Genetics for a warming world

Record high temperatures are being seen worldwide, thus placing strains on human health and disrupting the availability of essential resources such as food and water. Aberrant weather patterns in the form of intense storms or prolonged drought have put pressure on our agricultural systems and underscored the need for adaptation to a changing climate across many sectors. Complex problems require complex solutions, and genetic approaches could be a powerful tool for helping to mitigate the effects of climate change.

Currently, scarcely a day goes by without a new report of increasing temperatures, melting glaciers, rising sea levels or anomalous weather phenomena affecting areas worldwide. From the wildfires of California to the record-breaking heat experienced in France this summer; and from the accelerated warming of the arctic to the increasing intensity of life-threatening storms forming in both the Atlantic and Pacific oceans, it is clear that we are living in a new reality. The fact that 18 out of the 19 warmest years on record have been since 2001 cannot be ignored. Such an all-encompassing issue as the warming of the planet requires big and bold responses from potentially many different disciplines, and there will be no simple solutions. Even so, genetic approaches are poised to positively contribute to the adaptation and resilience of the environment, both natural and human made, to dampen or control the effects of a changing global climate.

Genetics holds particular promise for meeting the challenge of adapting to a warmer world in the agricultural space. A few weeks ago, *Nature Genetics* co-organized a conference with New York University, titled Plants of the Future. The focus of the meeting was how to best meet the twin challenges of human population growth and climate change through genetic, genomic or other biological approaches, and to envision what the 'plants of the future' might look like. There is a pressing need for sustainable ways to increase the efficiency and yield of staple crops, and we are excited to see the energy and ingenuity being devoted to this issue. Specifically, using genetics and genomics methods can accelerate the identification or generation of crop plants that can survive and thrive in changing environments.

One of the avenues with the greatest potential for increasing crop yield and decreasing the need for synthetic fertilizers is harnessing plant–microbe interactions. Since the dawn of agriculture, plants have been bred for visible above-ground traits. Now is an opportune time to use existing genetic diversity and select for root-associated traits, such as those that promote beneficial plant–microbe interactions, to increase the efficiency of nitrogen fixation and yield. This increased efficiency would decrease the need for nitrogen-based fertilizer or improve nitrogen retention, thus resulting in less run-off and fewer negative effects such as toxic algal blooms and biological dead zones. As part of this process, the complexity of interactions, beyond those that are just pairwise, should be embraced.

The plant world is already full of amazing diversity, and drought-resistant or salt-tolerant species have been studied. Understanding the biology and genetics of extremophiles that can tolerate high temperature or low moisture could lead to strategies for the transfer or manipulation of genes and pathways in important crops to recapitulate desired traits. Non-traditional model organisms whose natural habitats reflect warmer (or wetter, drier or more saline) environments serve as biological templates that can be valuable resources for analyzing successful evolutionary trajectories and specific adaptations to harsher climes. Genome sequencing, population genetics and CRISPR technology will help to harness and implement this knowledge. We encourage further research into improving crops for sustainable agriculture, with the goal of generating plants with the resilience to respond to changing, and uncertain, environments.

A warming planet will have widespread effects beyond those centered just on plants and agriculture. Shifts in ecosystems that lead to the creation or destruction of interactions among species can have major consequences. For example, pathogens that are no longer kept in check by normal weather patterns in their endemic regions can expand their geographic sphere, reaching new unexposed populations. Genetic tools for monitoring and managing the emerging changes in the global distribution of organisms hold promise for helping humans adjust to these pressures brought about by climate change.

Life on planet Earth has always been able to respond to changing conditions. We believe that genetics research and applications, especially in agricultural science, will help to secure a sustainable future for humanity. ❐

Published online: 31 July 2019
https://doi.org/10.1038/s41588-019-0488-6