Astronomy: A Beginner's Guide to the Universe, 7e **(Chaisson/McMillan)**
Chapter 3 Telescopes: The Tools of Astronomy

1) The simplest reflector telescope design is the prime focus reflector.
Answer: TRUE
Diff: 1
Section Ref.: 3.1

2) Galileo is credited with designing the first reflector telescope.
Answer: FALSE
Diff: 1
Section Ref.: 3.1

3) Chromatic aberration affects reflector telescopes.
Answer: FALSE
Diff: 1
Section Ref.: 3.1

4) All optical telescopes will bring the light from a star to a focus.
Answer: TRUE
Diff: 1
Section Ref.: 3.1

5) A telescope design that uses a lens and no mirrors is a refractor.
Answer: TRUE
Diff: 1
Section Ref.: 3.1

6) CCD detectors gather light 10-20 times faster than the most sensitive photographic film.
Answer: TRUE
Diff: 1
Section Ref.: 3.1

7) A Newtonian reflector needs no secondary mirror.
Answer: FALSE
Diff: 2
Section Ref.: 3.1

8) The Hubble Space Telescope gives us its best resolution with X-rays.
Answer: FALSE
Diff: 2
Section Ref.: 3.1

9) The Cassegrain reflector needs a primary concave main mirror and a smaller, convex secondary mirror to reflect light back through a hole in the primary.
Answer: TRUE
Diff: 2
Section Ref.: 3.1

10) Photography with film is still the preferred way of capturing fine detail in the faintest, most distant galaxies.
Answer: FALSE
Diff: 2
Section Ref.: 3.1

11) The light-gathering ability of a telescope is most dependent on the diameter of its primary objective.
Answer: TRUE
Diff: 1
Section Ref.: 3.2

12) Mt. Palomar's 200" Hale telescope is the largest reflector now in service.
Answer: FALSE
Diff: 2
Section Ref.: 3.2

13) A telescope with an 8-inch mirror will collect twice as much light as one with a 4-inch mirror.
Answer: FALSE
Diff: 3
Section Ref.: 3.2

14) The 400" Keck reflector can see objects 100 times fainter than the 40" Yerkes lens.
Answer: TRUE
Diff: 3
Section Ref.: 3.2

15) Radio telescopes have poorer angular resolution than optical telescopes because radio waves have a much longer wavelength than optical waves.
Answer: TRUE
Diff: 1
Section Ref.: 3.2, 3.4

16) All modern large optical telescopes are refractors.
Answer: FALSE
Diff: 1
Section Ref.: 3.2

17) Stars do not twinkle; the instability of the atmosphere causes this effect.
Answer: TRUE
Diff: 1
Section Ref.: 3.3

18) The opacity of the atmosphere is partially corrected via adaptive optics.
Answer: FALSE
Diff: 2
Section Ref.: 3.3

19) In the future, adaptive optics will greatly enhance the resolution of the Hubble Space Telescope.
Answer: FALSE
Diff: 3
Section Ref.: 3.3, 3.1

20) Optical telescopes are usually used only at night, but radio telescopes can be used day or night.
Answer: TRUE
Diff: 1
Section Ref.: 3.4

21) The Earth's atmosphere is the major factor limiting the use of ground-based radio telescopes.
Answer: FALSE
Diff: 1
Section Ref.: 3.4

22) Optical interferometry is more in use than radio interferometry.
Answer: FALSE
Diff: 2
Section Ref.: 3.4

23) Radio astronomy can only be done from up in space, due to our ionosphere.
Answer: FALSE
Diff: 2
Section Ref.: 3.4

24) Like radio and optical astronomy, infrared astronomy is easily done with ground-based telescopes.
Answer: FALSE
Diff: 1
Section Ref.: 3.5

25) Due to our ozone layer, ultraviolet astronomy must be done from space.
Answer: TRUE
Diff: 1
Section Ref.: 3.5

26) The mirrors for X-ray telescopes are the same shape as those of optical reflectors.
Answer: FALSE
Diff: 2
Section Ref.: 3.5

27) The Compton GRO was the first telescope used for our exploration of high-energy astronomy.
Answer: FALSE
Diff: 2
Section Ref.: 3.5

28) Galaxies look the same whether viewed in visible or X-ray wavelengths.
Answer: FALSE
Diff: 2
Section Ref.: 3.5

29) Which type of telescope has the simplest light path?
A) prime focus reflector
B) single lens refractor
C) achromatic refractor
D) Newtonian reflector
E) Cassegrain reflector
Answer: A
Diff: 1
Section Ref.: 3.1

30) Which of the following is NOT a reason to use a reflecting telescope rather than a refractor?
A) Lenses are subject to chromatic aberration.
B) Lenses are harder to focus than mirrors.
C) Lenses absorb light, while mirrors do not.
D) Heavy lenses, which can only be supported at their edges, tend to deform under their own weight.
E) A lens must have two precision surfaces; a mirror needs only one.
Answer: B
Diff: 2
Section Ref.: 3.1

31) What problem do refractor telescopes have that reflectors don't?
A) diffraction limited resolution
B) light loss from secondary elements
C) chromatic aberration
D) atmospheric blurring
E) bad seeing
Answer: C
Diff: 1
Section Ref.: 3.1

32) The most important advantage of CCDs over film is that
A) they record much more light in a given exposure time.
B) their images do not have to be developed as film does.
C) they record colors better than film can.
D) they can cover larger areas of the sky than film can.
E) their images never fade, as film can.
Answer: A
Diff: 1
Section Ref.: 3.1

33) The primary purpose of a telescope is to
A) collect a large amount of light and bring it into focus.
B) magnify distant objects.
C) separate light into its component wavelengths.
D) make distant objects appear nearby.
E) measure the brightness of stars very accurately.
Answer: A
Diff: 1
Section Ref.: 3.1

34) A major advantage of a Newtonian reflector over a refractor is
A) its compact size.
B) the elimination of chromatic aberration.
C) there are only two lenses to grind.
D) the central hole in the mirror is smaller.
E) the elimination of the secondary mirror.
Answer: B
Diff: 2
Section Ref.: 3.1

35) Adding a secondary concave lens of carefully chosen different glass to the primary lens on a refractor allows
A) chromatic aberration to be reduced.
B) X-rays to be focused.
C) effects of atmospheric turbulence to be reduced.
D) greater magnification.
E) more light to be gathered.
Answer: A
Diff: 3
Section Ref.: 3.1

36) It is diffraction that limits the _____ of a telescope of a given objective diameter.
A) magnification
B) light grasp
C) resolution
D) aperture
E) interference
Answer: C
Diff: 1
Section Ref.: 3.2

37) The angular resolution of an 8 inch diameter telescope is _____ times greater than that of a 2 inch diameter telescope.
A) 2
B) 4
C) 8
D) 9
E) 16
Answer: B
Diff: 1
Section Ref.: 3.2

38) The amount of diffraction and thus the resolution of the telescope depends upon
A) the wavelength used and the size of the main telescope objective lens or mirror.
B) the design of the telescope.
C) whether the telescope is a reflector or refractor.
D) the brightness of the object.
E) the size and sensitivity of the CCD chip used for imaging.
Answer: A
Diff: 1
Section Ref.: 3.2

39) What is the resolution of a telescope?
A) its ability to see very faint objects
B) its ability to distinguish two adjacent objects close together in the sky
C) its ability to make distant objects appear much closer to us
D) its ability to separate light into its component colors for analysis
E) its ability to focus more than just visible light for imaging
Answer: B
Diff: 1
Section Ref.: 3.2

40) Compared to a 5 inch prime focus reflector, a 5 inch Newtonian reflector will
A) have more light gathering power.
B) have the same light gathering power.
C) be easier to build.
D) have more chromatic aberration.
E) have a larger hole in the center of its mirror.
Answer: B
Diff: 2
Section Ref.: 3.2

41) What is the light-gathering power of an 8 inch telescope compared to a 4 inch telescope?
A) 2 times better
B) 4 times better
C) 8 times better
D) 16 times better
E) 32 times better
Answer: B
Diff: 2
Section Ref.: 3.2

42) Green light has a shorter wavelength than orange light. In a 5 inch telescope, green light will
A) provide better angular resolution than orange light.
B) come to the same exact focus as orange light.
C) provide worse angular resolution than orange light.
D) allow dimmer stars to be observed.
E) reduce the effects of atmospheric turbulence.
Answer: A
Diff: 3
Section Ref.: 3.2

43) What problem does adaptive optics correct?
A) defects in the optics of the telescope, such as the original Hubble mirror
B) the opacity of the Earth's atmosphere to some wavelengths of light
C) the light pollution of urban areas
D) turbulence in the Earth's atmosphere that creates twinkling
E) chromatic aberration due to use of only a single lens objective
Answer: D
Diff: 2
Section Ref.: 3.3

44) What is true of radio telescopes?
A) They have poorer angular resolution than a refractor of the same size.
B) They have better angular resolution than a reflector.
C) They are the smallest, most compact telescopes.
D) They can only be used above the atmosphere.
E) They are most sensitive to the opacity of the ozone layer.
Answer: A
Diff: 1
Section Ref.: 3.4

45) The Arecibo radio telescope is laid out like which optical telescope design?
A) prime focus reflector
B) Newtonian reflector
C) Cassegrain reflector
D) Coude reflector
E) grazing incidence reflector
Answer: A
Diff: 1
Section Ref.: 3.1, 3.4

46) In astronomy, an interferometer can be used to
A) yield better seeing conditions with optical telescopes.
B) decrease the effects of light pollution in getting darker sky backgrounds.
C) improve the angular resolution of radio telescopes.
D) increase the sensitivity of infrared telescopes to longer wavelengths.
E) speed up the processing of CCD images.
Answer: C
Diff: 2
Section Ref.: 3.4

47) Compared to optical telescopes, radio telescopes are built large because
A) they're less expensive to make than optical telescopes.
B) radio waves have very long wavelengths.
C) atmospheric turbulence is more of a problem.
D) radio sources are harder to find.
E) radio waves are absorbed by the atmosphere.
Answer: B
Diff: 3
Section Ref.: 3.4

48) One advantage of the Hubble Space telescope over ground based ones is that
A) it is larger than any Earth-based telescopes.
B) it can better focus X-ray images.
C) it can make better observations of the ozone layer.
D) its adaptive optics controls atmospheric blurring better.
E) in orbit, it can operate close to its diffraction limit at visible wavelengths.
Answer: E
Diff: 2
Section Ref.: 3.3

49) The design of modern X-ray telescopes depends on
A) lenses made of germanium.
B) the prime focus design, with mirrors made of iron.
C) grazing incidence optics.
D) achromatic lenses to keep the X-rays in focus
E) the Cassegrain design, with mirrors made of lead.
Answer: C
Diff: 2
Section Ref.: 3.5

50) Which of the following is currently supplying high resolution X-ray images from space?
A) ROSAT
B) Chandra
C) Einstein
D) HEAO-2
E) COBE
Answer: B
Diff: 2
Section Ref.: 3.5

51) The _____ focus reflector needs only a single optical surface to form images.
Answer: prime
Diff: 1
Section Ref.: 3.1

52) An advantage a reflector has over a refractor is the elimination of _____.
Answer: chromatic aberration.
Diff: 1
Section Ref.: 3.1

53) The separation of red and blue light in single-lens telescopes is called _____ aberration.
Answer: chromatic
Diff: 1
Section Ref.: 3.1

54) To a large degree, the _____ has replaced photographic film for astronomical imaging.
Answer: CCD
Diff: 1
Section Ref.: 3.1

55) A mirror must be _____ in shape to reflect the light back to a focus.
Answer: curved, concave, or parabolic
Diff: 1
Section Ref.: 3.1

56) A lens must be _____ in shape to focus the transmitted light.
Answer: convex
Diff: 1
Section Ref.: 3.1

57) The light-gathering power of a telescope varies with the _____ of the diameter of the lens or mirror.
Answer: square
Diff: 1
Section Ref.: 3.2

58) In general, as a telescope's diameter increases, its angular resolution _____.
Answer: increases or improves.
Diff: 1
Section Ref.: 3.2

59) The ability of a telescope to separate two closely spaced stars is called _____.
Answer: resolution
Diff: 2
Section Ref.: 3.2

60) The large reflector, the 10 m Keck, gathers _____ times more light than the 1.0 m Yerkes refractor.
Answer: 100
Diff: 3
Section Ref.: 3.2

61) The twinkling of starlight and the focusing of images by lenses are both due to _____ of light.
Answer: refraction
Diff: 1
Section Ref.: 3.3

62) If the _____ is good, the atmosphere is stable, and image quality is sharp.
Answer: seeing
Diff: 1
Section Ref.: 3.3

63) _____ optics greatly reduces the effect of atmospheric turbulence by deforming the shape of the mirror by computer control.
Answer: Adaptive
Diff: 1
Section Ref.: 3.3

64) _____ optics deform the shape of the mirror to compensate for the turbulence in the atmosphere and yield a close to diffraction-limited image.
Answer: Adaptive
Diff: 2
Section Ref.: 3.3

65) In design, most radio telescopes, like Arecibo, are _____.
Answer: prime focus reflectors
Diff: 2
Section Ref.: 3.4

66) When used in a single instrument to greatly enhance its resolution, the four separate mirrors of the VLT act as a(n) _____.
Answer: interferometer
Diff: 2
Section Ref.: 3.4

67) The _____ Space Telescope still gives us the highest resolution optical images.
Answer: Hubble
Diff: 1
Section Ref.: 3.5

68) Grazing incidence optics are critical to focusing _____.
Answer: X-rays
Diff: 2
Section Ref.: 3.5

69) Using _____ incidence optics, the Chandra is the X-ray equivalent of the HST.
Answer: grazing
Diff: 2
Section Ref.: 3.5

70) Name the four types of reflector designs.
Answer: prime focus, Newtonian, Cassegrain, and Coude
Diff: 1
Section Ref.: 3.1

71) Which type of reflector telescope would be the easiest to construct, and why?
Answer: The prime focus reflector needs only a single optical surface, on the front of the main mirror.
Diff: 1
Section Ref.: 3.1

72) Contrast image formation in reflectors and refractors.
Answer: Reflectors use a curved mirror to reflect the light back to a focus, while refractors use a convex lens to bend the transmitted light to a focus.
Diff: 1
Section Ref.: 3.1

73) How does the placement of the eyepiece with Newtonian and Cassegrain reflectors differ?
Answer: In the Newtonian, the eyepiece is located on the front side of the tube, but with the Cassegrain, it lies behind the hole in the main mirror.
Diff: 2
Section Ref.: 3.1

74) What are two advantages of CCDs over photographic films for astronomy?
Answer: CCDs are much more light efficient, can capture much fainter objects in a given exposure, and yield digital images that are instantly displayed without having to be developed.
Diff: 2
Section Ref.: 3.1

75) Why is it easier to travel to a remote viewing site with an 8" Cassegrain than an 8" Newtonian reflector?
Answer: The Cassegrain design is much more compact, and thus easier to carry, transport, and set up.
Diff: 2
Section Ref.: 3.1

76) You are a novice telescope builder. Should you attempt a 6" Newtonian or Cassegrain reflector first? Why?
Answer: The Newtonian uses only a curved main mirror and a small flat secondary. The primary for the Cassegrain also needs a hole to be drilled in its center, and its small secondary is convex in shape, harder to make than the flat for the Newtonian.
Diff: 2
Section Ref.: 3.1

77) There are ground-based telescopes much larger than Hubble, yet the HST still reveals the faintest objects yet seen. Explain.
Answer: In space, HST can operate close to its diffraction limit without the losses due to atmospheric turbulence. This allows it to produce sharper images of fainter objects.
Diff: 2
Section Ref.: 3.1

78) Contrast the main mirrors of Newtonian and Cassegrain designs.
Answer: Both use a curved mirror, but the Newtonian has a flat secondary mirror that sends the light to an eyepiece at the side of the telescope, while the Cassegrain mirror is similar, but usually more steeply curved, and needs a hole to be drilled in the center for access to the Cassegrain focus behind this mirror.
Diff: 3
Section Ref.: 3.1

79) With a prime focus reflector, why is digital imaging much easier than using an eyepiece for visual work?
Answer: A CCD is tiny, and blocks little of the light path. Your head would be in front of the mirror at prime focus, blocking much of the light if you tried to use it visually.
Diff: 3
Section Ref.: 3.1

80) Name two advantages of larger telescopes over smaller ones.
Answer: Larger objectives gather more light to see fainter objects, and give you better resolution and thus sharper images.
Diff: 1
Section Ref.: 3.2

81) Explain why the image seen in astronomical telescopes is inverted.
Answer: In both reflectors and refractors, the eyepiece must be located behind the prime focus, so the light reaching it has "flipped over" in passing through the focus.
Diff: 2
Section Ref.: 3.2

82) Why is a CCD image much faster to obtain than a photograph?
Answer: CCDs can obtain images faster because they are more efficient in gathering light compared to film. Thus, less exposure time is required.
Diff: 1
Section Ref.: 3.3

83) Why do stars appear to twinkle?
Answer: In space, the light of the stars appears steady and images are sharp. But in passing through our atmosphere, the narrow shafts of star light are shifted constantly by turbulence, hence the images dance around in the eyepiece for us on the ground.
Diff: 1
Section Ref.: 3.3

84) Why doesn't the Hubble Space Telescope need adaptive optics?
Answer: Adaptive optics correct poor seeing in our atmosphere, but above the atmosphere, Hubble has perfect seeing and sharp images all the time.
Diff: 3
Section Ref.: 3.3

85) Explain the basic principle behind the VLA.
Answer: The Very Large Array is a series of radio telescopes that can be linked together using interferometry. This gives the resolution of a very large telescope, equivalent to the maximum separation of the individual telescopes.
Diff: 3
Section Ref.: 3.4

86) Why is the angular resolution of radio telescopes much worse than that of smaller optical telescopes?
Answer: Radio waves are much longer in wavelength than light waves, so their angular resolution is limited by diffraction.
Diff: 2
Section Ref.: 3.4

87) Why is the Hubble Space Telescope equipped with more infrared and ultraviolet detectors than are optical telescopes on the ground?
Answer: Operating above the atmosphere, the HST can pick up energy from both sides of the optical range that are blocked by the opacity of the Earth's atmosphere.
Diff: 2
Section Ref.: 3.5

88) Why is UV astronomy difficult to do from the ground?
Answer: The atmosphere blocks most of the UV waves before they reach the ground. In order to see a wide range of UV wavelengths, you have to get very high in the atmosphere, such as with a balloon observatory, or above the atmosphere.
Diff: 2
Section Ref.: 3.5

89) Why are the designs of the Hubble and Chandra Space Telescopes different?
Answer: Hubble is a Cassegrain reflector, using visible as well as some IR and UV waves. By contrast, Chandra forms its X-ray images with grazing incidence optics. X-ray waves would not be brought to a focus using parabolic (curved) optics.
Diff: 3
Section Ref.: 3.5

90) Discuss several disadvantages of refractor versus reflector telescopes.
Answer: Refractors must use lenses, and thus all suffer from some chromatic aberration; mirrors reflect all wavelengths of light the same. Correcting for chromatic aberration means including more optical surfaces, requiring more work than any reflector design, which includes the secondary mirrors. Large refractor lenses must be supported by their edges, which means they will flex under their own weight. Mirrors can be built much larger, and supported from the back with no light blockage. Lenses require two precision surfaces; mirrors only need one. Thick lenses will absorb some light, which is not an issue for mirrors.
Diff: 2
Section Ref.: 3.1

91) In what ways are ground-based observatories catching up with Hubble?
Answer: Ground-based telescopes have now been built much larger than the Hubble's mirror, and with adaptive optics, can cancel out much of the seeing problems of the atmosphere, giving "space-like" image quality from the ground with huge mirrors for enhanced resolution and light-collecting ability. Optical interferometry is used with ground-based telescopes to further improve their resolution.
Diff: 2
Section Ref.: 3.1

92) Explain an advantage a good refractor corrected for chromatic aberration has over any design of reflector of the same size.
Answer: The lenses of the refractor can transmit more light without any central obstruction due to the secondary mirror, and thus form a shaper, crisper image with better contrast than can the reflector designs.
Diff: 3
Section Ref.: 3.1

93) Why would observing in blue light give better resolution than red light when observing objects close together in the same field of view?
Answer: The shorter the wavelength, the better the resolution of any mirror or lens of a given diameter.
Diff: 2
Section Ref.: 3.2

94) What are adaptive optics designed to overcome? How is this done?
Answer: Adaptive optics attempt to overcome the effect of atmospheric turbulence. The mirror is flexed to match the turbulence in the atmosphere, thus "calming" the image and giving much better seeing and far sharper images.
Diff: 2
Section Ref.: 3.3

95) What is a CCD, and how does it work? Why is it replacing film?
Answer: A charge coupled device consists of a grid of thousands of light-sensitive pixels that build up a digital image that can be stored on computer as light strikes it. It is digital, so it can be placed directly on magnetic tape or disks, or sent over a computer network. CCDs are also much more sensitive to fainter objects than are the fastest photo films.
Diff: 2
Section Ref.: 3.1

96) How do radio interferometers greatly enhance resolution in radio wavelengths?
Answer: Hooking two or more radio dishes together with a computer lets us get resolution not equal to the diameters of the dishes, but to the separations between the telescopes.
Diff: 2
Section Ref.: 3.4

97) Why were the two Keck 400" telescopes placed together atop Mauna Kea?
Answer: The light of both telescopes is combined with an optical interferometer to give resolution of the pair equal to the separation of the two telescopes on the top of the mountain, much better than can be done with any single telescope on its own.
Diff: 2
Section Ref.: 3.4

98) What are some advantages of radio telescopes over optical telescopes?
Answer: Radio telescopes can be used day or night, they are much less affected by cloudy skies, and they open a new window to observe the Universe. They allow us to observe astronomical objects at a different wavelength than an optical telescope, thus giving an opportunity to compare and contrast the images.
Diff: 2
Section Ref.: 3.4

99) Explain three advantages the Hubble Space Telescope has over all ground-based telescopes.
Answer: In space, HST can focus on infrared and ultraviolet waves invisible to ground-based observers. With no air, the seeing for Hubble is always perfect and images are much sharper than when viewed through our turbulent blanket of air, even with the best adaptive optics. As the Hubble orbits the Earth, it can be turned to view anything in the sky and not be limited by the local horizon.
Diff: 2
Section Ref.: 3.5