TechTalk with Dr. Shawn Burgess
Basics of Genome Editing (CRISPR/Gene Editing)
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What is the history of genome editing?

Gene editing started before we understood what "genes" were—with breeding animals and produce for specific desired traits. Spontaneous mutations have been occurring for more than 5,000 years, and for about the last 100 years, we have known that we can induce mutation through radiation, chemical, and insertional means. The discovery of Zinc Finger Nucleases (ZFNs) about 22 years ago and engineering of Transcriptional Activator-Like Effector Nucleases (TALEN) about 15 years ago served as precursors for Clustered Regularly Interspaced Short Palindromic Repeats/CRISPR Associated Protein 9 (CRISPR/Cas9) technology.

What is the basic premise of CRISPR?

CRISPR/Cas9 essentially acts as scissors, cutting across the double-stranded DNA in a targeted location.

Why has CRISPR become so influential?

Although cells are able to rebuild DNA that has been damaged or broken, CRISPR/Cas9 is so efficient and cuts so often, an error will eventually be introduced in the rebuilding process, thereby deactivating the targeted gene. It is also feasible to pair the CRISPR/Cas9 technology with methods to add or change base pairs, but this is not currently as reliable as the "knock-out" process.

What societal implications or ethical issues should we be aware of?

- Genetically modified organisms (GMOs): These have been around for a very long time. The US is relatively loose about GMO rules but many countries require labelling to identify GMOs in food and other goods. Transgenic plants and CRISPR/Cas9-modified plants are typically classified as GMOs, whereas plants with naturally-occurring mutations or mutagenesis through chemical induction have not been similarly classified, despite the same end product. This potentially means the law has yet to catch up with CRISPR technology.
- Gene drives: CRISPR technology can impact both sets of a given gene, resulting in "gene drive inheritance." This means that mutations made in this fashion will be transmitted to all offspring within three generations, and could therefore be used to modify entire populations. This has significant implications for the natural environment and biological development and would be difficult to control in the wild.
- Gene therapy/eugenics: Gene therapy represents a promising application of CRISPR technology, although the primary limitation is ensuring delivery to all necessary cells in vivo. However, it is feasible to use this method to alter the germ line, editing an embryo in vitro prior to implantation. A rogue scientist in China did just that, producing gene-edited human children. Although controversial terms of implication, the project was intended to prevent the children from inheriting HIV from their mother. Currently the two children are healthy, but this led to a full global moratorium on germ line editing and an annual summit on human genome editing.
- Intellectual property conflicts: An ongoing administrative trial within US patent law persists between Berkeley and Massachusetts Institute of Technology/Harvard, with patent disputes over the CRISPR technology.