I Wonder Why?

1. Student answers may vary but could include:

a) American astronomers

b) a hum or noise, like static in microwave radiation

c) uniformly from all directions in space

d) the big bang

e) they checked different directions to rule them out; e.g., not from cities like New York, not from Milky Way or solar system, not caused by pigeons in telescope either

f) leftover, uniform low-level radiation from all directions supported big bang theory early universe origins

2.

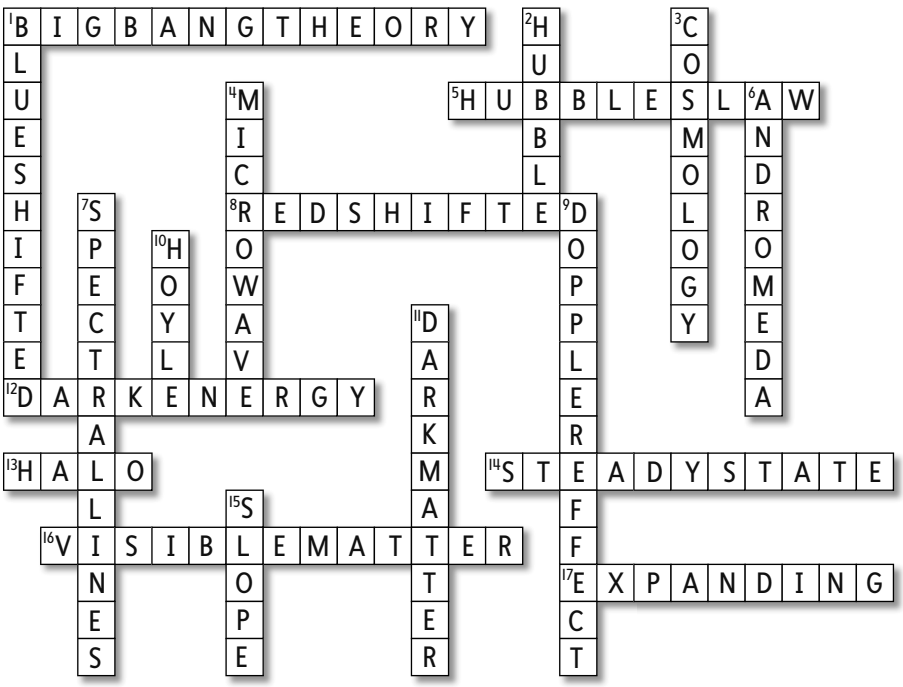
Date:	1922	1927	(1940s)	1948	1965
Scientist:	Friedmann	Lemaître	Hoyle	Gamow	Penzias and Wilson
Details:	-expanding universe	-universe initially small and dense	-steady state universe (but coined "big bang" name as an insult)	-predicted CMB radiation at -269°C	-found CMB radiation -270°C

What's In a Name?

Acronym	Full Name	Significance in Our Understanding of the Universe
NASA	**N**ational **A**eronautics and **S**pace **A**dministration	American agency responsible for space exploration and research, Apollo missions to Moon, Space Shuttle, partner in ISS
COBE	**Co**smic **B**ackground **E**xplorer	all-sky images of CMB radiation, showing only tiny temperature variations
WMAP	**W**ilkinson **M**icrowave **A**nistropy **P**robe	all-sky images of CMB radiation, showing only tiny temperature variations, confirming COBE date and showing even more detail
CMB	**C**osmic **M**icrowave **B**ackground	type of radiation left over from big bang, predicted by Gamow, confirmed by Penzias and Wilson, evidence of early universe
HST	**H**ubble **S**pace **T**elescope	located in space (low Earth orbit), still in use in 2018 (workbook publication date), detects visible, UV, and short infrared wavelengths, images of near and distant objects
JWST	**J**ames **W**ebb **S**pace **T**elescope	scheduled for 2020 launch into Earth orbit, planned replacement for HST, with greater distance viewing possible
CERN	**C**onseil **E**uropéen pour la **R**echerche **N**ucléaire	European organization for nuclear research, operates LHC
LHC	**L**arge **H**adron **C**ollider	operated by CERN, studies particles at high energies, nearing those found close to time of big bang

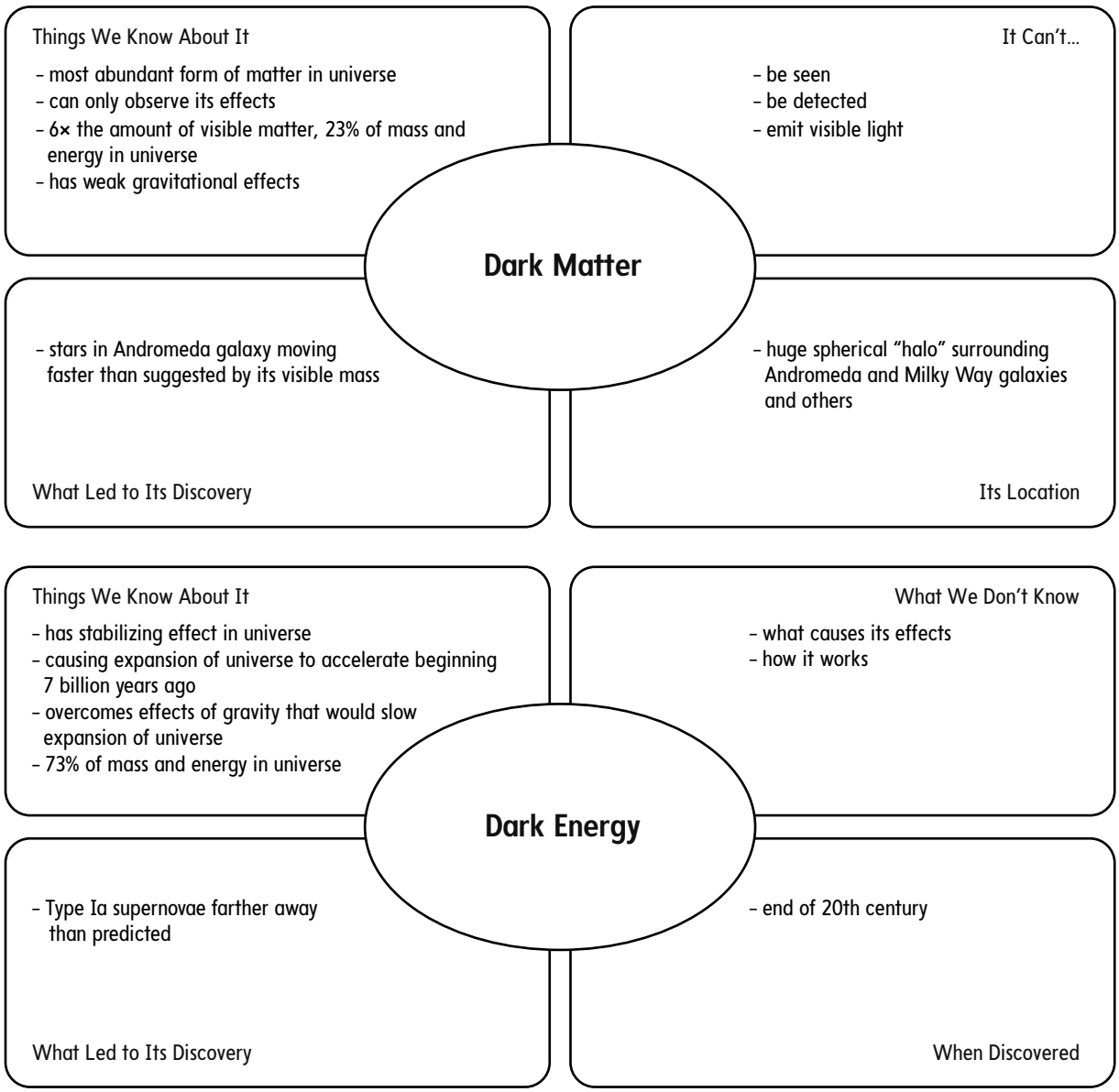
The Big Bang Theory and the Universe

Big Bang Theory



The Rest of the Universe: Dark Energy and Dark Matter

Student answers may vary but could include the following:



4.4 Assessment

1. F
2. I
3. H
4. K
5. J
6. D
7. B
8. C
9. A
10. G
11. E
12. B
13. C
14. A
15. A
16. B
17. C
18. D
19. D
20. A
21. B
22. C
23. B
24. C
25. A