrium.

Origin-of-life researchers have tried to think of other means of producing the required homochirality. There have been unsuccessful attempts to resolve racemates by other means.

### Circularly polarized ultraviolet light

With circularly polarized light, the electric field direction rotates along the beam, so it is a chiral

phenomenon. Homochiral substances have different absorption intensities for left and right CP light — this is called **circular dichroism** (CD).<sup>10</sup> Similarly, CP light is absorbed differently by left and right enantiomers. Since photolysis (destruction by light) occurs only when light photons are absorbed, CP light destroys one enantiomer more readily than the other. However, because CP light also destroys the 'correct' form to some extent, this method would not produce the necessary 100 % homochirality required for life. One of the best results has been 20 % optically pure camphor, but this occurred after 99 % of the starting material had been destroyed. 35.5 % optical purity would have resulted after 99.99 % destruction.<sup>11</sup> 'A practically optically pure compound (99.99 per cent) ... is obtained at an asymptotic point where absolutely no material remains'<sup>12</sup>

Another problem is that magnitude and sign (i.e. right-favouring or left-favouring) of CD depends on the frequency of the CP light.<sup>10</sup> This means that resolution can occur only with CP light over a narrow frequency band. Over a broad band, enantioselective effects would cancel.

Circularly polarised light has recently been revived as a solution in a paper by the Australian astronomer Jeremy Bailey in *Science*,<sup>13</sup> and widely reported in the media. His team has discovered circularly polarised infrared radiation in a nebula. They admit in the paper that they have not discovered the required circularly polarised *ultraviolet* light nor any evidence that amino acids are produced in nebulae. They are also aware of the very limited enantioselectivity of CP light, and the fact that the effect averages to zero over a whole spectrum (the Kuhn-Condon rule). However, their faith in chemical evolution colours the way they interpret the evidence.

Not all evolutionists are convinced by the proposal of Bailey's team. For example, Jeffrey Bada said, 'It's just a series of maybe steps. To me, that makes the whole thing a big maybe.'<sup>14</sup>

Another proposed source of circularly polarised light is synchrotron radiation from a neutron star,<sup>15</sup> but this is speculative and doesn't solve the chemical problems.

### Beta decay and the weak force

(3-decay is one form of radioactive decay, and it is governed by one of the four fundamental forces of nature, the *weak force*. This force has a slight handedness, called *parity violation*, so some theorists thought (3-decay could account for the chirality in living organisms.<sup>16</sup> However, the weak force is aptly named — the effect is minuscule — a long way from producing the required 100 % homochirality. One specialist in the chirality problem, organic chemist William Bonner, professor emeritus at Stanford University,

said, 'none of this work has yielded convincing conclusions'.<sup>11</sup> Another researcher concluded:

*'the exceptional prebiotic conditions required do not favour asymmetric  $\beta$ -radiolysis as the selector of the exclusive signature of optical activity in living nature.'*<sup>18</sup>

Another aspect of parity violation is that the L-amino acids and D-sugars have a theoretically slightly lower energy than their enantiomers so are slightly more stable. But the energy difference is immeasurable — only about  $10^{-17}$  kT, meaning that there would be only one excess L-enantiomer for every  $6 \times 10^{17}$  molecules of a racemic mixture of amino acids!<sup>19</sup>

### Optically active quartz powders

Quartz is a widespread mineral — the commonest form of silica ( $\text{SiO}_2$ ) on Earth. Its crystals are hexagonal and dissymmetric.<sup>20</sup> So some investigators tried to use optically active quartz powders to adsorb one enantiomer more than the other. But they had no success. Besides, there are equal amounts of left and right-handed quartz crystals on Earth.<sup>21</sup>

### Clay minerals

Some investigators have reported a very small chiral selection effect by clay minerals, but the effects may have been an artefact of the technique used. Selective adsorption and binding have now been rejected.<sup>22</sup> Even if modern clays did have a chiral bias, this could be due to previous absorption of optically active biomolecules (which are, of course produced by living things). Prebiotic clays would then have had no chiral bias.

### Self-selection

A small minority of chiral substances crystallise into homochiral crystals. Louis Pasteur was not only the founder of the germ theory of disease, the destroyer of 'spontaneous generation' ideas, and a creationist, he was also the first person in history to resolve a racemate. He used tweezers to separate the left and right-handed crystals of such a substance, sodium ammonium tartrate.<sup>23</sup>

This separation only happened because of outside interference by an intelligent investigator, who could recognise the different patterns. On the supposed primitive earth, there was no such investigator. Therefore the two forms, even if they could be separated by chance, would have re-dissolved together and re-formed a racemic solution.

Also, Pasteur was fortunate to choose one of the few substances that self-resolve in crystalline form. And even this substance has this property only below 23 °C, so it's perhaps fortunate that 19<sup>th</sup> century laboratories were not well heated!

### Fluke seeding

Some theorists have proposed that a fluke seeding of a supersaturated solution with a homochiral crystal would crystallise out the same enantiomer. However, the primordial soup, if it existed,<sup>24</sup> would have been extremely dilute and grossly contaminated, as shown by many writers.<sup>25</sup> Also, nothing could be done with the growing homochiral crystal, because it would be immersed in a solution of the remaining wrong enantiomer. Concentrating the solution would crystallise out this wrong enantiomer. Diluting the solution would dissolve the crystal, so the alleged process would have to keep starting from scratch.

### Homochiral template

Some have proposed that a homochiral polymer arose by chance and acted as a template. However, this ran into severe problems. A template of 100 % right-handed poly-C (RNA containing only cytosine monomers) was made (by intelligent chemists!). This could direct the oligomerisation (formation of small chains) of (activated) G (guanine) nucleotides. Indeed, pure right-handed G was oligomerised much more efficiently than pure left-handed G. But racemic G did not oligomerise, because:

*'monomers of opposite handedness to the template are incorporated as chain terminators ... This inhibition raises an important problem for many theories of the origin of life.'*<sup>26</sup>

### Transfer RNAs selected the right enantiomer

One attempt to solve the chirality problem was proposed by Russell Doolittle, a professor of biochemistry at the University of California at San Diego, and an atheist. He claimed: *'From the start of their [Transfer RNA synthetases'] existence, they probably bound only L-amino acids.'*<sup>27</sup> He never explains how such complicated enzymes could have functioned unless they were themselves homochiral, or how they would operate before RNA was composed of homochiral ribose. Doolittle's 'solution' is mere hand-waving. It is hardly worth refuting except that it appeared in a well-known anti-creationist book, which says something about the quality of its editing, or the quality of anti-creationist arguments.

It seems like Doolittle was trying to explain away his prior televised evolution/creation debate with biochemist Duane Gish held before 5,000 people at Liberty University on 13 Oct 1981. The pro-evolution journal *Science* described the debate as a 'rout' in favour of Gish.<sup>28</sup> The next day, the debate was reported by the pro-evolution *Washington Post* under the headline 'Science Loses One to Creationism'. The sub-headline cited Doolittle's anguished remark: 'How am I going to face my wife?' showing that Doolittle himself knew he was defeated.

## Magnetic fields

Some German chemists, led by Eberhard Breitmaier of the Institute for Organic Chemistry and Biochemistry at the University Gerhard-Domagk-Strasse in Bonn, announced that a very strong magnetic field (1.2-2.1 T) produced 98 % homochiral products from achiral reagents.<sup>29</sup> So organic chemists like Philip Kocienski, of the University of Southampton, speculated that the earth's magnetic field could have caused life's homochirality. Although the earth's magnetic field is about 10,000 times weaker than that of the experiment, Kocienski thought that vast time spans would result in the homochirality we see today.<sup>29</sup> He may have forgotten about palaeogeomagnetic field reversals!

Yet other chemists like Tony Barrett, of London's Imperial College, thought that the German experiment 'seems just too good to be true.'<sup>29</sup> This caution was vindicated about six weeks later. No-one else could reproduce the German team's results. It turned out that one of the team, Guido Zadel, the post-doctoral fellow on whose thesis the original work was based, had adulterated the reagents with a homochiral additive.<sup>30</sup>

## Conclusion

The textbook cited earlier states:

*We eat optically active bread & meat, live in houses, wear clothes, and read books made of optically active cellulose. The proteins that make up our muscles, the glycogen in our liver and blood, the enzymes and hormones ... are all optically active. Naturally occurring substances are optically active because the enzymes which bring about their formation ... are optically active. As to the origin of the optically active enzymes, we can only speculate.*<sup>31</sup>

If we can only 'speculate' on the origin of life, why do so many people state that evolution is a 'fact'? Repeat a rumour often enough and people will swallow it.

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