

# Science Summary

G R O U N D - B A S E D

|   |   | R&A | Keck | KI | LBTI |
|---|---|-----|------|----|------|
| <b>EMERGENCE OF THE MODERN UNIVERSE</b> |   |     |      |    |      |
| <b>Research Area One</b>                | <b>How did the cosmic web of matter organize into the first stars and galaxies?</b>   |     |      |    |      |
| INVESTIGATIONS                          | 1 Pristine gas, the first stars, and the first heavy elements   |     |      |    |      |
|   | 2 Black holes and structure in the early universe   |     |      |    |      |
|   | 3 Formation and evolution of galaxies   |     |      |    |      |
| <b>Research Area Two</b>                | <b>How do different galactic ecosystems (of stars and gas) form and which can lead to planets and living organisms?</b>               |     |      |    |      |
| INVESTIGATIONS                          | 4 Lifecycle of stars in the Milky Way and other galaxies  |     |      |    |      |
|   | 5 Habitats for life in the Milky Way and other galaxies   |     |      | ●  | ●    |
| <b>STARS AND PLANETS</b>                |   |     |      |    |      |
| <b>Research Area Three</b>              | <b>How do gas and dust become stars and planets?</b>  |     |      |    |      |
| INVESTIGATIONS                          | 6 Molecular clouds as cradles for star and planet formation   | ●   |      |    |      |
|   | 7 Emergence of stellar systems  | ●   | ●    |    |      |
|   | 8 Evolution of protoplanetary dust and gas disks into planetary systems   | ●   | ●    | ●  | ●    |
| <b>Research Area Four</b>               | <b>Are there planetary systems around other stars and how do their architectures and evolution compare with our own solar system?</b> |     |      |    |      |
| INVESTIGATIONS                          | 9 Evidence of planets in disks around young stars   | ●   | ●    | ●  | ●    |
|   | 10 Census of planetary systems around stars of all ages   | ●   | ●    | ●  | ●    |
| <b>HABITABLE PLANETS AND LIFE</b>       |   |     |      |    |      |
| <b>Research Area Five</b>               | <b>What are the properties of giant planets orbiting other stars?</b>   |     |      |    |      |
| INVESTIGATIONS                          | 11 Chemical and physical properties of giant extrasolar planets   |     |      | ●  | ●    |
|   | 12 Detect giant planets by direct imaging, and study their properties   |     |      | ●  | ●    |
| <b>Research Area Six</b>                | <b>How common are terrestrial planets? What are their properties? Which of them might be habitable?</b>                               |     |      |    |      |
| INVESTIGATIONS                          | 13 Which nearby stars host terrestrial planets that might be suitable for life?   |     |      |    |      |
|   | 14 Atmospheric compositions of terrestrial planets orbiting nearby stars  |     |      |    |      |
| <b>Research Area Seven</b>              | <b>Is there life on planets outside the solar system?</b>   |     |      |    |      |
| INVESTIGATIONS                          | 15 Optimal biosignatures for life on other worlds   | ●   |      |    |      |
|   | 16 Evidence for life on planets orbiting nearby stars   | ●   |      |    |      |

● Major Contribution    ● Contribution

Origins missions flow from the research areas and investigations in this roadmap.

S P A C E - B A S E D

| HST | FUSE | SIRTF | SOFIA | Opt/IR<br>Coronagraph<br>Mission | Kepler | SIM | JWST | TPF | SAFIR | Large<br>UV/OPT<br>Mission |
|-----|------|-------|-------|----------------------------------|--------|-----|------|-----|-------|----------------------------|
|     |      |       |       |                                  |        |     |      |     |       |                            |
| ●   | ●    |       |       |                                  |        |     | ●    |     |       | ●                          |
|     |      | ●     |       |                                  |        |     | ●    | ●   |       | ●                          |
| ●   |      | ●     |       |                                  |        |     | ●    |     | ●     |                            |
|     |      |       |       |                                  |        | ●   |      |     | ●     | ●                          |
|     |      | ●     |       |                                  |        | ●   | ●    | ●   | ●     |                            |
|     |      |       |       |                                  |        |     |      |     |       |                            |
| ●   | ●    | ●     | ●     |                                  |        |     | ●    |     | ●     |                            |
| ●   |      | ●     | ●     |                                  |        |     | ●    | ●   | ●     | ●                          |
| ●   | ●    | ●     | ●     | ●                                |        |     | ●    | ●   | ●     | ●                          |
| ●   |      | ●     | ●     |                                  |        | ●   | ●    | ●   | ●     |                            |
| ●   |      |       |       | ●                                | ●      | ●   | ●    | ●   | ●     |                            |
|     |      |       |       |                                  | ●      | ●   | ●    | ●   |       |                            |
|     |      |       |       | ●                                |        |     |      | ●   |       |                            |
|     |      |       |       |                                  | ●      | ●   |      | ●   |       |                            |
|     |      |       |       |                                  |        | ●   |      | ●   |       |                            |
|     |      |       |       |                                  |        |     |      | ●   |       |                            |
|     |      |       |       |                                  |        |     |      | ●   |       |                            |