New genomes to help protect Britain's wild and ancient apples

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Credit: National Trust Images / James Dobson

The full genetic codes for Britain's only native wild apple, the European crab-apple, Malus sylvestris, and four heritage edible apple varieties have been sequenced by scientists. Together, these top-quality genome assemblies will allow researchers to better understand our apple heritage and will help prevent our wild apples being hybridized out of existence by their domestic relatives.

The genomes were sequenced at the Wellcome Sanger Institute as part of the Darwin Tree of Life project, a partnership including the Royal Botanic Garden Edinburgh and Royal Botanic Gardens, Kew. The project aims to produce high-quality genomes for every plant, animal, fungus and single-celled protist in Britain and Ireland.

The apple genomes are published today in Wellcome Open Research.

The European crab-apple is probably one of our least understood and most under-appreciated native trees. M. sylvestris was one of the wild species that gave rise to our domestic apples in ancient times. But now its genetic integrity is being undermined by hybridization with widely-planted domestic relatives. Nearly 30% of the wild apple trees surveyed in a recent study turned out to be of hybrid origin. There are now calls for better protection in areas of northern Britain where "pure" crab-apples are still found in high numbers.

"Research on wild apple trees in Europe and the U.K. has shown that hybridization with domesticated apple can be widespread. This may lead to the genetic erosion of wild apple, an important contributor to many of our cultivated apple varieties. Having access to the full genome of both species we can increase our understanding of this process and how it may affect the future of our native species. For example, by screening hybrids we can investigate if certain genes are preferentially passed on during hybridization and thus likely to be incorporated long term in the genetic background of wild apple," says Dr. Markus Ruhsam, Royal Botanic Garden Edinburgh.

The genomes will enable researchers to see how domestic apple cultivars—cultivated varieties—were grown and transported across Britain and Ireland over centuries. Scientists can also go further back in time to study their evolutionary journey from the mountains of Central Asia.

Alongside the wild apple, scientists sequenced four varieties of the domestic apple, Malus domestica:

- The Flower of Kent—a cooking apple, also known as "Newton's Apple." Most existing trees are thought to descend from the one

at Woolsthorpe Manor which inspired Sir Isaac Newton's law of universal gravitation.
- The Costard—one of the oldest apples recorded in England's historical records, a popular variety for hundreds of years before falling out of fashion.
- The Brown Snout—a cider apple originating in the 19th century in Herefordshire, its russety top inspiring its name.
- The Bardsey Island Apple—an eating apple with a distinctive lemon aroma, rediscovered on an island off northwest Wales and believed to have originally been grown by medieval monks.

Despite a rich apple heritage, it is estimated that more than 50% of all apples sold in the U.K. are for the varieties Gala and Braeburn, which are not native to the U.K. but rather developed in New Zealand.

"Britain and Ireland have a rich history of apple growing, with the first apples reported on our islands over 800 years ago. This may well explain the remarkable diversity of around 2,500 apple varieties that have been developed here, out of an estimated 7,500 recognized globally, even if there is a limited diversity on our supermarket shelves. Nevertheless, the rich variety of apples sequenced by the Darwin Tree of Life project opens exciting opportunities for new discoveries and exploring new genomic data may reveal biochemicals with the potential benefit for medicines and human health, thus giving even more relevance to the well-known saying—an apple a day keeps the doctor away," says Dr. Ilia Leitch, Royal Botanic Gardens, Kew.

In order to better understand our apple heritage, scientists also produced DNA sequences for more than 40 additional British and Irish apple varieties. Using comparative genomics, they built an apple family tree that showed how varieties are related and how they had been moved around Britain and Ireland. This is particularly interesting for apples, which do not "grow true," meaning they do not produce an identical plant by planting pips alone. They instead need to be grafted onto another apple tree, a horticultural technique dating back thousands of years.

Researchers can use these genomes to look to the future as well as the past. In the case of important crops like apples, they can study the genetic code to create better and more resilient crops in the future—essentially turbocharging the selection processes farmers have relied upon for millennia. Not only will this help breed more appealing fruit in future, it could also prove important in protecting the industry from environmental impacts such as climate change.

This might involve identifying specific genes for resistance to diseases that affect apples, such as the fungal infection known as "scab." Researchers also hope to be able to increase the content of some of the chemical compounds produced by apples, which have been associated with important health-promoting benefits such as protection against cardiovascular disease and the treatment of diabetes.

"By generating genomes for every lifeform living in Britain and Ireland, we not only better understand our environment but also our place within it. Ours is a landscape shaped by humans and it is sobering to realize that our actions drive not only visible habitat degradation but also a hidden genetic degradation of important wild species. Genomic information also allows us to peer into the past history of important crops, to look to the future of agricultural science, and address the conservation issues of today. The reference genomes produced by the Darwin Tree of Life are powerful, freely available tools that help us transform the way we do biology," says Professor Mark Blaxter, Wellcome Sanger Institute.

Provided by Wellcome Trust Sanger Institute

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