



Engineering and Evolution

Earlier this year, the *Engineering Research Group* (headed up by Steve Laufmann) held a “Conference on Engineering and Living Systems.” The so-called *CELS* conference brought together biologists and engineers of every stripe to see how the disciplines might work together.

Of interest, this group is somewhat of an outgrowth of conferences held by The Blyth Institute over the years. In 2012, The Blyth Institute held an interdisciplinary conference at Oral Roberts University which brought together engineers with academics of many other disciplines to discuss how ideas, attitudes, techniques, and ways of thinking from engineering might usefully benefit other areas of inquiry, and vice-versa. Most of the talks from this conference are still available online at <https://www.youtube.com/playlist?list=PL392C752E633E1B6A>. This conference papers from this conference were collected and resulted in the book *Engineering and the Ultimate: An Interdisciplinary Investigation of Order and Design in Nature and Craft* (J. L. Bartlett, Halsmer, and Hall, 2014).

A few years later, The Blyth Institute did a followup online conference on methodological issues that stemmed from an engineering view of the world, titled the *Alternatives to Methodological Naturalism (AM-Nat)* conference. Most of the talks from this conference, too, are still available online, and can be found at <https://www.youtube.com/playlist?list=PL8ftIIJ7ANZhtWj1GMRC1yXKDsI6VTk7R>. The papers from this conference were collected into the volume *Naturalism and Its Alternatives in Scientific Methodologies* (J. L. Bartlett and Holloway, 2017).

Although the leadership of the *Engineering Research Group* were not part of these conferences, much of the early interest around these subjects grew out of these conferences, and many of the early members of the *Engineering Research Group* came out of these two conferences. Indeed, several of the talks given at the *CELS* conference were outgrowths of research projects which were presented at the two early conferences. While The Blyth Institute did not present at the *CELS* conference, we

are pleased to have played a part in laying the groundwork for these kinds of inquiries, conferences, and conversations.

Evotypes and the Engineering of Evolution

From a different angle, other research groups are considering the engineering applications of evolution. The *Biocompute Lab* from the University of Bristol is working on an “engineering theory of evolution.” Castle, Grierson, and Gorochofski (n.d.) proposes that, because evolution is so different from anything humans normally design, we need a theory of engineering which encapsulates the way evolution works so that evolving systems can be integrated into engineering ones.

They propose the “evotype,” which is essentially treating evolutionary capability as a phenotype. They consider the “design type” of a system to be a single system that exists as engineered, and the “evotype” captures the evolutionary dynamics of the system.

While Castle, Grierson, and Gorochofski (n.d.) was primarily concerned with using biological principles to build non-biological systems, similar ideas have been presented in the context of biological systems themselves. Caporale (2006) dealt with what she called the “implicit genome”—the set of all the likely future evolvable pathways, which is roughly equivalent to the “evotype.” J. Bartlett, Gaastra, and Nemati (2020) pointed out that this sort of potentiality can actually be measured using active information, and proposed how this information could be used in engineering contexts.

While the “evotype” is not a brand new concept, the creation of a standardized term for this notion can help to better orient future inquiries.

The Passing of a Generation

The last several months has heralded the deaths of many prominent scientists and biologists, including:

- **Richard Lewontin** (1929–2021): Lewontin was a geneticist who was much more in tune with his philosophical side than many of his colleagues. He not only pioneered the application of molecular biology to the study of evolutionary dynamics, but also concerned himself with the philosophy of science and its intersection with the public dialogue. His most widely-read work was a popular review of Carl Sagan's *The Demon-Haunted World*, titled "Billions and Billions of Demons" (Lewontin, 1997). However, his most lasting contribution is likely his critique of the overly simplistic relationship between adaptation and natural selection often suggested by many biologists (Lewontin, 1978). An obituary can be found in Brown and Rose (2021).
- **Steven Weinberg** (1933–2021): Weinberg is often considered the greatest theoretical physicist of all time, earning the Nobel Prize in 1979. He unified electromagnetism and the weak force in physics into the electroweak force (Weinberg, 1967). An obituary can be found in Giudice (2021).
- **Thomas Cavalier-Smith** (1942–2021): Cavalier-Smith was a highly regarded taxonomist who pushed forward Lynn Margulis' endosymbiotic theory. He argued for a "mitochondrial-late" model, in which the eukaryotes develop without mitochondria, eventually engulfing relevant bacteria through phagocytosis (Cavalier-Smith, 2006; Archibald, 2015; Gray, 2017). An obituary can be found in Richards (2021).
- **Gilbert Levin** (1924–2021): Levin was the principal investigator for the *Viking* Mission Labeled Release experiment, which, though controversial, he believed showed evidence that there was microbial life on Mars (Levin, 2016). He continued to play a prominent role in the field of astrobiology throughout his life.

While *CBI* does not normally post obituaries, the passing of so many seminal scientists in such a short period seemed noteworthy.

Evolutionary Primality of the Bacterial Flagellum

One issue that has been contentious over the past few decades is whether or not the flagellar motor evolved from the Type III secretory system. This has sparked debate over the years, but it seems that this question is coming to a close in favor of the primality of the flagellum. This has been confirmed by multiple studies, most recently Deng et al. (2017), Denise, Abby, and Rocha (2020), and Coleman et al. (2021). Even former vocal critics of this idea (Pallen and Matzke, 2006) are now convinced (Matzke et al., 2021).

Writing Using (only) Your Imagination

A recent paper describes an amazing new technology which allows paralyzed people to write using their thoughts alone (Willett et al., n.d.). Essentially, implanted electrodes allow a person to simulate the motor output for handwriting. This "handwriting" is then used as input to a neural network, which decodes the handwriting into typed letters. The research group was able to achieve 90 characters per minute, which is close to the speed at which most people text (115 characters per minute).

Correcting Misconceptions About Abiogenesis

Synthetic chemist James Tour recently put together a video series correcting common mistakes about abiogenesis (Tour, 2021). This video series covers widespread confusion about abiogenesis from ordinary individuals, the media, and even professionals. Tour presents many issues that are not adequately publicized about abiogenesis research, focusing especially on two issues.

The first is the prevalence of using chemicals that are only found *within* biology to perform abiogenesis chemical tasks. From a synthetic chemistry perspective, since these reactions would have to occur outside the context of biology, using biologically-derived chemicals, while it may allow the reaction to work, prevents studies from actually discovering much about abiogenesis.

The second is the problem of using a "relay synthesis." Oftentimes in abiogenesis studies, reactions will result in a mixture of a variety of compounds. This variety of compounds will

then prevent future reactions from going forward. Therefore, rather than using the products of the previous reaction to go into the next reaction, the desired isolated end-product is purchased pure and then diluted to the proper concentrations prior to the next reaction.

These two features are surprisingly common in abiogenesis research, and call into question much of the chemical claims for abiogenesis research about what could have been synthesized abiotically on the early earth.

The Science of Consensus-Forming

The AMISTAD lab from Harvey Mudd College in California shows that a “consensus” is only valid for believing a proof if the consensus was formed by people whose thinking was independent (Allen, Lay, and Montañez, 2020). That is, if multiple experts came to the same conclusion independently, then the consensus has a much higher probability of being true. However, if those same experts were coerced, or even influenced by the prior idea of a consensus, then the epistemic value of having a consensus shrinks quickly.

Novel Bacterial Evolved on the Space Station

Research has started to be done on the effect of space travel to evolution. Recently, four novel strains of *Methylobacteriaceae* have been found on the International Space Station (Bijlani, Singh, et al., 2021). These are being named after Ajmal Khan, a renowned Indian scientist and biodiversity specialist. In another article, the authors have discussed the present and future of space microbiology (Bijlani, Stephens, et al., n.d.).

Evolution and Teleonomy

A recent conference was held by the Linnaean Society of London called *Evolution ‘On Purpose’: Teleonomy in Living Systems*. This conference discussed the roles of intentionality in evolution, and how this affects evolutionary theory as a whole. Various aspects of teleonomy and teleology were discussed by a variety of renowned scholars, including Peter Corning, Richard Vane-Wright, Stuart Kauffman, Eugene Koonin, Eva Jablonka, and several others. Videos of the conference are available on the Linnaean Society YouTube channel on the playlist for

the conference at <https://www.youtube.com/playlist?list=PLgVH1uF5LKVUjNAwFiZKeTD0ZmFVaS4yd>. The Blyth Institute participated in the conference, giving a short analysis during the refereed commentary session and taking part the the discussion session.

Experimental Results

A new journal from Cambridge University Press was launched last year called the *Journal of Experimental Results*. The idea behind this journal is to record experiments that have less “story” to them. The aim of this journal is to support research groups doing replication experiments or who want to publish experimental results that don’t necessarily have a surrounding theory. The journal will also publish negative or inconclusive results.

Typically, journals are biased towards results that are (a) positive, (b) novel, and (c) attached to an underlying theory. However, this does in fact bias the output of journals. The goal of the new journal is to combat this bias by providing an outlet for experimental studies that don’t typically “fit in” in this way. The website for the journal can be found at <https://www.cambridge.org/core/journals/experimental-results>.

Human-Generated Machine Learning Models

Blyth Institute researcher Eric Holloway has done quite a bit of work with human-in-the-loop machine learning, which he terms “imagination sampling” where humans participate in building machine learning models (Holloway, 2017; Holloway, n.d.; Holloway and Marks II, 2016). Recently, another researcher has begun developing tools to facilitate imagination sampling with the “human learn” project (Warmerdam, 2020). This includes a tool that lets people draw groups around datasets, and the drawings get converted into machine learning models. We are excited that more people are recognizing the value of imagination sampling and its role in the machine learning ecosystem.

A demonstration of the tool can be found at <https://koaning.github.io/human-learn/#interactive-drawings>.

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