Key points from Lecture 24 of ASTR 350

1. There will be future detectors like LIGO but better, and with more detectors around the world this will help localization of events and will also mean that for a given event there is a better chance that several detectors will be on.
2. For a gravitationally bound object (that's virtually every big thing in the universe) of mass M and radius R the highest possible frequency is similar to the orbital frequency at R: $f_{\rm max} \sim (GM/R^3)^{1/2}$. For a black hole, $R \sim M$, so $f_{\rm max} \sim (M/M^3)^{1/2} \sim 1/M$.
3. This means that at lower frequencies we can see higher-mass black holes. We can also see neutron stars and lower-mass black holes farther from merger, as well as other binaries such as white dwarfs and (at yet lower frequencies) ordinary stars. This is part of the drive to look at lower frequencies, and the full GW spectrum runs from $\sim 10^{-17}$ Hz (roughly 1/age of universe!) to $\sim 10^4$ Hz.
4. Planned space mission: the Laser Interferometer Space Antenna (LISA); projected launch 2037. Frequency range $\approx 10^{-4} - 10^{-1}$ Hz, can see black holes of mass $\sim 10^4 - 10^7\ M_\odot$. There are also "calibration binaries", double white dwarf binaries we can see now with known amplitude and frequency, which will tell us whether LISA works!
5. We can also use extremely precise timing of pulsars to detect lower-frequency GW ($\sim 10^{-9} - 10^{-6}$ Hz). When GW pass by, they shift the arrival time of pulses. The expected sources are a large number (thousands) of supermassive black hole binaries which are thousands or more of years from merger. They form a stochastic background, and the net result is that the shifts in arrival time are correlated between pulsars, where the correlation depends on the angular distance between pulsars from our vantage point.
6. The final method for observing gravitational waves comes from polarization in the cosmic microwave background (CMB). Light has polarization, so on the sky you can think of a lot of arrows in different directions. These arrows make patterns, and one type of pattern ("B modes") can only be produced in the early universe by gravitational waves.
7. The discovery of this pattern was announced in 2014. Because this could have been an amazing probe of the inflationary-era universe, people were thinking about a Nobel Prize! ...or not; it was actually due to scattering off of dust in the Milky Way, because in the *late* universe dust can produce B modes as well. This is a story of sociology at least as much as science; had the team worked with another team they would have realized that it was dust and not made the announcement in that way. More sensitive experiments are underway, but unfortunately there isn't a clear prediction of how strong the effect should be and thus nondetections don't mean much.