**Predicting Minimum Time Required for Random Generation of Molecules of a Given Molecular Weight from Miller-Urey Experiments**

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Below is a table of amino acids produced and identified in the "classic" 1952 experiment, as published by Miller in 1953, the 2008 re-analysis of vials from the volcanic spark discharge experiment, and the 2010 re-analysis of vials from the H2S-rich spark discharge experiment.

The Marshall Model estimates the absolute minimum time (Tmin) required to generate a compound of any given molecular weight (MW) using **Tmin=2^(MW)\*Tp**, where Tp is Planck Time, 5.4e-44 (s). It is the smallest amount of time applicable to physical chemistry, used here as a Universal Clock Cycle counting through the binary number obtained from 2^(MW). The Tmin result is how long would it take to overflow the binary counter in seconds, since the singular favorable outcome is represented by the overflow (maximum) value of “all 1’s”, meaning all of the atoms are in position.

| MW,(Tmin), Amino acid name **(SOx) means regular chemical reaction with** **H2S seed compound may have occurred after the rich-spark generation, artificially inflating MW up to 32 or 48 or 64 Da (in 4 instances out of 30)** | **Produced in experiment**  | [**Proteinogenic**](https://en.wikipedia.org/wiki/Proteinogenic) |
| --- | --- | --- |
| **Miller–Urey Classic(1952)**  | **Volcanic spark discharge(2008)**  | **H2S-rich spark discharge(2010)**  |
| 89,(1e-17s) [β-Alanine](https://en.wikipedia.org/wiki/Beta-Alanine)  | Yes | Yes | Yes | No  |
| 103,(0.5ps) [α-Aminobutyric acid](https://en.wikipedia.org/wiki/Alpha-Aminobutyric_acid)  | Yes | Yes | Yes | No  |
| 89,(1e-17s) [α-Alanine](https://en.wikipedia.org/wiki/Alanine)  | Yes | Yes | Yes | Yes  |
| 75,(instant) [Glycine](https://en.wikipedia.org/wiki/Glycine)  | Yes | Yes | Yes | Yes  |
| 133,(5.8ms) [Aspartic acid](https://en.wikipedia.org/wiki/Aspartic_acid)  | Yes | Yes | Yes | Yes  |
| 103,(0.5ps) [γ-Aminobutyric acid](https://en.wikipedia.org/wiki/Gamma-Aminobutyric_acid)  | No | Yes | Yes | No  |
| 103,(0.5ps) [β-Aminoisobutyric acid](https://en.wikipedia.org/wiki/3-Aminoisobutyric_acid)  | No | Yes | Yes | No  |
| 103,(0.5ps) [β-Aminobutyric acid](https://en.wikipedia.org/wiki/Beta-Aminobutyric_acid)  | No | Yes | Yes | No  |
| 103,(0.5ps) [α-Aminoisobutyric acid](https://en.wikipedia.org/wiki/2-Aminoisobutyric_acid)  | No | Yes | Yes | No  |
| 117,(9ns) [Valine](https://en.wikipedia.org/wiki/Valine)  | No | Yes | Yes | Yes  |
| 105,(2ps) [Serine](https://en.wikipedia.org/wiki/Serine)  | No | Yes | Yes | Yes  |
| 117,(9ns) [Isovaline](https://en.wikipedia.org/wiki/Isovaline)  | No | Yes | Yes | No  |
| 105,(2ps) [Isoserine](https://en.wikipedia.org/wiki/Isoserine)  | No | Yes | Yes | No  |
| 147,(10s) [Glutamic acid](https://en.wikipedia.org/wiki/Glutamic_acid)  | No | Yes | Yes | Yes  |
| 135,(2ms) [S-methylcysteine](https://en.wikipedia.org/w/index.php?title=S-methylcysteine&action=edit&redlink=1)  | No | No | Yes | No  |
| 165**,(SO,48Da**) [Methionine sulfoxide](https://en.wikipedia.org/wiki/Methionine_sulfoxide)  | No | No | Yes | No  |
| 181,(**SO2,64Da**)[Methionine sulfone](https://en.wikipedia.org/w/index.php?title=Methionine_sulfone&action=edit&redlink=1)  | No | No | Yes | No  |
| 149,(39s)[Methionine](https://en.wikipedia.org/wiki/Methionine%22%20%5Co%20%22Methionine)  | No | No | Yes | Yes  |
| 131,(147us) [Leucine](https://en.wikipedia.org/wiki/Leucine)  | No | No | Yes | Yes  |
| 131,(147us) [Isoleucine](https://en.wikipedia.org/wiki/Isoleucine)  | No | No | Yes | Yes  |
| 183,(**SO2,64Da**) [Homocysteic acid](https://en.wikipedia.org/wiki/Homocysteic_acid%22%20%5Co%20%22Homocysteic%20acid)  | No | No | Yes | No  |
| 163,(**S,32Da**) [Ethionine](https://en.wikipedia.org/wiki/Ethionine)  | No | No | Yes | No  |
| 149,(39s) [β-Hydroxyaspartic acid](https://en.wikipedia.org/wiki/3-Hydroxyaspartic_acid)  | No | Yes | No | No  |
| 161,(44h) [α-Aminoadipic acid](https://en.wikipedia.org/wiki/Alpha-Aminoadipic_acid)  | No | Yes | No | No  |
| 165,(29d) [Phenylalanine](https://en.wikipedia.org/wiki/Phenylalanine)  | No | Yes | No | Yes  |
| 132,(0.3ms) [Ornithine](https://en.wikipedia.org/wiki/Ornithine)  | No | Yes | No | No  |
| 117,(9ns)[Norvaline](https://en.wikipedia.org/wiki/Norvaline)  | No | Yes | No | No  |
| 119,(35ns) [Homoserine](https://en.wikipedia.org/wiki/Homoserine)  | No | Yes | No | No  |
| 119,(35ns) [2-Methylserine](https://en.wikipedia.org/w/index.php?title=2-Methylserine&action=edit&redlink=1)  | No | Yes | No | No  |
| 161,(44h) [2-Methylglutamic acid](https://en.wikipedia.org/w/index.php?title=2-Methylglutamic_acid&action=edit&redlink=1)  | No | Yes | No | No  |
| 181,(5250y) [Tyrosine](https://en.wikipedia.org/wiki/Tyrosine)  | No | No | No | Yes  |
| 204,(44By) [Tryptophan](https://en.wikipedia.org/wiki/Tryptophan)  | No | No | No | Yes  |
| 119, (35ns) carboxyl side chain[Threonine](https://en.wikipedia.org/wiki/Threonine)  | No | No | No | Yes  |
| 168,(234d) [Selenocysteine](https://en.wikipedia.org/wiki/Selenocysteine)  | No | No | No | Yes  |
| 255,(10e25y) [Pyrrolysine](https://en.wikipedia.org/wiki/Pyrrolysine)  | No | No | No | Yes  |
| 115,(2ns) ring [Proline](https://en.wikipedia.org/wiki/Proline)  | No | No | No | Yes  |
| 146,(5s) [Lysine](https://en.wikipedia.org/wiki/Lysine)  | No | No | No | Yes  |
| 155,(41m) ring [Histidine](https://en.wikipedia.org/wiki/Histidine)  | No | No | No | Yes  |
| 146,(5s)[Glutamine](https://en.wikipedia.org/wiki/Glutamine)  | No | No | No | Yes  |
| 121,(140ns) [Cysteine](https://en.wikipedia.org/wiki/Cysteine)  | No | No | No | Yes  |
| 132,(0.3ms) [Asparagine](https://en.wikipedia.org/wiki/Asparagine)  | No | No | No | Yes  |
| 174,(41y) [Arginine](https://en.wikipedia.org/wiki/Arginine)  | No | No | No | Yes  |

Conclusion: The molecules that were formed via spark and not by potential chemical reactions with the added H2S, were formed in a time frame consistent with the Marshall Model and experimental conditions. The molecules that were not found via any of the above experiments fall into three categories: 1) Enough time, but special structure (ring or side group with potentially incompatible nanosecond-scale resonance), 2) Enough time, but other experimental conditions not favorable for the molecule to form or 3) Experiment not long enough for the molecule to form. It is assumed that if larger molecular weight organic, or proteinogenic molecules were found, they would have been reported. The model predicts that molecules of MW>200 would require a 4.7 Billion-year-long Miller-Urey process to randomly self-organize, with the latter time frame being the evolutionary geological age of the Earth. The largest molecule found was Homocysteic acid (183 Da). It is among 3 other subsequent chemical by-products reacting with the seeded H2S after the random self-assembly of Methionine (149 Da) which has a Tmin of 39 seconds. Taken together, the Marshall Model and Miller-Urey Experimental results suggest that the Earth is not geologically old enough to randomly form >200 Da molecules, and there was certainly not enough time to randomly form an average protein molecule of 50,000 Da via self-organization, even under electrical discharge conditions.