To Do Today

- Snacks for next week? (allergies?)
- Cookies & brownies?
- Reading questions
- Guided writing
- Working with sources
- Using quotations effectively

Reading Questions: Essay 2 Prep

- Can you identify common questions from nonscientists that the articles were trying to answer?
- Can you identify any specific misconceptions that they might be trying to head off?
"One common variety of black hole—the type that high-mass stars evolve into—contains several times the mass of the sun compacted deep within an event horizon that is only about a dozen miles across. In a fall toward such a black hole, you would begin to break apart within about 100 miles of the center. Other common black holes are up to billions of times the mass of the sun and are contained within event horizons that are nearly as wide as the entire solar system. One might find this type lurking in the center of some galaxies. While gravity in such a huge black hole is strong, the difference in gravity from your head to your toes near their event horizons is relatively small. In such cases, the tidal force would be so weak that you might even fall through the event horizon in one piece—you just wouldn’t ever be able to come back out and tell anybody about your trip." – Neil de Grasse Tyson, “Death By Black Hole”

Write a sentence about the two different types of black holes:
- First for an audience of 4th graders
- Then for an audience of adult newspaper readers
- Then for an audience of professional astronomers

Thinking about your audience

🌟 What are the differences?
- An audience of 4th graders
- An audience of adult newspaper readers
- An audience of professional astronomers

🌟 What characteristics of your writing do you change for different audiences?
Working with sources

☆ **Introduce** the quote with a signal phrase: “As Neil de Grasse Tyson notes . . .”

☆ **Do not** plop an entire sentence in the middle of your text:
  ☆ You you you. “Quote quote quote.”
  You you.

Using quotations

☆ From “Who knows the dark secret of black holes?”:
  ☆ "Undoubtedly, the most spectacular aspect of our long-term study is that it has delivered what is now considered to be the best empirical evidence that supermassive black holes do really exist," **extolled** Reinhard Genzel of the Max-Planck-Institute for Extraterrestrial Physics in Garching, near Munich.

☆ Let’s make a list of signal phrases/verbs to use for incorporating quotations.
Signal verbs/phrases

☆ Jane Doe explains . . . illustrates, demonstrates, points out . . .
☆ This is what John Doe calls . . .
☆ Jane Doe responds to this argument by . . .

Group Work

☆ Meghan, John, Dan
☆ Sam, DJ
☆ Eli, Dipesh
☆ Colleen, Rashik
☆ Jonathon, Justin
☆ Yan, Faheem
☆ Ethan, Ryan
☆ Nicki, Zun
Group work

☆ Each group is going to get a chunk from one of this week’s readings.
☆ Using the quotation I give you, share with the class THREE unique, stylish ways of incorporating some of that information into a sentence of your own devising.
☆ Remember that Essay 2 is going to be written as a newspaper article!

1. Tyson, “Death by Black Hole”

☆ If you were to fall freely feet-first into a black hole--do not try this at home--then the force of gravity would grow astronomically as you neared its center. Curiously, the black hole’s enormous gravity itself is not what will kill you--you are always weightless when in free fall. Instead, you would be pulled apart as a result of the difference between the force of gravity at your feet and at your head. This differential, known officially as the tidal force, tries to accelerate your feet toward the black hole faster than your head. If humans were made of rubber, then you would just stretch. But we are made of bones and muscles and organs. Your body would stay whole only until the tidal force exceeded the strength of the chemical bonds of your flesh. The moment this happened, your body would systematically snap into countless tiny segments.
2. Tyson, “Hollywood Nights”

At the end of the 1979 Disney film The Black Hole, which has a place on many people’s ten-worst-movies list (including mine), an H. G. Wellsian spaceship loses control of its engines and plunges into a black hole. What more could special-effects artists ask for? Was there any attempt to portray the extreme time dilation near the black hole’s event horizon, with the universe around the doomed crew evolving rapidly over billions of years while the crew members themselves aged only a few ticks of a clock? No. Were the craft and its crew ripped apart by the ever-increasing tidal forces of gravity as they approached the singularity—something a real black hole would do to them? No. One scene did show a swirling disk-shaped nebula surrounding the black hole. Good. Black holes do this sort of thing with gas that falls toward them. But did elongated jets of matter and energy spew forth from each side of the disk? No. Lastly, did the ship travel through the black hole and get spit out into another time? Into another part of the universe? Into another universe altogether? No, no, and no. Instead of working with these cinematically fertile and cutting-edge ideas, the filmmakers depicted the black hole’s innards as a dark cave filled with fiery stalagmites and stalactites, as though we were touring the hot and smoky basement of Carlsbad Caverns.

3. Connor, “Dark Secrets”

This, of course, highlights another aspect of black holes. They are very heavy—or massive, to use the more appropriate term. They are thought to result from the collapse of stars at the end of their nuclear-powered life, resulting in an object so small and dense that the escape velocity necessary for anything to leave its gravitational pull is greater than the speed of light—which is why nothing can escape, because nothing can travel faster than light.

We can thank the American theoretical physicist John Wheeler, who died earlier this year, for coming up with the term black hole. Until then, the notion of light being trapped by a super-dense object was generally described as a ‘frozen star’. Wheeler’s black holes have a far more sinister ring to them. . . . The other great aspect of black holes, of course, is that spooky things happen if you ever come too close to them. The theorists tell us that time slows down as you fall into the ‘singularity’ of a black hole, and you can actually travel through time if two black holes merge to form a ‘wormhole’ in space.
Before Wheeler came up with the catchy name, the phenomenon of light being interminably trapped in this way was generally known as a “frozen star”. Even then, scientists had a fairly good idea that at the end of their nuclear-powered lives, some stars would fall in upon themselves under the influence of their own gravity.

One of easiest ways to explain the concept of trapped light is to imagine throwing an alarm clock into the air. No matter how hard you can throw it, it will always fall back to the ground because of the gravitational attraction the clock has to the more massive Earth. But, put a rocket under the clock so it can be launched above a certain speed — called the escape velocity — and it will be able to go into space, or perhaps in orbit around the Earth. The Earth’s escape velocity is 11.2 km per second (about 25,000 mph).

The point about the escape velocity is that it depends on the size and the density of the planet or object in question. The Moon’s escape velocity is only 2.4 km per second, because it is smaller than the Earth, as well as being less dense.

But shrink the mass of the Earth down to the size of a marble — making it extremely dense — and weird things begin to happen. At this density, the escape velocity of the Earth becomes greater than the speed of light. It effectively becomes a black hole because nothing, not even a beam of light, can escape the gravitational field of the marble-sized Earth.

To appreciate the weirdness of a black hole, imagine falling into one. The force of gravity would continue to accelerate you as you fall through the Schwarzschild radius and into the center of the black hole (of course you would have been killed by the incredibly strong force of gravity, but let’s ignore that detail). An outside observer, however, would see something very different. Seen from a stationary perspective outside of the black hole, you would appear to begin falling toward the object but would slow down as you approached its Schwarzschild radius. No matter how long an observer watched, he would never see you pass through the Schwarzschild radius and into the black hole. According to Einstein’s theory, the way that time passes to two observers can be different. In the presence of a black hole, one observer (the one falling in) sees himself falling in quickly, while the other observer (the stationary one outside) sees time stretched out in such a way that the falling person never passes through the Schwarzschild radius and into the black hole.
Around 14 billion years ago, shortly after the Big Bang, the Universe was extremely hot and extremely dense – much more so than even the cores of stars – and was made up not of atoms or even protons and neutrons, but rather of their building blocks, quarks, gluons, and other particles, mixed in a physical state known as plasma. Eventually, as the Universe expanded and cooled, the quarks and gluons joined together to become the ordinary stuff that makes up the atoms in our present world. Random fluctuations in the temperature and density of the plasma could result in particularly dense pockets in space. Those pockets, if concentrated enough, could have attracted large enough quantities of matter to form black holes – albeit ones much smaller than those that would be formed through stellar evolution. In fact, these primordial black holes could be as light as a billionth of a billionth of the mass of the Sun (still about a billion tons). Could those small black holes be what we call dark matter?

Einstein calculated that the Sun would displace the position of a distant star lying behind it. The shift in the sky, or deflection angle, could be accurately predicted from his general theory of relativity. The astronomer Sir Arthur Eddington decided to measure this effect by monitoring such a displacement. To do so, he needed to make his observation during a total eclipse of the Sun, so that the image of the distant star would not be overwhelmed by the sunlight. In 1919 he travelled to the island of Principe, a Portuguese colony on the coast of West Africa. There he observed the position of a cluster of stars called the Hyades. On 19 May there was a total eclipse which coincided with the exact moment at which the Sun was passing in front of the Hyades. Eddington then measured the new position of this group of stars in the sky and found that they had been deflected ... The prediction and the observations agreed: Eddington’s observation was the first piece of quantitative evidence that Einstein’s theory of gravity was correct.
8. Ferreira, “State”

Einstein’s theory dramatically changes our understanding of space and time. It is no longer possible to define sequences of events unambiguously. Their spatial separation and the state of motion of the observer will lead to very different measurements of the time that has elapsed between the events in question. Indeed, what we see is an intermingling of time and space – an important point of view which was put forward by the German mathematician Hermann Minkowski. Minkowski advocated that the view of space and time as entities independent of each other was no longer possible in the light of the special theory of relativity. One would have to talk about one complete, unified structure: space-time. Special relativity is physics on space-time – how particles move through it, interact, and are created or annihilated.

Leftover time

. . . . To work on Essay 2
Ask me any questions
Draft 1 due Tuesday; BRING TWO COPIES!
Don’t forget there are office hours on Monday next week! Or email me for an appointment