The first part of this talk will cover the basics of the Laser Interferometer Gravitational-wave Observatory (LIGO) detectors and the science they enable, highlighting recent detector improvements and contextualizing LIGO in the growing field of gravitational-wave science. Next, I will turn to the future and discuss some as-yet-undetected classes of gravitational waves, particularly long-duration signals expected to emanate from rapidly spinning neutron stars. Throughout the talk I will emphasize efforts to identify and mitigate instrumental noise sources in the LIGO detectors, an endeavor which connects topics from astrophysics to instrument science.