BEZOS EARTH FUND

AI for Climate and Nature Grand Challenge

Sustainable proteins

Focus area

The problem

For plant-based, fermented, and lab-grown meat substitutes to be successful, they need to replicate the appearance, texture, taste, and nutrition of meat and come in at a price equal to or lower than meat for consumers. This is an enormous challenge — the unique textures and flavors of different meat products and cuts require a complex combination of novel ingredients, processed in the right way and combined into a product that pleases consumers with varied tastes and preferences. Traditionally, the development of these products has relied on repeated experimentation which is costly, given the number of inputs, processing steps, and methods. Given how labor intensive and pricey such experimentation is, costs remain high and smaller manufacturers are prevented from entering the market, limiting varieties and accessibility. Scaling also remains a significant challenge — according to one study, 90% of synthetic biology technologies fail to scale given that research and development is too expensive and slow.

The opportunity

While the current generation of sustainable proteins may fall short of convincing consumers of their ability to deliver a product equal or better to animal-sourced meat, they have only touched the surface of the possibilities in terms of optimizing ingredients and processing. New approaches to discovering and unlocking the myriad of ingredients and processing methods that deliver a product that best mimics the complexity of meat will bring about a new generation of sustainable protein products that can meet expectations of consumers. Some of the opportunity areas for using AI-based approaches to enhance the quality and cost of sustainable proteins include:

- **End-product formulation:** The complexity of food ingredients like "protein isolates," which contain thousands of molecules, make it difficult to have predictive capacity to determine which formulation adjustments will deliver the desired effects. Instead of a scientist doing this manually, with so many combinations of variables, AI can help them try and fail many times, quickly.

For example, scientists have recently used AI to find an isolated protein in mung beans that has similar properties to scrambled eggs. Without AI, it would have taken years to identify this solution.

- **Protein engineering:** The production of proteins themselves is central to the shift to sustainable proteins. Proteins have evolved over billions of years and are comprised of chains of amino acids that fold in complex three-dimensional shapes. AI can be used to design such patterns by modifying genetic sequences to optimize for certain properties. AI allows protein formulation to move from an iterative art to more of a predictive science.
- **Strain/cell line development:** Regardless of the organism being used to develop a sustainable protein product (plant crops for plant-based meat, microbial strains for fermentation-derived proteins, or animal cell lines for cultivated meat), AI can improve our understanding of what modifications to these organisms would facilitate greater growth efficiency or bias them toward desirable traits.
- **Feedstock optimization and cost reduction:** For fermentation and cultivated meat, feedstocks for cell growth are a major contributor to unit economics and are highly influential in the overall sustainability of the production process. Optimizing feedstocks and culture media formulations is a highly complex process that requires multi-variate analysis and nuanced tradeoffs between performance, cost, availability, and many other factors. Next-generation growth media can use AI to test thousands of novel combinations of ingredients and rapidly adapt feedstock formulations to changes in feedstock cost/availability.
- **Process development and efficiency improvement:** Digital twin technologies can facilitate rapid process development improvements for greater efficiency using manufacturing process simulations. Biosensors and process monitoring technologies coupled with AI can inform process tweaks for subsequent runs without the cost- and time-intensive need to test multiple parameter tweaks in an actual pilot- or demo-scale run.