

useful at all for multiplying two divergent series. Additionally, it should be evident that, even if the formula for the Cauchy product of a divergent series converges, it does not mean that the Cauchy product represents in any significant way the true value of the product of the two series. It simply means that, when half of the terms are not considered, the result is convergent. That does not yield a significant amount of confidence in such a result.

## Conclusions and Clarifications

In (Bartlett, Gaastra, and Nemati, 2020), Section 11.2 hedged on the consideration of series rearrangement, suggesting that we could not rule out that rearranging series might cause the series to differ by an infinitesimal. However, the problem was that we were considering the results of Cauchy Products, which, here, we have shown are not representative of true products of divergent series.

As already noted, divergent series can, using hyperreals, be evaluated in the same way as if they were finite series. However, even though they can be treated similar to finite series, that is not the same as saying that they can be treated as convergent series.

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Bartlett, J, L Gaastra, and D Nemati (2020). "Hyperreal Numbers for Infinite Divergent Series". In: *Communications of the Blyth Institute* 2.1, pp. 7–15.



## Following the Science

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More and more frequently we are hearing the words "follow the science" spoken by those who believe that they are right and are frustrated by those who disagree with them. It sounds good: we should avoid illogical or emotional responses and just focus on what is proven to be correct. Of course, no one wants to be wrong, and so we tend to just go along with the opinion of experts in the field. We don't want to waste time in rehashing old arguments that have been proven to be incorrect. Let's just move on.

But what if this phrase is used to stifle questions that don't fit a socially or politically accepted idea, especially if the questions are targeted at some weakly supported foundational concepts? If you don't want to permit debate on a topic that you might not decisively win, you might just tend to bluster your way out through intimidation. Stating "Follow the Science" implies that the opposing view is unscientific, and so should be immediately discounted and dropped from consideration. How could anyone possibly support such a weak idea?

Are there any specific examples in which the "Follow the Science" slogan has been used to support an increasingly weak argument and deflect a question that can't be clearly countered? We think that the complexity of cells is one such area. It is framed in the struggles between the two camps: Evolution versus Intelligent Design.

Take, for example, the article "The Flaws in Intelligent Design" (Collinsworth, 2006). In explaining what is wrong with Intelligent Design, the author first characterizes ID proponents as those who want to "challenge evolution and promote fundamentalist-friendly 'science' in public education and public discourse" implying that ID proponents are not really scientists. It then goes on to state:

"Regarding ID's specific claims, scientists object that the concept of "irreducible complexity" relies upon a mischaracterization of biological mutation as a relatively linear process involving only the addition of more and more "parts," rather than a dynamic process that can also reshape, rearrange, or fundamentally alter existing elements and features. Systems that must be fully formed to serve their current function could have developed from earlier forms that served a different function, or could be significantly reorganized versions of an earlier form that served the same function.

Mathematicians are similarly critical of ID's mathematical arguments against evolution, which rely on an excess of subjective calculations, manipulation of numbers, and misrepresentations of evolutionary models."

The narrative in the first paragraph about dynamic reshaping and rearranging of existing elements would be more compelling if it included references to data, observations, or at least models of such modified biological forms, rather than just a shallow statement that it "could have developed". The best long-term data on real-life mutations is the 50,000 generation study of *E. coli* by the Richard Lenski lab at Michigan State University (Lenski, 2021). The data shows only a "relatively linear" and minor history of changes, rather than dynamic rearranging

and reshaping. If millions of generations are needed to "fundamentally alter existing elements" by evolution, then some mathematical modeling should be included.

Within any community of researchers, certainly some work is bound to be questionable, but are all Intelligent Design proponents guilty of "subjective calculations" and "manipulation of numbers"? And are all evolution proponents "unbiased" scientists? We would encourage more specific criticisms of the mathematical models and underlying assumptions that have been proposed.

The website, *Rational Wiki* attempts to show the power of evolution by including Richard Dawkins' illustration of using a random letter generator to arrive at the phrase "METHINKS IT IS LIKE A WEASEL" from a random string of 28 letters and spaces after only 43 iterations (Rational Wiki, 2018). The problem with this illustration is that Dawkins programmed in the final outcome to decide which letters to keep for the next iteration. A truly random (undirected) experiment would not "know" its goal until it reached it. It would generate string after random string and compare it against the target phrase. Since there are about  $10^{40}$  possible combinations, even running the generator at once per second gives only an infinitesimal chance of arriving at the target in any reasonable time.

Even if you widen the target to any meaningful 28 character phrase, you still are swamped by wrong results. You might compare this to the chances of making some type of organelle out of pre-existing amino acids. Making the generous assumption that there might be 1 billion meaningful phrases, we would still have a hard time finding them among the other trillions of trillions that are meaningless gibberish. You can make a case that Dawkins' example is a one of "subjective calculations" and "manipulation of numbers". Ironically, Dawkin's example is actually a great example of irreducible complexity; all the letters need to be right at once to obtain the "functional" phrase. We need better illustrations of the power of Evolution.

Of course, the complexity of biology is such that you need many more than 28 characters of information (or of amino acids) to arrive at a functional unit (perhaps a protein), and the possible combinations grow exponentially. The numbers grow to where even the powers of trillions of trillions of organisms mutating over billions of years still fall short of what is necessary to produce the "current function" from an "earlier form", even by rearranging existing elements. We must remember that the organism and each sub-system must be marginally functional at each step in the process. It cannot continue to exist while waiting for the other needed components to be borrowed from other organisms. And there is no reason for components to be retained for future generations unless they perform some beneficial function in that generation.

We offer a specific challenge: to develop counter arguments to the assumptions and calculations in a paper describing the hurdle to adding a new feature to an existing organism. Several years ago, we calculated what it would take for a very simple, single-celled organism, *Chlamydononas reinhardtii*, to develop the ability to detect light. This organism is a motile, single-celled green alga. It has a chloroplast to make its own food (glucose), an eyespot to detect light, and flagella to swim to the light. We assumed that it was living in an appropriate environment and had assembled the structure of a simple eyespot, but only needed a few more proteins to begin to function. Obviously, a functioning eyespot would give it a great survival advantage. We assumed that most of the 200 or so proteins found in a modern day functioning eyespot were present, as well as the signaling and motility systems, and we would just need 10 more small proteins to make the eyespot functional. We calculated that there were over  $10^{600}$  ways of assembling amino acids into potentially functional proteins (E. A. Siewert and T. A. Siewert, 2017). Even if every particle in the universe (about  $10^{80}$ ) were an amino acid and they were interacting at 1000 Hz, they have only a negligible chance of forming the necessary proteins within the life of the universe, much less getting the proteins into the correct location in the eyespot. We would welcome alternative models/proposals to improve or criticize this model.

"Follow the Science" is good advice, but the hurdles to Evolution at the cellular level are substantial. We should carefully weigh all the data (both for and against) before we accept Evolution as a valid mechanism for the formation of complex life.

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