Millimeter-wavelength measurements of polarization in the Cosmic Microwave Background (CMB) have the potential to test the cosmological theory of inflation, probe physics at Grand Unified Theory (GUT) energy scales, constrain the sum of neutrino masses, and even provide precision tests of General Relativity. SPT-3G is a next generation CMB polarization experiment on the South Pole Telescope (SPT), to be deployed in late 2015. Through a major upgrade to the SPT optics and a multi-chroic polarization-sensitive camera employing 15,234 detectors, SPT-3G will provide over an order of magnitude increase in mapping speed over the currently deployed SPTpol instrument. So-called "B-mode" polarization anisotropy produced by gravitational lensing of the CMB by intervening matter was recently detected by SPTpol with 7.7-sigma significance. The SPT-3G program will enable the advance from statistical detection of B-mode anisotropy to high signal-to-noise B-mode maps. This will lead to precise constraints on the sum of neutrino masses with the potential to directly address the mass hierarchy. It will also allow a separation of the lensing and inflationary B-mode power spectra to improve the potential detection of the inflationary B-mode signal. Via the Doppler signal in pairs of galaxy clusters, it will also provide a precision test of General Relativity on ~200 Mpc scales. In this talk, I will describe the planned new camera and optics, and the new science that the SPT-3G experiment will enable.