FROM FREE LUNCH TO BLACK HOLE Harvard Case Solution & Analysis

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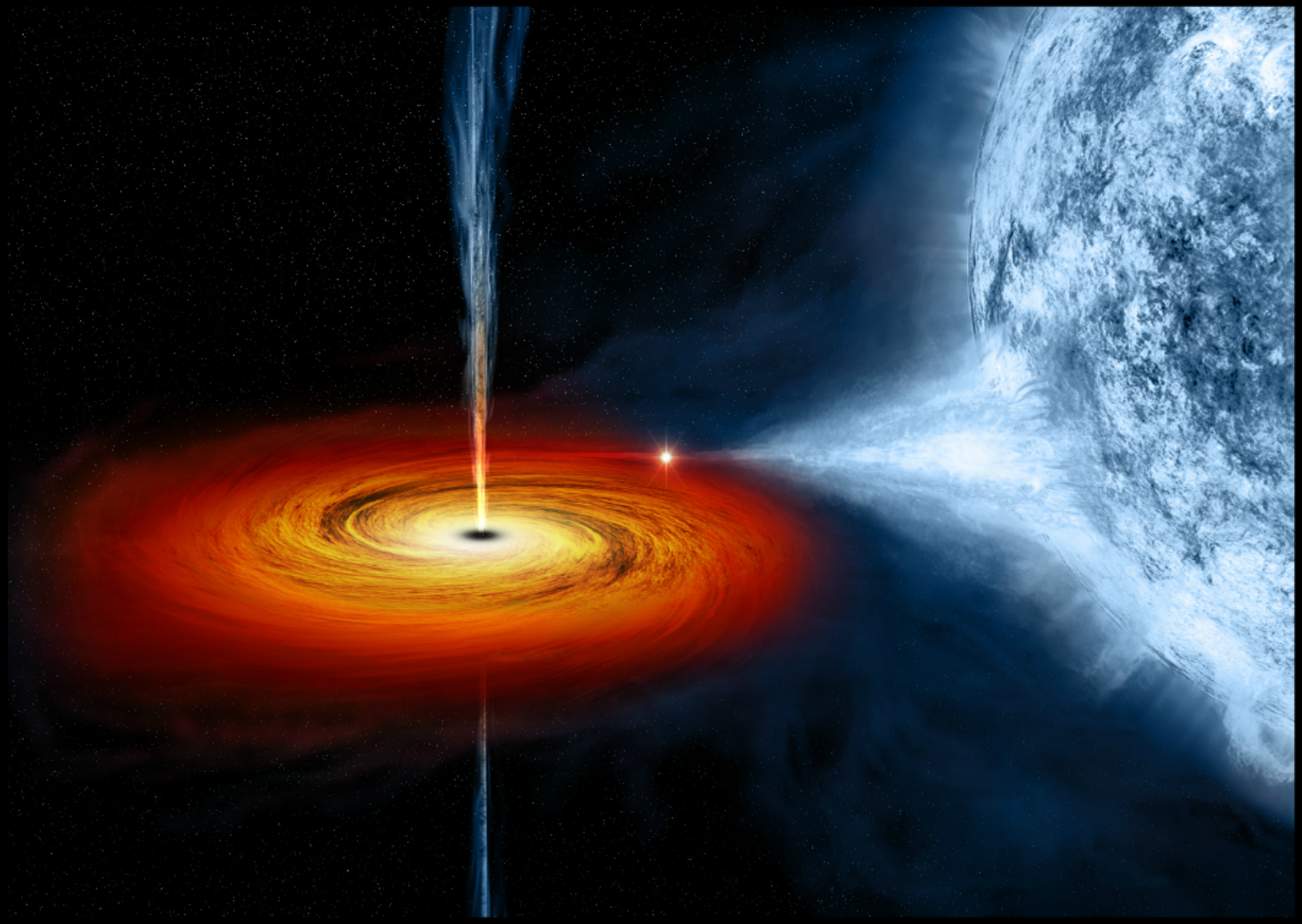
WHAT ARE THEY?



http://www.nasa.gov/sites/default/files/cygx1_ill.jpg

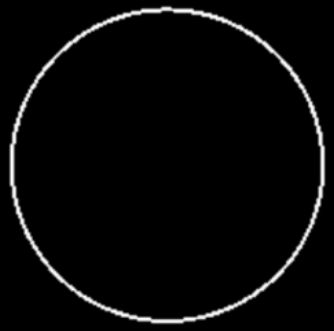
ABOUT

- Points with a great amount of mass in small space. They have such extreme gravity that any entering forces are overpowered. Even light cannot escape.
- Invisible to observers because light cannot escape them
- Scientists examine surrounding-star behavior to find black holes because these stars behave differently.
- Come in different sizes-the smaller ones may be the size of atoms (and weigh as much as large mountains) and the bigger ones (supermassive) may have the mass of a million suns.

(Dunbar)

Manhattan
(spaceimaging.com)

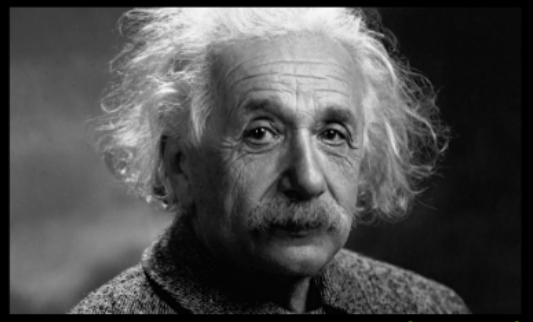
Neutron Star
$M=1.5\ M_{sun}$
$R \approx 10$ km



Black Hole
$M = 1.5\ M_{sun}$
$R_S = 4.5$ km

(Dunbar)

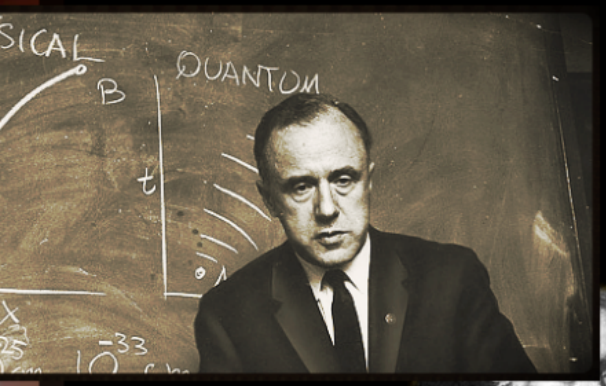
DISCOVERY



Einstein

- **1790s:** English clergyman John Michell and French scholar Pierre-Simon Laplace use Newton's Laws to suggest the idea of "the point of no return"/event horizon.

Michell



Wheeler

Laplace

-1915: Einstein's theory of general relativity theorizes about the existence of black holes.

-1967: Physicist John Wheeler coins the term "Black Hole".

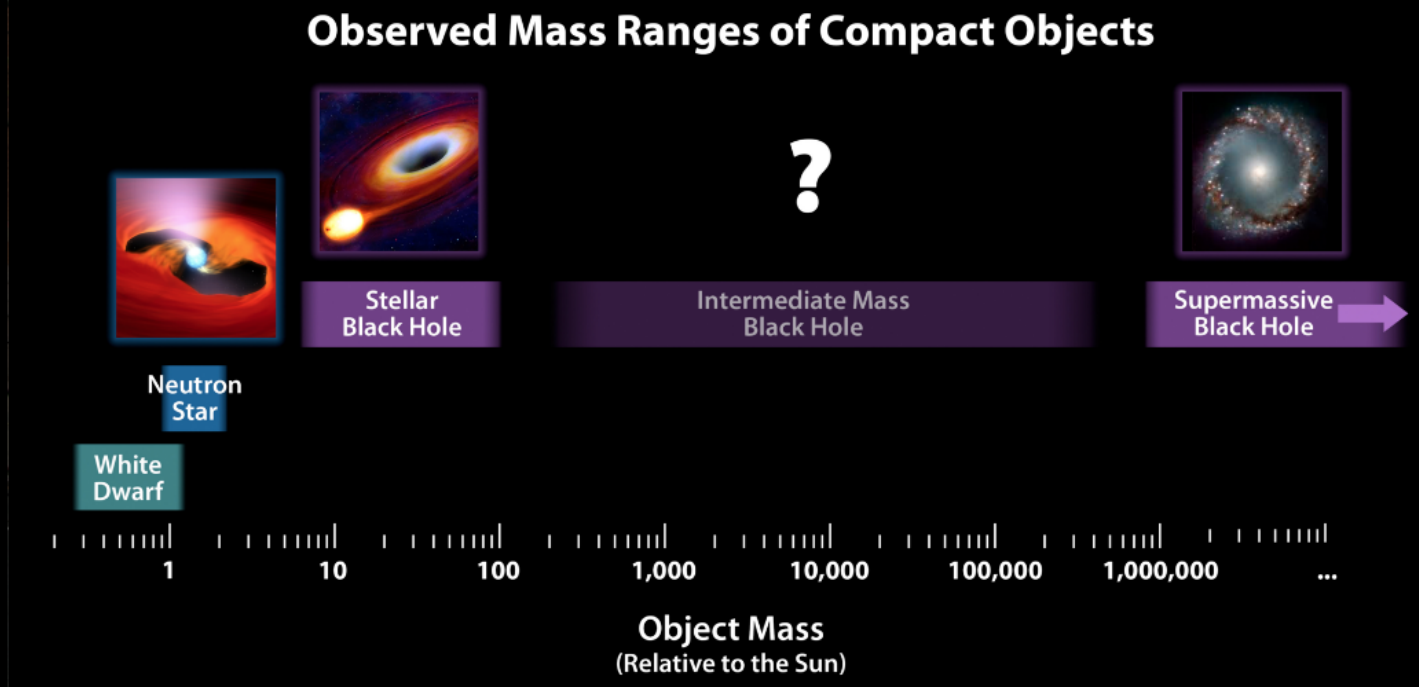
(John Michell)
(Albert Einstein)

Types of black holes

Distinguished by 3 properties: **mass**, **spin** (whether and how fast it rotates around an axis), **electric charge**

Stellar Black Hole

- formed when massive star runs out of nuclear fuel and collapses under its own weight
- supernova



(Types of Black Holes)

Types of Black Holes - Continued

Supermassive Black Hole

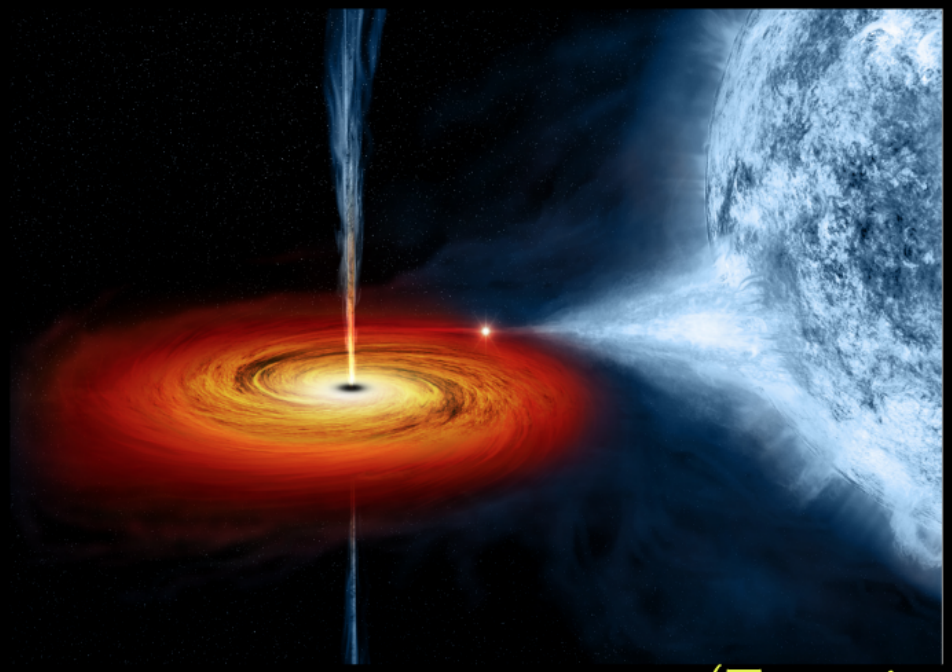
- formed at formation of galaxy or when smaller black holes merge
- mass of millions of Suns
- constantly growing due to steady consumption of matter

Intermediate-mass Black Hole

- mass varies from tens to millions times mass of Sun
- formation unclear

Mini Black Hole

- mass of asteroid or less
- none have ever been detected



(Temming)