



Name: _____

Date: _____

Asteroids and Black Holes, Worksheet - 1

"One of the great mysteries in astrophysics is how do supermassive black holes form? They are the million solar-mass elephants in the room," said Christopher Berry, a researcher at Northwestern University's Center for Interdisciplinary Exploration and Research in Astrophysics. "Do they grow from stellar-mass black holes, which are born when a star collapses, or are they born via an undiscovered means? Long have we searched for an intermediate-mass black hole to bridge the gap between stellar-mass and supermassive black holes. Now, we have proof that intermediate-mass black holes do exist."

Current theory holds that black holes with masses in the approximate range of 65 to 120 solar masses cannot form from the collapse of a single star. Theory holds that dying stars in that mass range would blow themselves completely apart. While uncertainties might allow for black holes with more than 65 solar masses to form in supernova explosions, that is not the case for the larger 85-solar mass black hole that merged to form GW190521.

"From our understanding of how stars age and evolve we expect to find black holes with either less than 65 solar masses or more than 120 solar masses, but none in between," said Frank Ohme, leader of an Independent Max Planck Research Group at AEI Hannover. "The 85 solar-mass black hole in the GW190521 origin system falls right in that gap where it shouldn't be.

"This can mean two things: our understanding of stars' evolution is incomplete or something different has happened here." The 85-solar-mass black hole likely is the result of earlier mergers between smaller black holes, but it's also possible it could have been a primordial black hole formed in the Big Bang. Either way, the merger marked the most powerful gravitational wave event yet detected.

- **What are LIGO and VIRGO? What have they discovered?**

- **What is special about this particular black hole merger?**

- **What types of black holes do we know? How do they form?**



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Asteroids and Black Holes, Worksheet - 2

Comets, Asteroids, and Meteors

E Y U W C P B H T Y Y R U Z U H M E O A T B C L
 T V D M N V G N A N T J J T V U V N O C B C N U
 V W C N Q G T M A P R N N I F L B C U F M U L G
 L V K N E E U Q N E K C I H C V H D P L A F M H
 A F M R C J V M Z B F R Z E C W Y J Z X I A J R
 J F M F E Y Q M V M P W Q U P H N O T M R K D C
 P H M X F V P B O C K U Y P Y Q L Y V C I P U Y
 Q W P N A N I I D J A N E F V T W N T E M O C L
 K L A B S U U W J T T U L T H V C E A M F V A V
 W M V E T C Z D A C E D H I W P O N E V Z L I F
 R P G C E L B I M R L J S J X R M A A T R I A I
 B Z B N R E Y O Z S Y P A P D L A W Z D H A W Z
 N P M E O U P R X F N B E E W S M U Y D O T B V
 F B E I I S R O E R N J F A Y E S H B U R T J U
 B K T C D N D E L I V C T R C H C Y Z D B S X F
 C E S S B G N T S E T I R O E T E M G E I U U H
 Y L Y U E L U E B Z V C X I K H B J J D T D M U
 M B S G L T S M M E T E O R H D I O R E T S A X
 M P R D T X T L E B R E P I U K W G M C U Q Z H
 Y T A I X K A N Y E N A T E C A P S B M L O T Q
 H E L J E D F A W F F E M S O O R T C L O U D Z
 C P O P L O J J L K V Z S K N X O A M T V H D I
 N P S N F W M L B U D W V U G A S T A I L R H P
 Y F M S S A N C H E Z Y U J T C X K S F G Y I S

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|--------------|------------|---------------|---------------|
| Ashley | Asteroid | Asteroid Belt | Chicken Queen |
| Coma | Comet | Dust Tail | Gas Tail |
| Joynena | Katelynn | Kuiper Belt | Meteor |
| Meteorite | Meteoroid | Miriam | Ms. Sanchez |
| Nucleus | Oort Cloud | Orbit | Science |
| Solar System | Space | Sun | |