Chapter 1

Distances in the Universe p. 11 Space is full of material. Space is relatively empty.

Distances in the Universe p. 11 We receive signals instantaneously from celestial objects. The light, radio waves, or other radiation from celestial objects takes a long time to reach us – from 8 minutes for the Sun to 4 years for the nearest star to 2.2 million years for the Andromeda Galaxy, and billions of years for light from quasars.

Spelling: "Millennium" in the title has only one 'n'. It is "millennium," not "millenium" with one 'n.'

Chapter 2

The Spectrum p. 25 All parts of the electromagnetic spectrum reach us on Earth. There are windows of transparency in the visible and radio as well as in parts of the infrared; we have to go up in balloons or spacecraft to observe other parts of the spectrum.

The Spectrum p. 25 All radiation is harmful. "Radiation" includes visible light; most radiation is not harmful.

The Spectrum p. 26 All celestial objects are brightest in visible light. Some objects give off mainly x-rays, others mainly infrared, and so on.

The Bohr Atom pp. 30–32 The Bohr atom can explain all kinds of spectra. The Bohr atom deals only with atoms that have one electron, principally the hydrogen atom. Ionized helium is explained to a lesser degree.

The Bohr Atom Spelling: infared, absorbtion, lense Spelling: infrared, absorption, lens.

Chapter 3

Light and Telescopes p. 44–48 The main purpose of telescopes is to magnify the image. The main purpose of most telescopes is to collect a lot of light, so that fainter objects can be detected.

Light and Telescopes p. 45 A Cassegrain telescope has a hole in its secondary mirror. A Cassegrain telescope has a hole in its primary mirror; the secondary mirror reflects light through that hole, where it eventually hits an eyepiece, film, a CCD, or other detector.

Light and Telescopes p. 48 Most telescopes use big lenses. The largest telescope with a big lens was made over 100 years ago; almost all modern telescopes depend on huge mirrors to collect light.

Light and Telescopes p. 51 Bigger telescopes see better detail. The detail you see from Earth with a large optical telescope is limited by Earth's atmosphere; the new technique of adaptive optics is compensating for the Earth's atmosphere to some extent, helping make use of the full aperture of large optical telescopes. For radio telescopes, which aren't affected by Earth's atmosphere, interferometers give full resolution according to the sizes of their longest diameters in given directions.

Light and Telescopes p. 51 The Hubble Space Telescope can see 10 times farther into space than ground-based telescopes. The Hubble Space Telescope sees about 10 times more clearly, so it can see a group of nearby objects just as clearly in a space 10 times larger. Big ground-based telescopes are already seeing most of the way back to the edge of the Universe (actually, to the beginning of time), so it is not possible to see 10 times farther.

Light and Telescopes pp. 54–56 The Hubble Space Telescope works only in visible light. The Hubble Space Telescope works in ultraviolet, visible, and near infrared.

Light and Telescopes p. 56 The James Webb Space Telescope is an exact successor to Hubble. The James Webb Space Telescope will work only in the infrared, though with a much bigger mirror than Hubble's.

Chapter 4

The Phases of the Moon and Planets pp. 76–78 The Moon is up only at night. The Moon is visible during the day if the sky is sufficiently clear; unpolluted skies help. Where the Moon is in the sky depends on its phase.

Celestial Coordinates pp. 93–94 The stars revolve overhead. We are on a moving platform, the Earth, as it rotates on its axis and orbits the Sun. The stars' apparent motion really merely reflects the Earth's rotation. The effect of the Earth's revolution around the Sun shows up as the small effect of parallax, detectable only for the nearest stars.

The Motions of the Sun, Moon, and Planets p. 96 The seasons are caused by the Earth's being closer to or farther from the Sun at various times of the year. The seasons are caused by the tilt of the Earth's axis (which we see as a variation in the declination of the Sun). The Sun is actually closest to Earth in the northern hemisphere's wintertime, proving that the distance effect is not the major one.

Pronunciation, p. 103 Eccentricity. wrong: es-sen-tricity. right: ek-sen-tricity.

Chapter 5

Copernicus and his Sun-Centered Universe pp. 112–113 The planets sometimes move backward in their orbit, accounting for why they appear to sometimes move backward in the sky with respect to the stars. This retrograde motion is caused by the different speeds with which the planets orbit the Sun, and appears when one planet passes another or is passed by the other in its orbit.

The Rotation and Revolution of the Planets pp. 123–124 Angular momentum is the same as “momentum.” “Linear momentum,” often called simply “momentum,” is the tendency of a body to keep moving straight ahead. “Angular momentum” is different, and is a measure of the spin taking account also of the distribution of weight with distance from the axis. Note that both linear momentum and angular momentum are “conserved,” that is, they do not change without some outside force changing them.

Chapter 6

Our Earth p. 137 The North Magnetic Pole stays fixed. The North Magnetic Pole is moving over time.

Our Earth pp. 139–141 Tides are caused when the Moon pulls the water toward it. Tides are a differential force, caused by the difference in the force in two locations. We have one high tide where the Moon pulls the water away from the solid Earth, and a simultaneous second high tide on the other side where the solid Earth has been pulled away by the Moon.

Our Earth pp. 141–142 The temperature decreases as you go up in the Earth’s atmosphere. The temperature decreases through the troposphere, but then begins to increase again at still higher levels.

Venus p. 142 The insides of greenhouses on Earth heat up because of the “greenhouse effect.” The greenhouse effect involves visible light going through something, hitting the ground, and warming up, and the resulting infrared rays do not penetrate back out. This is not the effect that warms terrestrial greenhouses, where a more important effect is that the glass keeps the wind from sweeping warm air away. But the effect does heat up the atmospheres of Earth and, to a greater extent, Venus.

Our Earth p. 143 The ozone hole is there all the time. The ozone hole is over Antarctica and opens each year during the Antarctic springtime.

Our Earth p. 143 “Antartica” is the continent around the South Pole. Note the spelling: the Arctic is in the north, and the second of those ‘c’s remains in "Antarctica."

Mars p. 168 Since we went to the Moon, it is easy to send people to Mars. Mars is a lot farther from Earth than the Moon: at least 4 light minutes compared with 1.5 light seconds. So sending people to Mars is a task we are not yet able to accomplish. The journey would take about 8 months, during which the astronauts would be subject to cosmic rays and boredom, among other problems.

Chapter 7

Jupiter p. 190 Jupiter is much like Earth. Jupiter dominates the Solar System, and its size and mass give it many properties very different from Earth's.

Jupiter p. 195 Only Saturn has rings. All the giant planets in our Solar System have rings.

Jupiter p. 200 Jupiter's moons are hard to see. Even binoculars or a very small telescope can show Jupiter's largest moons.

Jupiter p. 200 We know about all the moons in the Solar System. There are lots of small moons and other undiscovered objects in the solar system. At present, there are dozens of unconfirmed moons of Jupiter that are being considered. A new moon of Neptune was reported in 2013.

Saturn pp. 201–202 Saturn's rings are solid. Saturn's rings are composed of individual chunks of rock and ice.

Uranus pp. 211–212 Uranus's rings have been known a long time. Uranus's rings were discovered only in 1977, from a stellar occultation.

Neptune pp. 214–215 Neptune's Great Dark Spot is a permanent feature, like Jupiter's Great Red Spot. Neptune's Great Dark Spot, discovered by Voyager 2, disappeared a few years later.

Chapter 8

Pluto p. 226 Pluto was discovered because of its effect on Neptune, then the outermost planet known. Tombaugh's search was based on data about Uranus, since Neptune's orbit was not sufficiently well known. In any case, Pluto has so little mass that its effect on either of those bodies is not measurable.

Pluto p. 227 Pluto always orbits outside Neptune's orbit. Pluto's semimajor axis is larger than that of Neptune's, but sometimes Pluto is closer to the Sun than Neptune, most recently from January 21, 1979, to February 11, 1999.

Pluto pp. 232–233 Pluto is a normal planet, like the others. Pluto is so small, with such an inclined orbit, that it may be merely one of the largest Kuiper-belt objects. In 2006, Pluto was defined by the International Astronomical Union to be a dwarf planet since it doesn't "clear its orbit," even though it is massive enough to take a spherical shape.

Pluto pp. 232–233 Pluto's reclassification as a dwarf planet was a demotion. Since now Pluto is the most massive and perhaps the largest of a category, dwarf planets, the change can be considered a promotion. Subsequent to the reclassification, the International Astronomical Union even set up a new category: plutoids. (Ceres, an asteroid and a dwarf planet, is excluded from the plutoid category since it is in the asteroid belt.) So Pluto has been substantially honored.

Comets p. 237–238 Halley's Comet is the brightest comet known. Halley's Comet is reasonably bright every 76 years or so, but brighter comets appear from time to time. Don't miss the opportunity to see them.

Meteoroids p. 244 We can't study extraterrestrial matter directly. Meteorites are extraterrestrial matter that land on Earth, where we can study them.

Meteoroids p. 247 Meteorites won't harm us. Over 1000 people were injured when they ran to their windows on February 15, 2013, after seeing a brilliant light when a meteor exploded over central Russia, since a minute or so later a shock wave reached them and broke lots of window glass. An even bigger meteor could have caused still more damage.

Chapter 9

Extra-solar Planets pp. 268–269 Most planetary systems are like our own. The exoplanets we are discovering are mostly in orbits unlike those in our Solar System, so the distribution of orbits and planetary sizes in our Solar System is apparently unusual.

Extra-solar Planets p. 269 We look for life on all types of exoplanets. Life as we know it depends on water being in its various gas, liquid, and solid states, so exoplanet scientists search especially for "Goldilocks" exoplanets in the "habitable zone," within which the temperatures from the parent stars allow water to exist in all three phases.

Pronunciation: Eccentricity. wrong: es-sen-tricity. right: ek-sen-tricity

Chapter 10

The Basic Structure of the Sun p. 291 The Sun has a radioactivity zone. The Sun has, inside its convection zone, a radiation zone, that is, a zone in which energy is transported by radiation instead of by convection. Radioactivity, the decay of nuclear particles, is not a phenomenon that takes place in or on the Sun.

The Photosphere p. 293 SOHO stands for Solar Helioseismology... SOHO stands for Solar and Heliospheric Observatory (launched 1995), given that the heliosphere is the sphere around the sun (Helios) that is overwhelmingly influenced by the sun. The Voyager spacecraft are nearing the outer boundary of the heliosphere.

The Photosphere p. 293 Scientists study helioseismology by studying wavelengths. Scientists study helioseismology by studying waves on the surface of the Sun. The periods with which these waves oscillate are different for waves that penetrate the Sun to different distances.

The Photosphere p. 293 To use helioseismology, scientists send waves into the Sun. To use helioseismology, scientists observe waves that are naturally generated within the Sun.

The Photosphere p. 294 The Sun and stars have absorption spectra because the photosphere is cooler than the core. All the light we see comes from the photosphere; the core is well hidden below hundreds of thousands of kilometers of solar gas. The absorption lines and the continuum are both formed in the photosphere; the fact that absorption lines are detected shows that the outer part of the photosphere is cooler than the inner part of the photosphere. The photosphere is a few thousand kilometers thick, compared to 700,000 km for the radius of the Sun, so the continuum and the absorption lines are formed in less than the outer 1% of the Sun.

The Photosphere pp. 291, 294 The absorption lines are formed in cool clouds of gas outside the Sun and stars. The absorption lines are formed in the upper photosphere as continuum from the lower photosphere passes through it.

The Chromosphere p. 294 The chromosphere, seen every day by looking straight at the Sun, has emission lines because it is hotter than the photosphere. The chromosphere is too transparent to add emission lines to the solar absorption lines. Only when we see it at the edge of the Sun (known as the “limb”) do we detect emission lines, because then we see the chromosphere in silhouette against dark sky. We can see the chromosphere and prominences in this way every day with telescopes on Earth that use H-alpha filters or without filters at the times of total solar eclipses.

Sunspots and Other Solar Activity pp. 303–305 Sunspots are black. Sunspots are actually bright—bright enough to shine like a full moon if they were in the sky by themselves, but appear dark in contrast with the even brighter solar surface surrounding them.

Sunspots and Other Solar Activity p. 303–305 Sunspots drop the Sun’s radiation substantially. While the passage of a large sunspot group has been found to drop the Sun’s radiation, it is only by a tenth of a percent. Measurements have shown variations over the sunspot cycle of, say, 1372 to 1375 watts per square meter over the 11-year cycle, with the maximum brightness at sunspot maximum, when there are the most sunspots on the Sun.

Sunspots and Other Solar Activity p. 303–305 The sunspot cycle is 11 years long. Sunspot cycles have ranged from about 9 years to about 13 years.

Sunspots and Other Solar Activity p. 305 Sunspots will always be present. As of 2019, the average magnetic field within sunspots has been dropping for decades, and should soon reach a point where it is too low (about 1500 gauss) for sunspots to form even at photospheric regions of high magnetic field. Whether such an absence of sunspots will last for a single cycle, for a Maunder-minimum duration of several cycles, or forever we do not now know.

Chapter 11

Colors and Temperatures p. 318 The Sun gives off only yellow light. The Sun gives off all colors of light; together, the visible spectrum from the Sun is known as “white light.” When broken up into its spectrum, it shows all the colors of the rainbow.

The Spectral Types of Stars p. 319–321 OBAFGKM uses letters that were assigned arbitrarily to spectral types. Spectral types were first assigned in order of the strength of hydrogen lines, with A being the strongest hydrogen lines, B being the next strongest hydrogen lines, and so on. Later, it turned out that the order arranged by temperature is different from the order arranged by the strength of hydrogen lines. New spectral types were added in recent years, given our fairly new capability to observe in the infrared, showing cooler stars than were previously analyzed.

The Spectral Types of Stars pp. 319–321 The hottest stars have the strongest hydrogen lines. The hottest stars are types O and B, and so much hydrogen is ionized in their photospheres that the hydrogen lines are weaker than in the somewhat cooler A stars. Similarly, in stars cooler than A stars, the H and K lines of ionized calcium and other lines become stronger and the hydrogen lines become relatively weaker.

Temperature–Luminosity Diagrams pp. 327–328 The Sun is a giant star. The Sun is a dwarf star; “dwarf” is the name given to stars on the main sequence of the temperature–luminosity diagram. Most stars are dwarfs.

The Motions of Stars pp. 328–332 The pitch of a sound or the frequency of light or radio waves increases as something approaches us at constant speed. The pitch/frequency remains steady as the object approaches; it changes as it goes from approaching to receding, and then remains steady as the object recedes.

Chapter 12

How Stars Shine: Cosmic Furnaces p. 358 Stars stay the same forever. Stars evolve, from protostars to main-sequence stars to giant stars and so on.

Stars in Formation p. 359 We can see all the stars in the Universe. Even relatively close stars, like some of those in the Orion Nebula or the Eagle Nebula, are hidden in cocoons of dust. The dust can be penetrated by infrared.

Stellar Energy Cycles pp. 364–366, 369 The carbon cycle fuels the Sun. The fusion process that provides almost all the Sun's energy is the proton-proton chain. The carbon cycle (also known as the carbon-nitrogen-oxygen cycle) is important only in stars hotter than the Sun.

The Solar Neutrino Experiment pp. 370–373 Matter is conserved; that is, it cannot be destroyed. Matter and energy are interchangeable; Einstein's $E=mc^2$ shows the relation between the two, where E is energy, m is mass, and c is the speed of light. When a particle and its antiparticle meet, they obliterate each other, with pure energy as the result.

Chapter 13

The Death of the Sun pp. 381–382, 386 The Sun is a giant star. The Sun is a dwarf star, halfway through its 10-billion-year main-sequence lifetime. It will finish that main-sequence life in about 5 billion years and then will spend only about 1 billion years as a giant.

The Death of the Sun pp. 382–384 Planetary nebulae are in solar systems. Planetary nebulae are dying stars that have thrown off gas; the name "planetary" came from observers over a hundred years ago, because these nebulae looked a bit like the outer planets in the telescopes of the time.

Supernovae: Stellar Recycling pp. 388–392 All supernovae are giant stars that explode. Type Ia supernovae come from white dwarfs in binary systems that take on too much mass from their companions. These white dwarfs come from low-mass stars. Only Type II supernovae come from exploding supergiant stars. These supergiants come from high-mass stars.

Pulsars: Stellar Beacons pp. 402–404 Pulsars are stars that pulse in and out. Pulsars are rapidly rotating neutron stars from which we get pulses of radio radiation. Each pulse occurs as a beam of radio waves, given off by the neutron star, sweeps by us, much as we see pulses of light from a lighthouse as its beam sweeps by us.

Pulsars: Stellar Beacons pp. 402–405 Pulsars are stars that pulse in visible light. Pulsars are detected by their pulsations in radio waves. Only the Crab and Vela pulsars have been seen to pulse in visible light. Other objects known as "x-ray pulsars" or "gamma-ray pulsars" are detected pulsing in those other parts of the spectrum.

Chapter 14

The Event Horizon pp. 417–419 If the Sun shrunk to become a black hole, the Earth would fly off. The gravity affecting an orbiting body acts as though it is concentrated at the center of the central body, in this case, the Sun. So whether the Sun is full-size or shrunken to the size of a black hole, the gravity at Earth's orbit would remain the same, and Earth's path in its revolution around the Sun would not change.

Supermassive Black Holes pp. 418–419 We would be stretched into oblivion as we entered a black hole's event horizon. In a supermassive black hole, the gradient of gravity is not sufficiently strong at the event horizon that we would notice it right away. But we would see strange effects.

Mini Black Holes p. 433 Particles can escape from black holes. In Hawking radiation, we have the situation that energy that spontaneously appears outside a black hole (which it can do for a limited time within Heisenberg's uncertainty principle) converts into a particle/antiparticle pair. If one of the pair goes into the black hole and is lost while the other escapes, it appears that the escaping particle has been emitted from within the black hole.

Chapter 15

The Milky Way p. 464 The spiral arms of our galaxy show us where there is more matter. Matter is more evenly distributed through the plane of our galaxy than it looks; the matter is compressed and heated by a rotating spiral density wave and we see the effect as relatively newly formed stars.

The Milky Way pp. 450–456 We can see the center of our galaxy. The center of our galaxy is hidden by dust that keeps visible light from penetrating. Looking in the infrared does allow us to detect the center; a few stars have been studied with adaptive optics long enough to have their orbits traced out, revealing a central black hole at Sgr A* of about 4 million times the Sun's mass.

The Milky Way p. 466 It is easy to see our own galaxy's spiral arms. We are in the plane of our galaxy, so we determine our galaxy's spiral structure only arduously, by mapping out positions and distances of various kinds of objects.

The Milky Way p. 464 Galaxies have spiral arms because they spin and draw out material. The spiral arms we see in a galaxy are illusions caused by density waves.

The Milky Way pp. 450–456 Interstellar space is invisible. Dust prevents us from seeing far through interstellar space.

Chapter 16

Galaxies: Island Universes pp. 480–484 The spiral shapes seen with telescopes in the sky are nebulae – gas and dust – in our galaxy. As was shown in the 1920s, the "spiral nebulae" are really independent galaxies, large regions of gas, dust, and stars that are located far beyond our own Milky Way Galaxy.

Types of Galaxies p. 486 The Hubble tuning-fork diagram shows evolution from one end to the other, from ellipticals to spirals. A galaxy's type basically depends on how it forms, and galaxies do not evolve from ellipticals to spirals. In fact, many or most ellipticals may arise from collisions of spirals.

Types of Galaxies p. 486 The relative sizes of the bulges are the same for all types of spiral galaxies. The relative sizes of the bulges vary from S0 to Sa to Sb to Sc (see column 2 of Figure 16-8b).

The Dark Side of Matter pp. 494–497 We see most of the matter in the Universe. The matter that we see with our eyes or detect with radio telescopes or other telescopes may make up only about 5 percent of the total matter/energy content of the Universe. Another 33 percent is thought to be dark matter. The rest is increasingly thought to be some kind of energy, such as the "cosmological constant."

The Dark Side of Matter p. 497 We know what makes up dark matter. We don't know what composes dark matter. It could be made of small, dark masses known as MACHOs (massive compact halo objects), or it could be unknown types of elementary nuclear particles, such as those known as WIMPs (weakly interacting massive particles).

The Birth and Life of Galaxies pp. 503–504 Hubble's law, $v=Hd$, shows that a galaxy's velocity increases as its distance increases. We see an individual galaxy over a negligible length of time, so never see any changes in velocity.

The Birth and Life of Galaxies p. 504 The Universe has a center and is expanding into space. The Universe has no center; Hubble's law merely corresponds to any point you look from that seems to be the center. The Universe contains all space, and space expands with it. See also Chapter 16

The Birth and Life of Galaxies pp. 504–506 The Hubble constant's units correspond to velocity. The units, km/sec/Mpc, correspond to distance/time/distance, which corresponds to 1/time. Inverting the Hubble constant, and working out the conversions, gives a measure of the age of the Universe in time units.

The Birth and Life of Galaxies p. 506 Our Virgo Cluster of galaxies is expanding. Though groups of galaxies are receding from each other according to Hubble's law, members of a given group or cluster of galaxies are gravitationally bound to each other and don't recede from each other.

Chapter 17

Quasars p. 528 Quasars are like pulsars and are quite different from galaxies. Quasars were active events in the centers of galaxies. They are on a galactic scale, emitting tremendous amounts of energy, and are far bigger and more energetic than the stellar scale of a pulsar. We have concluded that they are powered by giant black holes, with masses millions or billions of times that of the Sun.

Quasars p. 535 Quasars are evenly distributed throughout the Universe. There was an era when quasars (that is, quasar activity in the centers of galaxies) was more common than it is now, so when we look outward, we see back in time until at a certain distance, we are seeing objects during the quasar era.

Quasars pp. 536–542 You cannot have $z > 1$. To have $z > 1$ merely means that the amount of a spectral line's redshift is greater than the original wavelength of the spectral line. The simple Doppler formula $\delta\lambda/\lambda = v/c$ doesn't work anymore, but a relativistic formula exists that gives you the velocity, which always turns out to be less than the speed of light. Astronomers have detected several objects with z = ~10. See also Figure It Out 16.4.

Quasars p. 542 The apparent velocities greater than the speed of light, which we sometimes see when we watch the separation of blobs in the jets of quasars, are real. Nothing can go faster than the speed of light. We are merely seeing an effect accounted for by the special theory of relativity. The material in the jet is approaching us so close to the speed of light that light emitted from the jet later on comes from a place very much closer to us than light emitted from the jet earlier.

Chapter 18

An Expanding Universe pp. 557–558 We see galaxies receding from us in all directions, so we are at the center of the Universe. There is no center to the Universe; a uniformly expanding substance gives the effect at any given location in it that all things are expanding away from it.

The Age of the Universe pp. 558–559 Hubble's law applies perfectly to all galaxies. Hubble's law is true in general, but there are also slight gravitational effects that show up in nearby clusters of galaxies but that are overwhelmed by the expansion effect sufficiently far out.

The Age of the Universe pp. 564–565, 598 We know what dark energy is made of. We know, from observations of such spacecraft as WMAP and Planck, that about 70% of everything in the Universe is undetected except by its effects, and we call it "dark energy." But nobody knows what dark energy is made of, though there are some theories involving Einstein's "cosmological constant" or another theoretical substance called "quintessence."

Chapter 19

The Steady-State Theory p. 590 The law of conservation of energy is definitely true. The law of conservation of energy is certainly true to any conceivable level of our testing, but the rate required by the steady-state theory, which has since been rejected on other grounds, is below our experimental level.

The Cosmic Microwave Radiation p. 591 We can see back to the Big Bang. When we look back to about 300,000 years after the Big Bang, the Universe was dense and opaque, and we cannot see farther back in any part of the spectrum.

The Early Universe pp. 592–593 The Universe has always been made of almost all matter, with very little antimatter, as it is now. There was probably once a huge amount of matter and a huge amount of antimatter, with the two annihilating each other, leaving only the matter we have now.

The Inflationary Universe p. 606 The Universe is flat like a pancake. "Flat" doesn't really mean a shape, but means that geometrical things match their behavior on flat surfaces on Earth. In particular, two and only two parallel lines can be drawn through a point, and the sum of the angles of a triangle is 180 degrees.

The Inflationary Universe pp. 606–608 There are three spatial dimensions and one time dimension. Promising and widely accepted theories of physics now have an 11-dimensional space, with 7 of the dimensions too small to see. There have been suggestions that one of those dimensions might actually be large enough to be detected.

The Inflationary Universe pp. 607–608 All gravity pulls inward; all mass is equivalent to positive energy, which we just call "energy." Energy and its equivalent mass pulling inward is balanced in the Universe by negative gravitational energy, so that the total energy of the Universe is zero.

Dark Energy pp. 564–565, 598 We know what dark energy is made of. We know, from observations of such spacecraft as WMAP and Planck, that about 70% of everything in the Universe is undetected except by its effects, and we call it "dark energy." But nobody knows what dark energy is made of, though there are some theories involving Einstein's "cosmological constant" or another theoretical substance called "quintessence."

Chapter 20

Suitable Stars for Intelligent Life pp. 626–627 Planets anywhere in a planetary system are equally likely to have life on them. Though we can't really say, it seems reasonable that planets within a narrow range of distances from their stars, known as the 'habitable zone,' in which it is not too cold or too hot, are more likely to harbor life; see Chapter 9.

Suitable Stars for Intelligent Life pp. 627–630 Looking for radio signals (television signals are transmitted by radio) is the only way to look for extraterrestrial life in other planetary systems. Looking for radio signals has been the dominant way of searching, but perhaps other methods of transmitting signals, such as with lasers or with neutrino beams, are really better.

Life in the Universe pp. 630–632 If we don't send out a message, people on other stars can't detect us. Our radar signals and television signals are travelling out into space, and could be detected by sufficiently sensitive receivers.

The Statistics of Intelligent Extraterrestrial Life pp. 633–635 Figuring out whether there is life in the Universe is just a guess. We can quantify the problem of the chance that there is life in the Universe with the Drake equation, though we do have to guess at some of the intermediate values it uses.

UFOs and the Scientific Method pp. 637–639 Astronomers generally accept that there could be life elsewhere in the Universe, so they must accept that UFOs also visit Earth. UFOs, or "unidentified flying objects," are not the best explanation for various reports of lights in the sky, and astronomers therefore do not accept that aliens are flying around in spacecraft and are visiting Earth.

