Black Holes

Because we can't actually go and grab a black hole, and bring it into the lab, and because we've never actually observed one, i.e. we have no data, we can only conduct "thought experiments" to explore their properties. Following are a few thought experiments to help you think about what's happening near and around a black hole.

1. Imagine a big rubber sheet. It is very stiff, and not easily stretched, but it does have some "give" to it. Roll some golf balls across it. What happens to them?
2. Now put a bowling ball (very much heavier than a golf ball) in the middle of the sheet, so that it makes a big, slope-sided pit. Roll some more golf balls. What happens when:
    1. They are far from the bowling ball?
    2. They come closer than the edge of the dip?
    3. They go directly towards the bowling ball?
3. In each of the three above cases, what happens if the golf balls are moving very quickly? What if they are moving very slowly?
4. What happens to the depth and width of the pit as the golf balls fall into the center near the bowling ball? (It may be easiest to imagine if you imagine putting lots of golf balls in.)
5. All of the above relates to ordinary stuff. Stars, people, planets, everything, interacts in this way because of gravity. In the case of black holes, things are a bit different. In this case, it is more accurate to think of the bowling balls as holes in the sheet, rather than as objects that sit on it. But they still affect the sheet in the same way. So. Imagine that at the bottom of the pit, where the bowling ball sits, there is a hole. Now think again about what happens when you roll the golf balls down the pit, directly towards the hole. They go away, and can never come back. When they do this, they make the pit deeper and wider. Why?
6. The hole is a good analogy for the event horizon of a black hole. (Except, of course, an object with the mass of a bowling ball does not have an event horizon that is the radius of the bowling ball!) Objects outside the event horizon will know that the black hole is there, because the sheet is sloping, but they won't get captured unless they come within the event horizon. Think about light for a moment, as though it were, say, grains of sand rolling across the sheet. What happens to the light as it passes the pit? What happens when it gets to the hole?
7. Now, suppose that you roll another bowling ball across the sheet. What happens to the sheet when the second bowling ball falls in after the first? Would this affect your golf balls and grains of sand? How? What happens to the hole? What happens to the size of the pit?
8. None of these thought experiments take into account the relativistic effects (length contraction and time dilation). Imagine for a moment that you are travelling close to the black hole. Because you are in a strong gravitational field, your rulers are shorter, and your seconds are longer than elsewhere in the Galaxy. Look out into the Galaxy, and describe what you see. Consider the lifetimes of stars, the distances between them, their motions in your sky, and how they die. Add anything else that occurs to you. This particular question is really good "bus fodder". As you are standing there like a piece of degenerate neutron matter, closer to your neighbors than you really want to be, you can think about what the Galaxy would look like to you if you lived very slowly, and were very small.