	Selected Emerging Agriculture Technologies Through 2040				
What is the Emerging Technology?	**Cellulosic ethanol** is the advanced biofuel nearest to commercial development but is still probably a decade away from commercialization. This second-generation biofuel is derived from various types of biomass feedstocks including agricultural and forest residues, such as switchgrass and poplar, and municipal waste.	**Molecular breeding** in both plants and animals uses gene technology to identify the genetic origin of a trait or group of traits that are either desired or undesired and then selectively bred to develop improved organisms.	**Vertical Greenhouse Farming** is based on the concept of containing a greenhouse operation within a skyscraper building. Such buildings are often solar powered, use hydroponics and aeroponics to grow crops, and recycle all water and waste.	**Open Ocean Systems** use large cages or containment structures in open seas—which can be free floating, secured to a structure, moored to the ocean bottom, or towed by a vessel—to raise and harvest fish.	**Precision Agriculture** techniques tend to focus on discovering how factors like soil quality, water availability, and drainage patterns vary within a single field, and then adapting planting, harvesting, and management strategies to address those variations.
Why is the Technology Important?	By 2030, a transition to next-generation technologies that convert biomass, rather than food crops, to advanced biofuels and chemicals will be essential to minimize disruptions to food commodity markets.	Using marker assisted-breeding to determine the best cross breeding and progeny shortens the development time for an improved cultivar or breed of animal by two to five years over conventional breeding. With the uncertainty of climate change and the expected resistance to genetically engineered crops, drought-tolerant and salt-tolerant plants are being developed through molecular biology techniques.	A vertical greenhouse farm is a self-contained, self-powered operation that can be built nearly anywhere, including in a desert or urban area. The technology might be able to produce yields 20 times those of conventional agriculture with 95 percent less water, but it will be energy inefficient unless renewable energy sources can be interwoven into the design.	With oceans occupying most of the earth's surface, the ability to use these spaces could dramatically change the nature of human food production. With capture fish production stagnating and more fisheries being overexploited, the increase in demand for fish products will have to be met by aquaculture.	Precision agriculture management strategies can significantly increase crop yields or reduce costly inputs like seed, fertilizer, and herbicides.
Drivers and Barriers to Adoption	**Key Drivers:** High crude oil prices, the desire to lessen dependency on foreign oil sources, moving away from competition with food crops, and government policies to increase renewable energy sources. **Key Barriers:** Developers are just beginning to scale up new biofuel technologies to commercial production and face significant technical and financial risks. The push for very high-efficiency vehicle technology, including hybrid and pure electric vehicles and hydrogen-powered fuel-cell vehicles, could depress demand for traditional fuels and biofuels.	**Key Drivers:** The cost of gene sequencing and mapping is steadily declining to the point where these technologies are more readily available, and the need to develop plants and animals that can withstand harsher or more extreme environmental conditions is rising. **Key Barriers:** The cost of developing these new plants through molecular breeding is still higher than conventional breeding and tested genetically-modified varieties.	**Key Drivers:** Declining water and land resources and the ability to produce food closer to the source of consumption. **Key Barriers:** The cost of building the greenhouses and the level of automation that can be applied, as well as high energy needs.	**Key Drivers:** Growing demand for marine seafood while capture fisheries are depleting. Difficulty in raising many open ocean fish in traditional aquaculture systems. **Key Barriers:** Costs of large offshore installations designed to survive harsh seas and limit harmful environmental effects. Mechanization of key tasks is needed to minimize human involvement at sea while continuously monitoring environmental conditions and fish behavior and health.	**Key Drivers:** As farm sizes grow, greater emphasis on understanding intra-field variations and their effects on crop yield. In addition, the increasing affordability of satellite–navigation systems and various information technology resources necessary to generate, update, and take advantage of customized field maps. **Key Barriers:** Currently limited to large-scale industrial-agriculture practices that rely heavily on sophisticated farm vehicles. Automated guidance and application systems will have to decrease in size and cost to work well on small-scale plots in the developing world.