The Promise of Cellular Seafood Production

To the list of methods of seafood production that include wild capture and aquaculture, we can now add cellular culture in sterile laboratories. The products of this process, which has even been called cellular aquaculture, are termed lab-grown, cell-based, cell-cultured, clean or in vitro seafood. Basically, the practices of biological tissue engineering are applied to the production of artificial muscle proteins that are then used as food. The product can be considered biologically equivalent to seafood obtained by traditional means.

For seafood, the procedure starts with a biopsy of an anesthetized fish. The tissue sample is digested with collagenase or trypsin. Stem cells are isolated and grown in bioreactors under optimum conditions. The nutrient solution contains elements required for cell growth: amino acids, fatty acids, sugars, salts and vitamins. In some cases with meat, fetal bovine serum is also used. The solution is agitated to keep cells in suspension and avoid clumping. Cells are then concentrated with a centrifuge and applied to a scaffold of collagen for adhesion and further proliferation into muscle tissue. The scaffolds create channeled networks for cell growth. It seems likely that 3-D printing technology will be applied in the near future to print scaffolds in the form of specific and familiar shapes and that apply cellular bio-ink.

Cellular seafood production has followed the broader trend of cultured meat, which broke onto the scene in 2013 with a plant-based meat burger produced in a laboratory. Cultured meat (and seafood) are part of a larger trend of alternative protein production that include plant-protein analogues and edible insect protein. It seems like the stuff of science fiction but is quickly becoming part of modern life. There are about 20 companies worldwide working on growing cellular meat and about six that are working on cellular seafood. Start-up cellular agriculture companies have attracted significant investment capital and the interest of companies like Tyson and Cargill.

The company Impossible Foods makes a plant-based meat burger that the fast-food chain Burger King is now selling as the Impossible Whopper. Beyond Meat uses a plant-based version of heme to make a burger that faithfully imitates a real one. The company called Just makes chicken nuggets in the laboratory.

In the seafood world, Finless Foods was the first company to develop fish products, starting with carp croquettes and is now working on bluefin tuna that can be used in sushi rolls. Finless Foods can grow muscle, fat and connective tissue from stem cells. BlueNalu is working on high-value fish species that are difficult to farm, such as mahi mahi and Patagonian toothfish. Wild Type is working on cell-based salmon production. Shiok Meats from Singapore is making lab-grown shrimp and is working on crab and lobster. There are also related companies that do not use stem cells but rather produce plant-based seafoods, including New Wave Foods, Ocean Hugger Foods, Good Catch Foods and Sophie's Kitchen.

The companies involved in producing cellular meat and seafood have been vocal about the promise and potential of cellular agriculture and aquaculture, especially its "clean" aspects. Cellular seafood would be free from environmental contaminants such as mercury and other persistent toxins, hormone and antibiotic residues and microplastics. Bacterial contamination (spoilage) would be better controlled.

The environmental footprint of cellular meat is smaller than conventional products across a range of impact categories. Life cycle assessments of hamburger meat indicate lower greenhouse gas emissions, lower eutrophication potential, and less land and water use in producing the cellular product. The environmental issues surrounding concentrated animal production could be avoided. Cellular seafood would address concerns about overfishing, IUU fishing, and use of slave labor. There are no animal welfare issues associated with crowding or slaughter.

Despite the rosy outlook envisioned, many technical and social impediments remain. Consumers are generally wary of food produced by cellular agriculture, which is seen as not natural and maybe a little disgusting. At least in the US, there is considerable uncertainty about how to regulate cellular seafood, with overlapping jurisdiction by the USDA, with regulatory authority over "food," and the FDA, with regulatory authority over "food products."

However, seafood is not just a collection of food products; these have connections to living animals, to particular places of land and water, and to the people who catch or raise them. The realness of seafood is related to the story of those connections. Cellular meat and seafood is seen by some as somehow fake and artificial.

Further, it seems likely that cellular agriculture will be ultimately controlled by large transnational agribusiness corporations in alliance with Silicon Valley start-ups. However, one can also envisage relatively small cellular seafood production facilities producing a highly-tailored local "craft" product.

At one level, this is about the political implications of particular food choices. The rise of vegan diets and planetary health diets indicates that a certain segment of consumers wants to eat diets that are simultaneously healthy and sustainable. Eating cellular meat and seafood may be a better choice in that context.

The implication of the discussion or debate between advocates and opponents of cellular seafood is that cultured seafood can replace or substitute for wild or farmed seafood. It is similar to arguments that were made about how aquaculture will take pressure off of wild fish stocks, arguments that have not been borne out. Really, cellular seafood should be seen as just another source to add to the seafood supply, even though it currently accounts for a trivial quantity. It can coexist with fisheries and aquaculture.

We are going to be hard-pressed to feed 10 billion people by 2030. Thus, the idea is not to replace seafood produced in fisheries or aquaculture with cellular seafood but to add to the overall supply. There's room and a need for all sources to improve global seafood security.

— John A. Hargreaves, Editor-in-Chief