Key points from Lecture 9 of ASTR 350

1. In addition to mass, black holes can have angular momentum and electric charge. But nothing else! They have none of the complexities that characterize other big things in the universe.
2. Since net electric charge will be close to zero (opposite charges will be strongly attracted if not), astrophysical black holes have effectively only mass and angular momentum. The general solution in that case is the Kerr solution, after Roy Kerr. There is a maximum to the amount of angular momentum J of a black hole of a given mass M. This maximum is usually represented using a dimensionless spin parameter $a = cJ/GM^2$. The magnitude of a cannot be more than 1 for a black hole, although it can for other objects (e.g., for Earth it is nearly 1000).
3. Rotation of a black hole (or anything else) drags spacetime in the direction of rotation; the dragging effect drops off rapidly with increasing distance from the black hole.
4. One consequence of rotation is the existence of a new region which does not exist without rotation: the *ergosphere*. The ergosphere is outside the event horizon, so you could go into the ergosphere and then come back out. But once in the ergosphere you *must* move in the direction of rotation; even light can't go backward!
5. The ergosphere is called that because particle or magnetic interactions within the ergosphere have the potential to extract rotational energy from the black hole. The magnetic possibility is called the Blandford-Znajek effect after its discoverers, and it is thought without conclusive evidence to play a role in generating some jets from accreting black holes.
6. Another consequence of rotation is that it affects the location of the innermost stable circular orbit. For Schwarzschild (non-rotating and thus $a = 0$) black holes, the radius is $r_{\rm ISCO} = 6GM/c^2$. For gas orbiting in the same direction as a maximally rotating black hole (which thus has $a = 1$), $r_{\rm ISCO} = GM/c^2$. For gas orbiting in the opposite direction, $r_{\rm ISCO} = 9GM/c^2$. The radius of the event horizon decreases with increasing rotation, from $r_{\rm horizon} = 2GM/c^2$ for a Schwarzschild black hole to $r_{\rm horizon} = GM/c^2$ for a maximally rotating black hole.
7. But remember that all this weirdness applies only close to a BH; far away, gravity is extremely similar to Newtonian gravity!