



openstax™

Astro- nomy

BRIEF ASTRONOMY VIDEOS

FOR USE WITH EACH CHAPTER OF OPENSTAX ASTRONOMY

A List by Senior Author, Andrew Fraknoi
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Note: This listing includes a wide range of short videos (15 minutes or less) that can be used in introductory astronomy courses. It is organized by the chapter topics in the OpenStax *Astronomy* textbook. We don't include simulations. To suggest other video that you have found particularly useful for Astro 101 courses, please drop a line to the compiler at: fraknoi@fhda.edu

* = either from a government agency (should be copyright free) or with CCC-by License

Chapter 1: Science and the Universe

Scientific Notation: (3 min, PBS, 2014) Cartoon explaining how scientific notation works and why it's useful: <http://www.pbslearningmedia.org/resource/muen-math-ee-scientificnotation/scientific-notation/>

Explaining Scientific Notation (6 min, Open University, 2014) A well-organized British introduction to the way scientists write large and small numbers:
<https://www.youtube.com/watch?v=goialvVrVAs>

* How Big is Space? (2 min, NASA, 2019) Shows the length of light-time units, from a light-second to hundreds of thousands of light years:
<https://www.youtube.com/watch?v=MX3PIkbTQwQ>

Wanderers (4 min, Erik Wernquist, 2015) A tour of the solar system with words by Carl Sagan, imagining other worlds with dramatically realistic paintings:
<https://www.youtube.com/watch?v=YH3c1QZzRK4>

Powers of Ten (9 min, Eames Office, 1977) Classic short tour of the physical universe, narrated by physicist Philip Morrison: <http://www.youtube.com/watch?v=OfKBhvDjuy0>

The Known Universe (6 min, American Museum of Natural History, 2009): a modern tour of the universe, with realistic animation, music, and captions:
<https://www.youtube.com/watch?v=17jymDn0W6U>

* ALMA is a Time Machine (2 min, ESO, 2018) ESOCast #135; cartoon explaining how the delay in the travel of light through the universe allows astronomers to look into the past:
<https://www.eso.org/public/videos/esocast135a/>

Science as a Way of Thinking: Interview with Carl Sagan (9 min, The Inspiration Journey, date unknown) A discussion with Sagan about the scientific method and the danger of not training young people to think critically, with images and music:
<https://www.youtube.com/watch?v=J1cNaFG1VII>

Chapter 2: Observing the Sky: The Birth of Astronomy

* Apollo 15 Hammer and Feather Drop (2 min, NASA, 1971) Apollo 15 astronaut David Scott took a hammer and feather to the Moon and dropped them in a vacuum to show Galileo was right: <https://www.youtube.com/watch?v=oYEGdZ3iEKA>

Difference between geocentrism and heliocentrism (ongoing animation showing planet orbits in each model): <http://www.malinc.se/math/trigonometry/geocentrismen.php>

Excerpt on Erathosthenes and his measurement of the Earth from the *Cosmos* TV series with Carl Sagan (6 min, PBS, 1979): <https://vimeo.com/78787366>

Mini-biography of Galileo (3 min, Biography, 2013) with pictures and interviews with astronomers Laura Danly and Amy Mainzer: <https://www.youtube.com/watch?v=2J0-ZbbrD6U>

Derren Brown on Astrology (8-min, excerpt from British TV “Trick of the Mind”, 2007) Magician and skeptic Brown cleverly exposes astrology as a pseudo-science: <https://www.youtube.com/watch?v=haP7Ys9ocTk>)

Astrology Debunked (9 min, *Enemies of Reason*, 2008) A segment of a TV show where Richard Dawkins discusses astrology versus astronomy and gives reasons why astrology is just an ancient superstition: <https://www.youtube.com/watch?v=dIMiKrwCRQ0>

Astrology Debunked (9 min, uncredited, 1979-2015) This compilation video includes commentary by Carl Sagan, Neil deGrasse Tyson, Richard Dawkins, and the Amazing Randi, looking skeptically at astrology: <https://www.youtube.com/watch?v=y84HX2pMo5U>

Chapter 3: Orbits and Gravity

* Solar System Dynamics: Orbits and Kepler’s Laws (7 min, NASA, 2010) Nice discussion of Kepler’s career, and how he came up with the laws of planetary motion – which are demonstrated: <https://www.youtube.com/watch?v=wjOOrr2uPuU>

Tycho Brahe, Johannes Kepler, and Planetary Motion (14 min, German TV, 2013) A summary of the history in English: <https://www.youtube.com/watch?v=x3ALuycrCwI>

Isaac Newton rap battles Bill Nye (3 min, Epic Rap Battles of History, 2014): <https://www.youtube.com/watch?v=8yis7GzIXNM>

Richard Feynman on the Discovery of Neptune (5 min, b&w Cornell lecture, 1964): <https://www.youtube.com/watch?v=FgXQffVgZRs>

* How You Wash Hair in Space (3 min, NASA, 2013) Astronaut Karen Nyberg demonstrates how she washes her hair in free-fall aboard the International Space Station: <https://www.youtube.com/watch?v=uIjNfZbUYu8>

* Space Station Assembly Animation (3 min, NASA, 2011) Shows how the parts of the International Space Station got put together; with a timeline: <https://www.youtube.com/watch?v=vgfWH3g9kpY>

Conservation of Angular Momentum (5 min, U of Nebraska, 2016) Explores angular momentum with discussion and a number of good classroom demonstrations: <https://www.youtube.com/watch?v=1Bdyrv3cc0M>

Precession of Earth (3 min, U of Nebraska, 2013) Nice demonstration of the precession of a spinning ball, then related to the precession of the Earth’s axis over the millennia: <https://www.youtube.com/watch?v=0qHjtp4cdCA>

Chapter 4: Earth, Moon, and Sky

Bill Nye, the Science Guy Explains the Seasons (5 min, from his old TV show) For kids, but college students can enjoy the bad jokes too: <https://www.youtube.com/watch?v=KUU7IyfR34o>

- * The Seasons in 12 Seconds (12 sec, NASA, 2011) Compresses the turning of the Earth over a year into 12 seconds, showing from geosynchronous orbit how the terminator changes from equinoxes to solstices: <https://www.youtube.com/watch?v=LUW51lvIFjg>
- * Lunations (5 min, NASA, 2018) Sped-up video of the Moon and its phases over the course of a year, with a lot of information: <https://www.youtube.com/watch?v=5Om7NbfUC6Y> (for a full user guide, see: <https://svs.gsfc.nasa.gov/4604>)
- Exploratorium Videos on Observing Eclipses Safely (a series of short videos with how-to instructions: <http://www.exploratorium.edu/eclipse/how-to-view-eclipse>)
- Geography Lesson on the Arrangement and History of Time Zones (3 min, TWIG, 2012): <https://www.youtube.com/watch?v=-j-SWKtWEcU>
- * Shadow of the Moon (2 min, NASA Goddard, 2015) Explains eclipses of the Sun, with discussion and animation, and showing what an eclipse looks like from space): <https://www.youtube.com/watch?v=XNcfKUJwnjM>
- Strangest Time Zones in the World: A History of Time Zones and Examples of Places that Keep Their Own Time (9 min, WonderWhy, 2014): <https://www.youtube.com/watch?v=uW6QqcmCfm8>
- Understanding Lunar Eclipses (2 min, LRO/NASA Goddard, 2014) Explains the reason why there isn't an eclipse every month, with good animation: <https://www.youtube.com/watch?v=INi5UFpales>
- How to Observe a Lunar Eclipse (5 min, California Academy of Sciences) Animated, narrated introduction to what these eclipses are and what you can see and appreciate during one: <https://www.youtube.com/watch?v=JRv0tF0te44>

Chapter 5: Radiation and Spectra

- * NASA has a 2010 series of useful short videos, called “Tours of the Electro-magnetic Spectrum,” which focus on one band of the spectrum each, looking at both its terrestrial and astronomical aspects:
 - 1) Introduction and overview (5 min): <https://www.youtube.com/watch?v=1wfJPc-rSXw>
 - 2) Radio Waves (4 min): <https://www.youtube.com/watch?v=OzDmEA8x0nQ>
 - 3) Microwaves (3 min): <https://www.youtube.com/watch?v=UZeBzTI5OmK>
 - 4) Infrared (5 min): <https://www.youtube.com/watch?v=i8caGm9Fmh0>
 - 5) Visible Light (5 min): <https://www.youtube.com/watch?v=PMtC34pzKGc>
 - 6) Ultraviolet Waves (4 min): <https://www.youtube.com/watch?v=QW5zeVy8aE0>
 - 7) X-rays (3 min): <https://www.youtube.com/watch?v=CCAYcuCWOmM>
 - 8) Gamma-rays (4 min): <https://www.youtube.com/watch?v=TA5SLDiIUWs&t=20s>
- * Unweaving the Rainbow (6 min, ESA/Hubble, 2012) HubbleCast 59: An explanation of how astronomers use spectra, particularly with the Hubble, but also in general: <https://www.spacetelescope.org/videos/hubblecast59a/>
- * Seeing the Invisible (9 min, IAU/ESA/Hubble, 2008) HubbleCast #23: An introduction to the non-visible bands of the electro-magnetic spectrum, to the telescopes that allow us to detect them, and what objects are prominent: <https://www.spacetelescope.org/videos/hubblecast23a/>
- * Infrared: More Than Your Eyes Can See (7 min, Spitzer/NASA, 2008) A lively introduction, with astronomer Michelle Thaller, to infrared radiation, its applications on Earth and in astronomy: <https://www.youtube.com/watch?v=v4J56lnl1UE>

- The Electromagnetic Spectrum (5 min, Institute of Physics, 2012) Introduction to the bands of the spectrum, the telescopes that lets us observe them, and what celestial phenomena we can see in each band: <https://www.youtube.com/watch?v=5GIvktBSxvw>
- Blackbody Radiation (5 min, U. of Nebraska, 2014) A student-made video with useful discussion and demonstrations about the properties of blackbodies and spectra: <https://www.youtube.com/watch?v=Otkbp8yk-w>
- How a Prism Works (3min, RimStar, 2013) Short video by an amateur scientist on how a prism bends light to make a rainbow of colors: https://www.youtube.com/watch?v=JGqsi_LDUn0
- * The Doppler Effect (5 min, ESA, 2014) Features a Doppler ball to demonstrate the effect and the motion of satellites: http://www.esa.int/spaceinvideos/Videos/2014/07/Doppler_effect_-_classroom_demonstration_video_VP05

Chapter 6: Astronomical Instruments

- * The History of Telescopes: In these two episodes of the HubbleCast from ESA, host Dr. Joe Liske takes viewers on a good-natured tour of telescopes, how they work, and how they evolved over the years: 1) New Views of the Skies (13 min, 2008): <https://www.spacetelescope.org/videos/hubblecast17a/> and 2) Bigger is Better (10 min, 2008): <https://www.spacetelescope.org/videos/hubblecast19a/>
- * Flexible Giants: The Evolution of Telescope Mirrors (8 min, ESO, 2014) ESOCast #63: On the recent history of large telescope mirrors and observatories, focusing on ESO's instruments: <https://www.eso.org/public/videos/esocast63a/>
- * Day in the Life of an ESO Astronomer (6 min, ESO, 2009) ESOCast #4: What it's like to observe with a large telescope in our modern era: <https://www.eso.org/public/videos/esocast4/>
- Keck Observatory (6 min, National Academies of Science, etc., 2011) A silent film about the Keck telescopes and the work being done there, nice footage: https://www.youtube.com/watch?v=EzpGxyuKo_M
- * The European Southern Observatory (3 min, ESO, 2016) An introduction to ESO (with music and captions), its observatory locations, and its telescopes: <https://www.eso.org/public/videos/esotrailer/>
- * Catching Starlight (4 min, ESO, 2017) ESOCast #112 : A history of astronomical sensors (detectors) with a nice explanation of CCDs: <https://www.eso.org/public/videos/esocast112a/>
- * Catching Light (11 min, ESO, 2012) ESOCast #46: A dramatic introduction to modern telescopes, detectors, and spectrographs, made on the occasion of the 50th anniversary of ESO: <https://www.eso.org/public/videos/esocast46a/>
- * How to Stop a Star's Twinkle (9 min, ESO, 2011) ESOCast #34: On the adaptive optics technique for getting better resolution, focusing on a laser guide-star instrument being developed in Europe: <https://www.eso.org/public/videos/esocast34a/>
- * Seeing the Invisible (9 min, IAU/ESA/Hubble, 2008) HubbleCast #23: An introduction to the non-visible bands of the electro-magnetic spectrum, to the telescopes that allow us to detect them, and what objects are prominent: <https://www.spacetelescope.org/videos/hubblecast23a/>

- * Making the Universe Come to Life: Behind the Hubble Images (5 min, ESA/Hubble, 2007) HubbleCast #10: Explains how the raw data from Hubble are converted into the beautiful Hubble images that fill our textbook: <https://www.spacetelescope.org/videos/hubblecast10a/>
- * SOFIA: An Airborne Observatory (11 min, NASA, 2014) On the Infrared Observatory inside a converted 747 airplane: <https://www.youtube.com/watch?v=g5z6fZKOtP4>
- * One Whole Day at the Very Large Array (5 min, NRAO, 2018) Beautiful drone footage of the array of radio telescopes in the New Mexico desert: <https://www.youtube.com/watch?v=TZXer4qadbw>
- * Seeing Beyond: The James Webb Space Telescope (14-min, JWST, 2013) introductory video to the next big space telescope: <https://www.youtube.com/watch?v=073GwPbyFxE>
- * Galaxies Viewed in Full Spectrum of Light (6 min, NASA/Spitzer, 2009) Scientists with the Spitzer Observatory show how a galaxy looks different at different wavelengths: <https://www.youtube.com/watch?v=368K0iQv8nE>
- * Battle of Giants: Telescopes in Space and on the Ground (6 min, ESA/Hubble, 2007) HubbleCast #6: Compares the advantages of ground-based and space telescopes: <https://www.spacetelescope.org/videos/hubblecast06a/>
- * Comparing the Hubble and James Webb Telescopes (5 min, ESA/Hubble, 2019) HubbleCast #126: From infrared to ultraviolet, contrasts their capabilities: <https://www.spacetelescope.org/videos/hubblecast126a/>
- * Nancy Roman: The Mother of the Hubble (5 min, ESA, 2018) The life and career of the woman astronomer at NASA whose work led to the Hubble Space Telescope: <https://www.spacetelescope.org/videos/hubblecast113a/>
- * Hubble's History by Hubble Scientists (10 min, ESA/Hubble, 2010) HubbleCast #42: Interviews with key people show how the Hubble was planned, built and repaired: <https://www.spacetelescope.org/videos/hubblecast41a/>
- * Mission Accomplished: Healing Hubble (6 min, ESA/Hubble, 2009) HubbleCast #29: On the fifth and final Space Shuttle trip to service the Hubble Space Telescope in orbit: <https://www.spacetelescope.org/videos/hubblecast29a/>
- * Overview of the James Webb Space Telescope (3 min, NASA, 2018): <https://www.youtube.com/watch?v=aC6BGIAvccE>
- * Introduction to the James Webb Space Telescope (4 min, NASA Goddard, 2020) Very basic primer for the public: <https://www.youtube.com/watch?v=6VqG3Jazrfs>
- * 15 Years in Space: Spitzer Space Telescope (2 min, NASA, 2018) Overview of the work of this infrared instrument in orbit, with the scientists speaking about their favorite discoveries: <https://www.jpl.nasa.gov/video/details.php?id=1543>
- * The Atacama Large Millimeter Array (ALMA) (3 min, ESO, 2016) A dramatic, musical, visual, and captioned introduction to the giant array of radio telescopes in South America: <https://www.eso.org/public/videos/almatrailer2016a/>
- WISE Surveys the Skies (2 min, California Academy of Sciences, 2011) On NASA's Wide-field Infrared Survey Explorer, an infrared camera in orbit and what it is discovering, such as brown dwarfs; includes interviews with astronomers: <https://www.youtube.com/watch?v=nyG22PfAwYQ>
- * From Silver to Silicon (8 min, ESA/Hubble, 2008) HubbleCast #21: A history of astronomical detectors from drawings to CCD's: <https://www.spacetelescope.org/videos/hubblecast21a/>

- * Special Technology to the Rescue (9 min, ESA/Hubble, 2008): HubbleCast #20: A good discussion of how technology has recently enabled astronomers to build bigger and more efficient telescopes: <https://www.spacetelescope.org/videos/hubblecast20a/>

Chapter 7: Introduction to the Solar System

Shane Gellert's "I Need Some Space" (7 min, BlueDog Films, 2014) Uses NASA photography and models to show the various worlds with which we share our system:
<https://vimeo.com/78449289>.

"Wanderers" (4 min, Eric Wernquist, 2015) We see some of the planets and moons as tourist destinations for future explorers, with commentary taken from recordings by Carl Sagan:
<https://vimeo.com/108650530>

Brief PBS *Evolution* series excerpt explaining how we use radioactive elements to date the Earth (2 min, PBS, 1998):

<http://www.pbslearningmedia.org/resource/tdc02.sci.phys.matter.radiodating/radiometric-dating/>

Radiometric Dating (5 min, Discovery Channel, 2011) A geological explanation of how we date rock layers on Earth: <https://www.youtube.com/watch?v=cpnIxIDVmHw>

Origins of the Solar System (13-min, NOVA/PBS, 2011) From *Nova ScienceNow*, focusing on the evidence from meteorites, narrated by Neil Tyson:

<http://www.pbs.org/wgbh/nova/space/origins-solar-system.html>

The spins and inclinations of the planets shown graphically (40 sec video from NASA/JAXA):
<https://www.youtube.com/watch?v=my1euFQHH-o>

- * Zodiacal Light (6 min, ESO, 2016) ESOCast #82; on the light (visible in the dark skies above the best settings for telescopes: reflected light from the dust in the plane of the solar system):
<https://www.eso.org/public/videos/esocast82a/>

[Also see "What is a Planet" under Chapter 12]

Chapter 8: Earth as a Planet

- * Views of Home (4 min, NASA, 2017) How NASA missions have provided dramatic images of the Earth from space (and even from Mars):

<https://www.youtube.com/watch?v=VfpaxVQSbTQ>

Earth at Night (2 min, California Academy of Sciences, 2013) Narrated story of the SUMI-NPP satellite, which takes images of our planet at night:

<https://www.youtube.com/watch?v=SfII0I49QEE>

- * What would have happened to Earth's ozone layer by 2065 if CFCs had not been regulated (2 min, NASA, 2009) NASA's scientific visualization studio shows the extent of damage:

<http://svs.gsfc.nasa.gov/vis/a000000/a003500/a003586/index.html>

- * Earth's Magnetosphere (4 min, NASA, 2018) A narrated introduction to the protective magnetic zone around us and its role in space weather affecting Earth:

<https://www.youtube.com/watch?v=o4FSg-90XIA>

- * The Physics of the Greenhouse Effect (2 min, PBS/NSF, 2018) Quick overview:

<http://www.pbslearningmedia.org/resource/phy03.sci.phys.matter.greenhouse2/global-warming-the-physics-of-the-greenhouse-effect/> (There are several other useful short videos on global warming issues on the same page.)

Real Time Globe of Earth showing wind patterns which can be zoomed and moved to your preferred view: <http://earth.nullschool.net/>

Earth Globes Movies (including Earth at night): <http://astro.uchicago.edu/cosmos/projects/earth/>

- * What Does It Feel Like to Fly Over Earth (1 min, James Drake, 2011) 600 images stitched together from astronaut photography:
http://www.openculture.com/2011/09/what_it_feels_like_to_fly_over_planet_earth.html
- * Flying over the Earth at Night (2 min, NASA, 2012) Footage from the International Space Station set to music: <http://apod.nasa.gov/apod/ap120305.html>
- Meteor Hits Russia Feb. 15, 2013 (10 min, FortNite, 2013) Archive of Eyewitness Footage from the meteor explosion high above Chelyabinsk:
<https://www.youtube.com/watch?v=dpmXyJrs7iU>
- * Departing Earth from the Messenger Spacecraft (11 sec, NASA, 2015) Shows the turning globe of our planet receding: <https://www.youtube.com/watch?v=48-XvX5VfxI>
- * Understanding the Outer Reaches of Earth's Atmosphere (4 min, NASA, 2018) Explains how new space probes are helping us to understand changes in our ionosphere:
<https://www.youtube.com/watch?v=dD5S4Va2Kh8>
- * Near Earth Objects (6 min, ESO, 2018) ESOCast #168, with astronomer Olivier Hainaut. Introducing near-Earth asteroids and comets, and how we study them and worry about their impacts: <https://www.eso.org/public/videos/esocast168a/>

Chapter 9: The Moon and Mercury

- * Evolution of the Moon (3 min, NASA, 2012) Produced by the Lunar Reconnaissance Orbiter team tracing the development of the Moon, from its origin about 4.5 billion years ago to the Moon we see today: <https://www.youtube.com/watch?v=mIRPeYGKfic>
- * Tour of the Moon (5 min, NASA Goddard, 2012) Using LRO images, narrated tour, nicely done): <https://www.youtube.com/watch?v=2iSZMv64wuU>
- * Exploring the Presence of Water on the Moon (4 min, NASA, 2019) Narrated by astronomer Jim Green, this video explains the LCROSS mission to detect water and what we might do with it: <https://www.youtube.com/watch?v=TA5SLDiIUWs&t=20s>
- Water on the Moon (2 min, California Academy of Sciences, 2009) How LCROSS found water on the Moon and where it might come from:
<https://www.youtube.com/watch?v=NfOfrlVf4rs>
- Where Did the Moon Come From (3 min, BBC, 2011) Beautiful recreation of the giant impact theory of the Moon's origin, narrated by space scientist Maggie Aderin-Pocock:
<https://www.youtube.com/watch?v=c0FCE4H0Dro>
- * Rotating globe of Mercury, in false color (1 min, NASA/JHU, 2013) Shows some of the variations in the composition of the planet's surface:
<https://www.youtube.com/watch?v=DmYK479EpQc>
- * Mercury Visualized (1 min, NASA, 2017) Just a turning globe of Mercury, in black and white, showing detail from the Messenger mission, with music:
https://www.youtube.com/watch?v=g-sk_cH6MXc

Chapter 10: Mars and Venus

- Magellan Maps Venus (3 min, BBC, 2011) TV clip with Dr. Ellen Stofan on the radar images of Venus and what they tell us: <https://www.bbc.co.uk/programmes/p005y07s>
- Planet Venus: The Deadliest Planet (2 min, Nat'l Geographic, 2009) Venus surface and atmosphere summary: <https://www.youtube.com/watch?v=HqFVxWfVtoo>
- * Collection of Magellan Venus Radar Mapping Results (5 min, NASA, 2012) Several flyovers of Venus features, without narration, just credits and music. The height of features is exaggerated for clarity: <https://www.youtube.com/watch?v=3xrMu3jq6P8>
 - * Magellan: Venus False-color Terrain (1 min, NASA, 2016) A rotating globe of Venus, showing the highlands and basins from radar results; no narration: <https://www.youtube.com/watch?v=yUrIzPRI4GE>
 - * Venus Close-up (3 min, ESA, 2014) A summary of the work of the Venus Express mission from the European Space Agency: <https://www.youtube.com/watch?v=7YUy2k-edEo>
 - * 7 Minutes of Terror (5 min, NASA/JPL, 2012) Dramatic overview of Curiosity rover's complex landing sequence: <http://www.jpl.nasa.gov/video/details.php?id=1090>
 - * 50 Years of Mars Exploration (4 min, NASA/JPL, 2015) Summary of all Mars missions through *MAVEN*; good quick overview: <http://www.jpl.nasa.gov/video/details.php?id=1395>
 - * Our Curiosity (6 min, Jeffrey Marlow CC licensed, 2014) Mars Curiosity rover 2-year anniversary video narrated by Neil deGrasse Tyson and Felicia Day: <https://www.youtube.com/watch?v=XczKXWvokm4>
 - * Grand Canyons of Earth and Mars (4 min, NASA, 2019) Comparing the two canyon systems with flyover videos: <https://www.youtube.com/watch?v=CBvrn0Ki714>
 - * 15 Years Imaging the Red Planet (5 min, ESA, 2018) An un-narrated flyover of some of the most spectacular Mars images from Mars Express: https://www.esa.int/ESA_Multimedia/Videos/2019/01/Fifteen_years_imaging_the_Red_Planet#.XfGRNA9OXRk.link
 - * Flight into Mariner Valley (4 min, NASA, 2012) Video tour of Valles Marineris canyons, narrated by planetary scientist Phil Christensen: <https://www.youtube.com/watch?v=JUbQM47QXwQ>
 - * Mars Express: 15-year Summary of Best Image Flyovers (2019, ESA, 5 min): <https://www.youtube.com/watch?v=uoblCdedNNM>
 - * Opportunity: NASA Rover Completes Mars Mission (4 min, NASA, 2019) A narrated, illustrated mission summary: <https://www.youtube.com/watch?v=1LI-VHYxWXU>
 - * NASA's Curiosity Mars Rover on Vera Rubin Ridge: 360 View (1 min, NASA, 2018) A nice martian panorama, in which you can move your cursor and see fully around the scene (the location is named for a noted woman astronomer): <https://www.youtube.com/watch?v=lcJLZfPiyfc>
 - * Methane Stinks? On Earth, Mars, and Beyond (5 min, NASA, 2016) On the search for methane on Mars and elsewhere in the solar system, and what it tells us about the worlds where it's found: <https://www.youtube.com/watch?v=-0K1jkLZiZQ>

Chapter 11: The Giant Planets

- * Voyager: The Grand Tour (15 min, NASA/JPL, 2002) Describes the Voyager mission and what the two probes found: <http://www.jpl.nasa.gov/video/details.php?id=1215>

- * Jupiter Globe Rotation (1 min, NASA/Hubble, 2014) Beautiful video showing the rotation of Jupiter with its many atmospheric features, made from Hubble Space Telescope photos: https://www.youtube.com/watch?v=QND_NtNFAvI
- * Perijove 16: Passing Jupiter (1 min, NASA, 2019) Animation of Juno spacecraft images to simulate a flyby with remarkable (exaggerated) colors and detail: <https://www.youtube.com/watch?v=c4TU3arrZR8>
- * Fly into the Great Red Spot of Jupiter (1 min, NASA, 2017) A remarkable animation from Juno data, flying above and into the Red Spot (with a bar showing your altitude): <https://www.youtube.com/watch?v=uj3Lq7Gu94Y>
- * Jupiter's Magnetosphere (2 min, NASA, 2011) About the magnetosphere of Jupiter and why we continue to be interested in it (featuring astronomer Fran Bagenal): <https://www.youtube.com/watch?v=e0tqmrZn6kY>
- * Flyover of Jupiter's North Pole in Infrared (1 min, NASA, 2018) A "fictionalized" arbitrary-color tour of the storms at the pole from Juno data: <https://www.missionjuno.swri.edu/news/juno-provides-infrared-tour-of-north-pole>
- * New Science from Jupiter (5 min, NASA, 2018) A brief review of the first Juno mission results, with amazing images: <https://www.youtube.com/watch?v=txNjLEmtsw>
- * Four Days at Saturn (2 min, NASA/JPL, 2016) Cassini was focused on the planet Saturn for 44 hours to obtain this labeled, sped-up movie of changes in its atmosphere: <https://www.youtube.com/watch?v=GTYKmxlbtio>
- * Saturn's Stunning Double Show (5 min, ESA/Hubble, 2010) HubbleCast #33: What we could learn about the aurorae at both poles when Saturn's rings were edge-on to us.
- * The hexagon in Saturn's polar region (1 min, NASA/JPL, 2013) Quick NASA videos of the atmospheric flow, in b&w and exaggerated color: <http://www.jpl.nasa.gov/spaceimages/details.php?id=PIA17652>
- * Jupiter, the Largest Planet (7 min, NASA/Goddard, 2010) Dramatic introduction produced with Science on a Sphere. (7:29): <http://www.youtube.com/watch?v=s56pxa9lpvo>.
- * Lightning Across the Solar System (4 min, NASA, 2019) Compares lightning on Earth with giant lightning bolts at Jupiter and Saturn: <https://www.youtube.com/watch?v=F253nFr-rtQ>
- * Cassini: 15 Years of Exploration (2 min, NASA, 2013) Quick visual summary of mission highlights: https://www.youtube.com/watch?v=2z8fzz_MBAw
- * Voyager's Last Encounter (4 min, NASA/JPL, 1989) Voyager 2 at Neptune: with results and quotes by mission scientists: <https://www.youtube.com/watch?v=UqVuDhfh9W8>
- * NASA at Saturn: Cassini's Grand Finale (4 min, 2017, JPL) Describes the accomplishments and final descent into Saturn of this mission: <https://www.youtube.com/watch?v=xrGAQCq9BMU>
- * Hubble Watches Dark Spot on Neptune Die (3 min, NASA Goddard, 2018) Hubble observations of changes in the atmosphere of Neptune, with nice images: <https://www.youtube.com/watch?v=iKHtx5y6C4M>

Chapter 12: Rings, Moons, and Pluto

- * Europa: Ocean World (4 min, NASA/JPL, 2014) Planetary scientist Kevin Hand explains why Europa is so interesting for future exploration: <https://www.youtube.com/watch?v=kz9VhCQbPAk#t=75>

- * Introduction to Europa (1 min, NASA, 2018) A quick overview of why Europa is interesting to NASA: <https://www.youtube.com/watch?v=xQRTgr-Upws>
- * 360 Degrees of Io (1/2 min, NASA, 2013) A brief movie showing a rotating Io with its dramatic surface features: <https://www.youtube.com/watch?v=uhwYkXOE3TI>
- * Titan Approach Movie (3 min, NASA/JPL, 2016) From the images taken by Cassini and Huygens: <https://www.youtube.com/watch?v=TMxL3ZhO8A8>
- * What Huygens Saw on Titan (5 min, U of Arizona, 2015) A reprocessed and improved video showing images recorded during the descent of the Huygens Probe and explaining conditions on Titan: <https://www.youtube.com/watch?v=9L471ct7YDo>
- * Triton Flyover (1 min, NASA, 2014) Animation of images from the 1989 flyby of Neptune's moon: https://www.lpi.usra.edu/icy_moons/neptune/triton/movie/index.shtml
- * Flyover of Titan's Northern Lakes district (2 min. NASA/JPL, 2013) Colorized movie from Cassini images of the hydrocarbon lakes: <https://www.youtube.com/watch?v=RrGptCdItBw>
- * F Ring Shepherd Moons: A very brief movie showing the two moons on either side of Saturn's F ring and the waves they raise in the ring's structure: <http://photojournal.jpl.nasa.gov/catalog/PIA07712>
- * Amazing Moons (5 min, NASA, 2016) Quick overview intriguing moons in our solar system, such as Enceladus, Titan, Europa, and Io: <https://www.youtube.com/watch?v=CQjZf2bW9XQ>
- * Ocean Worlds (6 min, NASA, 2017) Discusses moons with possible underground oceans in the outer solar system (Europa, Ganymede, Callisto, Enceladus, Ceres and more): https://www.youtube.com/watch?v=gw_bX0ZQOy0
- Tidal Heating of Io (5 min, U. of Nebraska, 2018) Student film about the factors that cause the interior of Io to be heated, with some nice demonstrations using an infrared camera: <https://www.youtube.com/watch?v=9qHrzs6Mbp4>
- * Briny Breath of Enceladus (3 min, NASA/JPL, 2009) Brief film on the geysers of Enceladus and what is emerging: <https://www.youtube.com/watch?v=OZsU75Eit-E>
- Dr. Carolyn Porco's TED Talk on Enceladus (3 min): <https://www.youtube.com/watch?v=TRQdHrGuVgI>
- Titan (8 min video from Open University, with interviews, animations, images): <http://www.youtube.com/watch?v=iTrOFefYxFg>
- Phase Changes: Triton Geysers (4 min, U of Nebraska, 2015) Nice student video explaining the geyser's on Neptune's moon Triton; with a brief experiment that demonstrates a crucial part of the story: <https://www.youtube.com/watch?v=0eeoQIfNo0A>
- * What is a Planet? (8 min, NASA, 2015) Narrated story of the changing definition of the word planet, plus the story of the new IAU definition and what it means for Pluto. Mentions disagreements with IAU: <https://www.youtube.com/watch?v=SQUjB0Xdcl4>
- Seeking Pluto's Frigid Heart (7 min, NY Times, 2016) Dramatic New York Times production, narrated by Dennis Overbye: https://www.youtube.com/watch?v=jIxQXGTl_mo
- * Pluto flyover movie (2 min, NASA, 2017) New Horizons images are made into an animation of what the spacecraft cameras saw on Pluto; no narration: <https://www.youtube.com/watch?v=g1fPhhTT2Oo>
- * Charon flyover movie (1 min, NASA, 2017) New Horizons images are made into an animation of the terrain on Pluto's large moon: <https://www.youtube.com/watch?v=f0Q7O7TZ7Ks>

- * New Horizons Discoveries Keep Coming (4 min, NASA, 2017) Reviews New Horizon mission Pluto discoveries, and previews flyby of MU69 (now called Arrekoth):
<https://www.youtube.com/watch?v=r8PEhLDDGeM>
- Chaotic rotation of Pluto's moons (1 min, SETI Institute):
<http://www.seti.org/sites/default/files/dps-slides-showalter1.mp4>
- Pluto Flyover Movie (1 min, NASA, along that big strip, labels but no sound, very effective):
<https://www.youtube.com/watch?v=NEdvyrKokX4>
- * Pluto approach and close up movie (2 min, NASA, 2016) Very nice flyover of one section of Pluto's surface, not narrated, but captioned: <http://pluto.jhuapl.edu/News-Center/News-Article.php?page=20160714-2>
- * Clyde Tombaugh (8 min, NASA, 2015) Video remembering the discoverer of Pluto, featuring his children: <https://www.youtube.com/watch?v=Crbi2in-PHc>
- * Faraway Eris is Pluto's Twin (5 min, ESO, 2011) ESOCast #38: New observations of an occultation of Eris, allowing astronomers to measure its diameter:
<https://www.eso.org/public/videos/eso1142a/>

Chapter 13: Comets and Asteroids

- * Big Questions about Small Worlds (5 min, NASA, 2019) Overview of why we study asteroids, comets, and Kuiper Belt objects, with a focus on NASA missions to them:
https://www.youtube.com/watch?v=P4gXeF_SmsU
- Asteroids in the Sloan Digital Sky Survey (3 min, Alex Parker, 2013) Shows the orbits of 100,000 asteroids found by one sky survey: <https://vimeo.com/87092212>
- * Dawn mission animated "flyover" of Vesta (5 min, NASA, 2013) Compiled from mission images: <https://www.youtube.com/watch?v=0ZpRc-MicHY>
- * Dawn mission animated "flyover" of dwarf planet Ceres (1 min, NASA, 2015):
<https://www.youtube.com/watch?v=6-hYSBghEn0>
- Hayabusa Lands on Asteroid Ryugu (2 min, JAXA, 2019) A Japanese spacecraft lands on and bounces off an asteroid: <https://www.youtube.com/watch?v=HZ67zLTsJEW>
- The Comet: Comet Churyumov-Gerasimenko (3 min, Christian Stangl, 2019) A video artist has made a remarkable animation of 400,000 images from the European Space Agency's Rosetta spacecraft as it orbited comet C-G (or 67P): <https://vimeo.com/347565673>
- Video compilation of the Chelyabinsk meteor streaking through the sky over the city on February 15, 2013: <https://www.youtube.com/watch?v=dpmXyJrs7iU>
- * The International Asteroid Hunt (4 min, NASA, 2018) Reports on how nations are joining to find and keep track of Near-Earth Objects that might be a danger to us:
https://www.youtube.com/watch?v=sLIHB6uC1_s
- * Asteroid Moons (2 min, California Academy of Sciences, 2018) Interview with Franck Marchis, an expert on discovering asteroids that have moons orbiting them:
<https://www.youtube.com/watch?v=vS0CXXqFkCQ>
- * Why Are We Seeing So Many Sungrazing Comets? (3 min, NASA, 2015) How the SOHO space probe shows us comets near the Sun: <http://www.nasa.gov/feature/goddard/soho/solar-observatory-greatest-comet-hunter-of-all-time>
- Asteroid DA14 (2 min, California Academy of Sciences, 2013) About asteroid 2012 DA14, which came very close to Earth; an interview with Don Yeomans at JPL shows how NASA

computes orbits and figures out how safe we are from NEAs:

<https://www.youtube.com/watch?v=G92rcBPt41Y>

* NEOWISE: Four Years of Asteroid and Comet Data (1 min, NASA, 2018) Shows and categorizes the asteroid discoveries from this infrared instrument:

<https://www.jpl.nasa.gov/video/details.php?id=1531>

Rosetta's Moment in the Sun (3 min, ESA, 2015): Close-up images of a comet generating plumes of gas and dust as it nears the Sun; discusses dangers an active comet poses for the spacecraft:

http://www.esa.int/spaceinvideos/Videos/2015/08/Rosetta_s_moment_in_the_Sun

Amino Acids in Space (1.5 min, California Academy of Sciences, 2009) A brief introduction to the discovery of glycine, a simple amino acid, in Comet Wild 2, by the Stardust mission:

<https://www.youtube.com/watch?v=7IH78ze1y5Y>

* The Lasting Impact of Comet Shoemaker-Levy 9 (4 min, NASA, 2019) Review of the event and what it taught us: <https://www.youtube.com/watch?v=gbsqWozEBBw>

* Watch the History of the Solar System Fly By with MU 69 [Arrokoth] (4 min, NASA, 2019) Context and images from the New Horizons flyby:

<https://www.youtube.com/watch?v=Uc1p7cU-e4w>

Chapter 14: Meteors, Meteorites and the Origin of the Solar System

How to Observe Meteor Showers (4 min, California Academy of Sciences, 2014) Friendly, animated short: <https://www.youtube.com/watch?v=EBF4wFhw2Kg>

* Revolutionary ALMA Image Reveals Planetary Genesis (5 min, ESO, 2014) ESOCast #69: New observations of HL Tau and what they reveal about planet formation:

<https://www.eso.org/public/videos/eso1436a/>

Meteorites and Meteor-wrongs (7 min, Washington U., 2011) With Dr. Randy Korotev about identifying and valuing meteorite samples:

<https://www.youtube.com/watch?v=VQO335Y3zXo>

Top Tips for Watching Meteor Showers (3 min, At-Bristol Science Center, 2013):

<https://www.youtube.com/watch?v=xNmglwInCA>

Simulating the Origin of the Solar System (4 min, California Academy of Science, 2016)

Narrated section of a planetarium show with dramatic simulations:

<https://www.youtube.com/watch?v=yXq1i3HlumA>

Origins of the Solar System (13-min, Nova ScienceNow, 2012) Narrated by Neil Tyson:

<http://www.pbs.org/wgbh/nova/space/origins-solar-system.html>

* Kepler Orrery V (1 min, Ethan Kruse/NASA, 2018) Shows stars with multiple planets:

https://www.youtube.com/watch?v=5I_FOEh47RY

Chapter 15: The Sun's Structure, Solar Activity, and Space Weather

The "boiling" action of granulation: 30-second time-lapse video from the Swedish Institute for Solar Physics: https://www.youtube.com/watch?v=W_Scoj4HqCQ

Our Violent and Brilliant Sun (6 min, Institute of Physics, 2012) Basic introduction to the Sun, and to ways we observe the activity on our star and space weather; features solar astronomer Lucie Green: <https://www.youtube.com/watch?v=9IpsHd81Pwk>

- * The Mystery of the Aurora (2 min, NASA, 2008) Narrated video explaining the nature of the aurora and their relationship to solar weather and the Earth's magnetic field:
<https://www.youtube.com/watch?v=PaSFAbATPvk>
- Overview and introduction to the Sun by science reporter Dennis Overbye of the NY Times (3 min): <http://www.nytimes.com/video/science/100000003489464/out-there-raining-fire.html?emc=eta1>
- * *What Happens on the Sun Doesn't Stay on the Sun* (5 min, Nat'l Oceanic and Atmospheric Administration, 2012) Introduction to the Sun, space weather, its effects, and how we monitor it: https://www.youtube.com/watch?v=bg_gD2-ujCk
- Sun Storms* (a 5-min video from the Starry Night company about storms from the Sun now and in the past): <http://www.livescience.com/11754-sun-storms-havoc-electronic-world.html>
- Journey into the Sun* (2010 KQED Quest TV Program, 12 min, mostly about the Solar Dynamics Observatory spacecraft, its launch and capabilities, but with good general information on how the Sun works): <https://www.youtube.com/watch?v=fqKFQ7z0Nuk>
- Space Weather Impacts Videos* from the National Weather Service and NOAA (four short videos): <http://www.swpc.noaa.gov/content/education-and-outreach> -- also on YouTube at: <https://www.youtube.com/playlist?list=PLBdd8cMH5jFmvVR2sZubIUzBO6JI0Pvx0>
- * Solar Dynamics Observatory: Three Years in Three Minutes (5 min, NASA Goddard, 2013) 3 years of observations of the Sun made into a speeded up movie, with commentary by solar physicist Alex Young: <https://www.youtube.com/watch?v=QaCG0wAjJSY&src>
- Sunspot Group AR 2339 Crosses the Sun* is a short video (with music) animates Solar Dynamics Observatory images of an especially large sunspot group going across the Sun's face (1 min 14 sec): <http://apod.nasa.gov/apod/ap150629.html>
- Space Weather: Storms on the Sun:* (7-minute science bulletin from the American Museum of Natural History, giving the background to what happens on the Sun to cause space weather): <https://www.youtube.com/watch?v=vWsmP4o-qVg>
- * Fiery Looping Rain on the Sun (4 min, NASA, 2013) A 2012 flare on the Sun and the activity – CME and magnetic displays – that followed, recorded by the Solar Dynamics Observatory satellite, with dramatic music: <https://www.youtube.com/watch?v=3Ghaf2du-XM>
- * Solar Dynamics Observatory: 5 Years (5 min, NASA, 2015) A compilation of sequences of some of the most dramatic solar activity observed by SDO:
<https://www.youtube.com/watch?v=GSVv40M2aks> (You can see the full 6th year of SDO in time lapse at: <https://www.youtube.com/watch?v=8MImmQvqCSg>)
- * Effects of the Solar Wind (4 min, NASA, 2019) Narrated video explains the Sun's wind and its effects on Earth, focusing on the Parker Solar Probe:
<https://www.youtube.com/watch?v=twB62NYsaIg>

Chapter 16: The Sun: A Nuclear Powerhouse

- Neutrinos: Nature's Identity Thieves (6 min, Fermilab, 2013) Video with Don Lincoln introducing various types of neutrinos and giving the story of Raymond Davis' experiment): <https://www.youtube.com/watch?v=RGv-pcKRf6Q>
- How Does Fusion Power the Sun (2-min, Science channel, 2015) Introduction to fusion with Michelle Thaller and Lawrence Krauss: <https://www.youtube.com/watch?v=W1ZQ4JBv3-Y>
- Why I Love Neutrinos (1 min, Fermilab, 2015) Quick introduction to neutrinos with a very enthusiastic Prof. Josh Klein: <https://www.youtube.com/watch?v=6h8CSLjtBUG>

Why Does the Sun Shine (3 min, They Might Be Giants, 2009) The nerd musical group “They Might Be Giants” sings the song that declares the Sun is a mass of incandescent gas: <https://www.youtube.com/watch?v=3JdWISF195Y> (They later did a little correction song called “The Sun is a miasma of incandescent plasma”: <https://www.youtube.com/watch?v=sLkGSV9WDMA>)

Chapter 17: Analyzing Starlight (Brightness, Color, and Spectra)

The Effect of Proper Motion on the Appearance of the Big Dipper over 200,000 years (9 sec): <http://www.astronomy.ohio-state.edu/~pogge/Ast162/Movies/proper.html>

Understanding the Magnitude System for Stars (5-min, Eyes on the Sky, 2012) video with Robert Fuller: https://www.youtube.com/watch?v=9P8Veb_AIJ0

* WISE Mission Shows Local Brown Dwarfs are Rarer than We Thought (1 min, JPL, 2012) Narrated by astronomer Davy Kirkpatrick: <http://www.jpl.nasa.gov/video/details.php?id=1089>

RECONS Video (4 min, Research Consortium on Nearby Star-Systems, 2014) Fly-through of the stars within 25 pc of the Sun: https://www.youtube.com/watch?v=up_MqNBv0FE

Chapter 18: The Stars (Mass, Diameter, and the H-R Diagram)

* How Big is a Star? (2 min, ESO, 2017) ESOCast #95: Brief animation showing the relative size of the Sun compared to planets, and then of stars of different diameters compared to the Sun: <https://www.eso.org/public/videos/esocast95a/>

The Nearest Stars (a 2-min excerpt from TV’s *The Big Bang Theory*, where Sheldon goes down the apartment-building stairs while reciting the closest stars in order): <https://www.youtube.com/watch?v=vg3noqtm0L0>

* Constructing a Hertzsprung-Russell Diagram for Globular Star Cluster (2 min, NASA/Hubble, 2010) Nice discussion of making the diagram for Omega Centauri, with animation: <https://www.youtube.com/watch?v=HWQslu4S5eQ>

The Hertzsprung-Russell Diagram (2 min, David Butler, 2018) A very basic introduction with graphics showing how the diagram becomes clear as you add more stars: <https://www.youtube.com/watch?v=Yfbs0xydBWE>

Chapter 19: Celestial Distances

* Astrolympics: Distance (4 min, Chandra/NASA, 2016) Uses Olympic images and sports to take a very basic look at distances in space, and to define a light-year: https://www.youtube.com/watch?v=2zvkd88rc_Q

How Do We Measure Distances to the Stars (2 min, Scientific American, 2018) Explains parallax and distance measurements with cartoon drawings: <https://www.youtube.com/watch?v=co7I3c3uA7A>

Measuring the Universe (4 min, Royal Observatory Greenwich, 2012) Basic explanation of parallax, standard candles, Doppler shift, and Hubble’s Law using animated drawings (narrated by Dr. Olivia Johnson): <https://vimeo.com/41434123>

How Big is the Universe (6 min, Institute of Physics, 2012) Very basic introduction to astronomical distances, including the concepts of parallax, standard candles, light-years and the Hubble Deep Field : https://www.youtube.com/watch?v=K_xZuopg4Sk

* Henrietta Leavitt: Ahead of Her Time (4 min, ESA, 2019) HubbleCast #116; On Leavitt's work on Cepheids and how it made it possible to measure distances to stars and galaxies: <https://www.spacetelescope.org/videos/hubblecast116a/>

Introduction to the Gaia Mission (20 min, Cambridge University, 2013) Previews the Gaia mission and what scientists hope to learn: <https://www.youtube.com/watch?v=oGri4YNggoc>

* Gaia Astronomical Revolution (3 min, ESA, 2019) Explains the mission to find the position and motion of a huge number of stars: https://www.youtube.com/watch?v=Q_SnUBqXTEs

* Gaia Mission Makes Most Detailed Star Map (3 min, ESA, 2018) About the release of the first batch of star data, allowing astronomers to make the most accurate map of the nearby regions of the Galaxy: https://www.youtube.com/watch?v=T_qMdaqQB_c

How Big is the Universe (6 min, IOP, 2012) With astronomer Pete Edwards from the British Institute of Physics, this is a step by step introduction to the concepts of distances: https://www.youtube.com/watch?v=K_xZuopg4Sk

Measuring Large Distances Using Triangulation (3-min, fizzics, 2014) video which sets out the basic trigonometry and distance measurement on Earth and in astronomy; it's not a visually dramatic video, but the narration in a nice British accent is helpful): <https://www.youtube.com/watch?v=Saw1Eg2iZaI>

Chapter 20: Between the Stars: Interstellar Matter

* Cosmic Soccer Balls: Fullerenes, Buckyballs, or Buckminsterfullerenes (2-min, NASA/JPL, 2010) Explains what buckyballs are and illustrates how they were discovered in space: <http://www.jpl.nasa.gov/video/details.php?id=918>

* Cosmic Ray Detector for ISS (7-min, NASA, 2015) Space Station Live: segment about the Calorimetric Electron Telescope mission, a cosmic ray detector at the International Space Station): <https://www.youtube.com/watch?v=MCiRuTkIkhw>

* New Views of the Pillars of Creation (6 min, ESA/Hubble, 2015) HubbleCast 82: New Hubble images shed new light on the Eagle Nebula, where star formation is happening: <https://www.spacetelescope.org/videos/heic1501a/>

* The Orion Nebula in a New Light (3 min, ESO, 2010) ESOCast #14: On a new infrared view of this region of gas, dust, and star formation: <https://www.eso.org/public/videos/eso1006a/>

* The Horsehead Nebula Seen in Infrared (6-min, ESA/Hubble, 2013) HubbleCast 65: A report on nebulae in general and about the Horsehead specifically: <http://www.spacetelescope.org/videos/heic1307a/>

* The Horsehead Nebula in New Light (3 min, ESA, 2013) Tour of the dark nebula in different wavelengths; no audio narration, just music, but explanatory material appears on the screen: http://www.esa.int/spaceinvideos/Videos/2013/04/The_Horsehead_Nebula_in_new_light (or see: Cosmic Tour the Horsehead Nebula (2 min, NASA/Hubble, 2018): <https://hubblesite.org/contents/media/videos/2013/12/1176-Video.html>)

Interstellar Reddening (4 min, Penn State, 2009) Video demonstrating how reddening works, with Scott Miller of Penn State; a bit nerdy but useful: <https://www.youtube.com/watch?v=H2M80RAQB6k>

- * Astrochemistry: Finding Molecular Fingerprints in Space (3 min, NRAO, 2017) Astronomer Tony Remijan explains how the ALMA telescope is able to identify complex molecules in the Orion Nebula: <https://www.youtube.com/watch?v=IMyjcEONBc0>

Chapter 21: Birth of Stars and Discovery of Exoplanets

- * Born in Beauty: Proplyds in the Orion Nebula (6 min, ESA/Hubble, 2009) HubbleCast #32: On Hubble Telescope observations of places where new star and planet systems can be seen in the process of forming: <https://www.spacetelescope.org/videos/heic0917a/>
- Observations of HL Tau (The director of NRAO describes the high-resolution observations of the young star HL Tau; with nice artist's animation of a protoplanetary disk; 1 min): <https://public.nrao.edu/gallery/nrao-video-webcast-hl-tau/>
- * Revolutionary ALMA Image Reveals Planetary Genesis (5 min, ESO, 2014) ESOCast #69: Radio observations of HL Tau and the disk in which planets are forming: <https://www.eso.org/public/videos/eso1436a/>
- * Mysterious Ripples Found Racing through a Planet-forming Disk (5 min, ESA/Hubble, 2015) HubbleCast #88: Discovery of interesting features in the disk around AU Microscopii: <https://www.spacetelescope.org/videos/heic1521a/>
- Tour of the Orion Nebula region (4 min, NASA/Hubble, 2011): A narrated fly-through from outside down to a proplyd: <https://www.youtube.com/watch?v=JoeKQeJuHvw>
- * Nobel Winners Michel Mayor and Didier Queloz Talk About 51 Peg b Discovery (1.5 min, NASA, 2019) Quick interview segments: <https://www.youtube.com/watch?v=CBvrn0Ki714>
- * Hubble, Exoplanets, and the Search for Life (6 min, ESA/Hubble, 2016) HubbleCast #97: A progress report on our discovery of exoplanets and habitable zones: <https://www.spacetelescope.org/videos/hubblecast97a/>
- The Search for Earthlike Worlds (3 min, California Academy of Sciences, 2017) An interview with astronomer Natalie Batalha about the work of the Kepler space telescope finding exoplanets: <https://www.youtube.com/watch?v=7CF9RnwY3RE>
- Kepler Mission Orrery with stars with multiple planets: <http://apod.nasa.gov/apod/ap151205.html>
- * Kepler End-of-Flight Documentary (5 min, NASA, 2018) Interviews with mission scientists summarize Kepler's work: <https://exoplanets.nasa.gov/resources/2187/kepler-end-of-flight-documentary/>
- The Search for Planets Beyond Our Solar System (16 min, TED, 2015) Sara Seeger talk on exoplanets and how to find out about them: https://www.ted.com/talks/sara_seeger_the_search_for_planets_beyond_our_solar_system
- * ESOCast: 20 Years of Exploring Exoplanets (8 min, ESO, 2015) ESOCast 79: explains different methods of finding exoplanets, especially with ESO instruments: <http://www.eso.org/public/videos/esocast79a/>
- * Discovering Exoplanets from Transits (6 min, ESA, 2018) HubbleCast #121; on what we can learn from the transit method: <https://www.spacetelescope.org/videos/hubblecast121a/>
- * Fifty New Exoplanets (4 min, ESO, 2011) ESOCast #35: The discovery of planets, particularly super-Earths, using the HARPS instrument and the radial velocity method: <https://www.eso.org/public/videos/eso1134a/>

- * The Ultra-cool Dwarf and the Seven Planets (4 min, ESO, 2017) ESOCast #96 on the discovery of the TRAPPIST 1 system with 7 exoplanets, with some in the habitable zone: <https://www.eso.org/public/videos/eso1706a/>
 - * Planet Found Around Closest Star (6 min, ESO, 2016) ESOCast # 87; On the discovery of a planet around Proxima Centauri: <https://www.eso.org/public/videos/eso1629a/>
 - * Dramatic Change on a Faraway Planet (5 min, ESA/Hubble, 2012) HubbleCast #56: on an exoplanet whose star emitted a powerful flare that began to blow away the planet's atmosphere: <https://www.spacetelescope.org/videos/heic1209a/>
 - * Murk on a Monster Planet (6 min, ESA/Hubble, 2007) HubbleCast #12: The discovery of cloud structure or haze on a hot Jupiter exoplanet: <https://www.spacetelescope.org/videos/heic0720a/>
 - * Homes Away from Home: Revisiting the Seven Planets of TRAPPIST-1 (6 min, Spitzer/NASA, 2018) A good introduction of how we have observed and learned about this intriguing system around a red dwarf: <https://www.youtube.com/watch?v=c2UdJDksdEQ>
- History of Exoplanet Discoveries Shown Graphically 1991-2019 (1 min animation, going from 0 planets to 4,003 planets): https://www.youtube.com/watch?v=aiFD_LBx2nM
- * TESS Mission's First Earth-sized World in Star's Habitable Zone (3 min, NASA Goddard, 2020) A news bulletin about the planet TOI 700b: <https://www.youtube.com/watch?v=QU0qsIGS6MQ>

Chapter 22: Stellar Evolution from Main Sequence to Red Giants (plus Star Clusters)

- * Evolution of Stars in a Dwarf Galaxy (1-min, ESA, 2012) Animation traces how stars evolve with time on the H-R diagram: <http://www.spacetelescope.org/videos/heic1211a/>
 - * H-R diagram for globular cluster Omega Centauri (2 min, ESA, 2010) Narrated animation of how the stars on a Hubble image are plotted and related to stellar evolution: <http://www.spacetelescope.org/videos/heic1017b/>
- Three Short Hubblecast Videos from 2007-2008 on discoveries involving star clusters: <https://www.youtube.com/watch?v=rGPRLxrYbYA>
- * A Tour of Planetary Nebula NGC 5189 (5-min, ESA/Hubble, 2012) Hubblecast 61 with Joe Liske, explaining planetary nebulae in general and one example in particular: <https://www.spacetelescope.org/videos/heic1220a/>
- The Life Cycle of Stars (5-min, IOP, 2012) Summary of stellar evolution from the Institute of Physics in Great Britain, with astronomer Tim O'Brien: <https://www.youtube.com/watch?v=PM9CQDIQI0A>
- * NASA Missions Take an Unparalleled Look into Superstar Eta Carinae (4-min, NASA/Goddard, 2015) On observations in 2014 and what we know about the pair of stars in this complicated system: <https://www.youtube.com/watch?v=0rJQi6oaZf0>
 - * Celestial Fireworks: Star Cluster Westerlund 2 (1 min, NASA Hubble, 2017) Simulation, flying through some nebulosity and then into an open star cluster: <https://www.youtube.com/watch?v=dtY44sPNHcU>
 - * Zooming in to Terzan 5 (30 sec; spacetelescope.org; 2016) Takes us from the Milky Way at large to a globular cluster seen with the Hubble: <https://www.youtube.com/watch?v=jtQOAtiJq3o> (A similar 2012 movie by ESO, zooming to globular cluster M4 for 1 min, is at: <https://www.youtube.com/watch?v=x8VxLRMV760>)

- * Exploring the Structure of the Ring Nebula (2 min, NASA/Hubble, 2013) Narrated fly-through of this famous planetary nebula, with good explanations of the shape we see:
https://www.youtube.com/watch?v=_a94pl2lrYM
- * ESO Telescope Sees Surface of Dimmer Betelgeuse (1 min, ESO, 2012) Brief, unnarrated news item about the VLA actually resolving the disk and shape of the red giant star:
<https://www.youtube.com/watch?v=k38One1TINQ>

Chapter 23: Death of Stars (White Dwarfs, Supernovae, Neutron Stars, Pulsars, Gamma-ray Bursts)

- Supernova 1987A (1 min, Hubble/NASA, 2010) Zoom Movie flying into the LMC and toward the remnant: <https://www.youtube.com/watch?v=3T-FoEgcvXY>
- * A Tour of Supernova 1987A (3 min, Chandra/NASA, 2017) A history of the supernova with Hubble and x-ray observations discussed:
<https://www.youtube.com/watch?v=ITvAdZzNFb0>
- * A Tour of M82 and Supernova SN 2014J (3 min, Chandra/NASA, 2014) A Type Ia supernova discovered in M82 is explained, with brief animations of the two mechanisms by which such a supernova could form: <https://www.youtube.com/watch?v=6aKLnjooJaI>
- * The Death of Stars (7 min, ESA/Hubble, 2012) HubbleCast #52: About the evolution of low-mass stars like the Sun and Hubble images of the kinds of objects our Sun will become:
<https://www.spacetelescope.org/videos/hubblecast52a/>
- * It All Ends with a Bang (10 min, ESA/Hubble, 2013) HubbleCast #64: An introduction to Supernovae and their long-term effects; with Dr. Joe Liske:
<http://www.spacetelescope.org/videos/hubblecast64a/>
- * Tour of the Crab Nebula (3 min, Chandra/NASA, 2020) Combines visible-light and x-ray observations to permit a remarkable 3-D visualization of the supernova remnant:
<https://www.youtube.com/watch?v=DJ46S7sQ5hM>
- * Vision Across the Full Spectrum: The Crab Nebula (1 min, STScI, 2018) A brief, silent animation showing images of the famous supernova remnant in wavelength bands from radio to x-rays: <https://hubblesite.org/video/1023/science>
- * A Tour of Tycho's Supernova Remnant (4 min, NASA/Chandra, 2019) A narrated overview, with emphasis on x-ray observations: <https://www.youtube.com/watch?v=pF05nG96BiM>
- * Uncovering the Veil Nebula (6 min, ESA/Hubble, 2007) HubbleCast #7: An introduction to supernovae and their remnants, with a focus on the famous remnant in Cygnus:
<https://www.spacetelescope.org/videos/heic0712a/>
- * A Tour of Cas A (3 min, NASA/Chandra, 2019) Examination of the supernova remnant that was the first target for the Chandra x-ray telescope. Updates what we know about the remnant 20 years later: <https://www.youtube.com/watch?v=44lHuKCmTWc>
- * What is a Pulsar? (2 min, NRAO, 2011) Astronomer Scott Ransom explains what pulsars are in everyday language with diagrams: https://www.youtube.com/watch?v=G08RsjkR_28
- * Millisecond Pulsars (2 min, NRAO, 2011) Dr. Scott Ransom, of the National Radio Astronomy Observatory, explains how millisecond pulsars come about, with some nice animation:
<https://www.youtube.com/watch?v=m112a76tjKQ>
- * Two Sides of the Same (Neutron) Star (4 min, NASA, 2018) Discusses radio pulsars and x-ray emissions from magnetars, and asks how the two are related; interesting for a NASA video

because it addresses an open question to which there is no answer at present:

<https://www.youtube.com/watch?v=R9IbfB0B4FU>

- * Black Holes: What Masses Can Different Stellar Remnants Have (2 min, NRAO, 2011) A discussion by astronomer Scott Ransom on the mass limits of white dwarfs, neutron stars, and black holes: <https://www.youtube.com/watch?v=4kMkfr2MkLY>
- * Doomed Neutron Stars Create Blast (1 min, NASA, 2017) Simulation of the merger of two neutron stars, producing both an explosion and a source of gravitational waves: https://www.youtube.com/watch?v=x_Akn8fUBeQ
- Gamma-Ray Bursts: Flashes in the Sky (6 min, American Museum of Natural History, 2012) Science Bulletin introducing the bursts, and focusing on the work of the Swift satellite: <https://www.youtube.com/watch?v=23EhcAP3O8Q>
- Brief Animation of What Causes a Long-Duration Gamma-ray Burst (1 min, NASA, 2013): <https://www.youtube.com/watch?v=7uN1AjMui5k>
- * Chasing Gamma-Ray Bursts at Top Speed (6 min, ESO, 2010) ESOCast #25: On gamma-ray bursts, and how the Very Large Telescope can be rapidly directed to the site of one: <https://www.eso.org/public/videos/eso1049a/>
- * NASA's NICER Reveals First-ever Pulsar Surface Map (4 min, NASA Goddard, 2019) About an x-ray telescope on the International Space Station mapping a pulsar: <https://www.youtube.com/watch?v=zukBXehGHas>

Chapter 24: Black Holes and General Relativity (plus Gravitational Waves)

Aboard NASA's Vomit Comet (8 min, Rochester Institute of Technology, 2008) How NASA uses a "weightless" environment to help train astronauts:

<https://www.youtube.com/watch?v=2V9h42yspbo>

Weightless Astronaut Pushes Herself with a Single Hair (2 min, NASA, 2013) Astronaut Karen Nyberg demonstrates how, aboard the ISS, she can propel herself with the force of a single human hair: <https://www.youtube.com/watch?v=WMK36dpHIkg>

Death by Black Hole (6 min, OpenCulture, 2012) Neil deGrasse Tyson, on stage, with only his hands, explains spaghettification):

http://www.openculture.com/2009/02/death_by_black_hole_and_its_kind_of_funny.html

* Five Things about Black Holes (4 min, NASA/Goddard, 2019) Brief introduction to the properties of black holes with astronomer Regina Caputo:

https://www.youtube.com/watch?v=26ilf0jO_ZM

* Black Holes Explained Very Simply for a Family Audience (5 min, SETI Institute, 2011) Video with Andrew Fraknoi, one of the senior authors of our textbook:

https://www.youtube.com/watch?v=7DX_cc-IjY

* NASA Guide to Black Hole Safety (3 min, NASA Goddard, 2019) This very whimsical cartoon introduction for tourists thinking about visiting black holes will not be every instructor's cup of tea; but if you or your students like somewhat silly humor, you might enjoy showing it: <https://www.youtube.com/watch?v=aMTwtb3TVIk>

What Happens Inside a Black Hole (5 min, Royal Institution, 2020) Physicist Jerome Gauntlett explains in a non-technical way what happens if you go inside the event horizon and confront the singularity that is there: <https://www.youtube.com/watch?v=F-6C4aXJ6WQ>

Gravitational Waves:

- LIGO: Opening a New Window onto the Universe (5 min, LIGO, 2016) A history of the LIGO Observatory, through the first detection, with brief interviews with key players: <https://www.youtube.com/watch?v=5in0EVv02Ys>
- Journey of a Gravitational Wave (3 min, LIGO at Caltech, 2016) An introduction to how gravity waves were found from the merger of two black holes; narrated by scientist David Reitze: <https://www.youtube.com/watch?v=FIDtXIBrAYE>
- LIGO's First Detection of Gravitational Waves (10 min, PBS, 2016) Explanation and animations from PBS Digital Studio: https://www.youtube.com/watch?v=gw-i_VKd6Wo
- * Two Black Holes Merge into One (0.4 sec; LIGO Caltech; 2016) Excellent simulation: https://www.youtube.com/watch?v=I_88S8DWbcU
- What the Discovery of Gravitational Waves Means (11 min, TED, 2016) TED Talk by Allan Adams: <https://www.youtube.com/watch?v=jMVAgCPYYHY>
- * First Light from Gravitational Wave Source (4 min, ESO, 2017) ESOCast #133 on the first observations of electro-magnetic radiation from an event seen with gravity waves: <https://www.eso.org/public/videos/eso1733a/>

Chapter 25: The Milky Way Galaxy

- * How Big is Space? (2 min, NASA, 2019) Shows the length of light-time units, from a light-second to light years, ending up with the diameter of the Milky Way: <https://www.youtube.com/watch?v=MX3PIkbTQwQ>
- * A Guide to Our Galaxy (3 min, Gaia/ESA, 2014) An unnarrated fly-through of our Galaxy, starting with the stars orbiting the central black hole and moving outward. Ends with comparing the survey volumes of Hipparcos and Gaia: <https://www.youtube.com/watch?v=G5AdrupH788>
- What and Where are the Arms of the Milky Way (4 min, A. Goodman, 2018) Dr. Alyssa Goodman at Harvard explains and illustrates where the main spiral arms of our Galaxy can be found: <https://www.youtube.com/watch?v=oSYWTsNCoyI>
- Stars Orbiting the Central BH in Milky Way (11 sec; Andrea Ghez, 1996-2010) Animation of Ghez' data: <https://www.youtube.com/watch?v=EvuV3GdVaY4>
- * Massive Cloud on Collision Course with the Milky Way (3 min, NASA, 2016) Discovery that one of the high-velocity clouds near our Galaxy is on a collision course with us: <https://www.youtube.com/watch?v=rmmjpc15mBk>
- * A Black Hole's Dinner is Fast Approaching (5 min, ESO, 2011) ESOCast #39: About the discovery of a cloud approaching the massive black hole at the center of the Galaxy: <https://www.eso.org/public/videos/eso1151a/>
- Andrea Ghez on Supermassive Black Holes (16 min, TED, 2009) TED talk on searching for supermassive BHs, particularly the one at the center of the Milky Way: https://www.ted.com/talks/andrea_ghez_the_hunt_for_a_supermassive_black_hole
- * Diner at the Center of the Galaxy (3 min, NASA, 2012) NuSTAR observations of flares from our Galaxy's central black hole: <https://www.youtube.com/watch?v=UP7ig8Gxftw>
- * Crash of the Titans (5 min, ESA/Hubble, 2012) Hubblecast 55: Featuring Jay Anderson and Roeland van der Marel explaining how Andromeda will collide with the Milky Way in the distant future: <http://www.spacetelescope.org/videos/hubblecast55a/>
- Spitzer Space Telescope Panorama of the Milky Way Galaxy in the Infrared (3 min, Spitzer/NASA, 2014): <http://www.spitzer.caltech.edu/video-audio/1444>

- * Big Questions: Dark Matter (7 min, Fermilab, 2013) Dr. Don Lincoln explains how astronomers discovered dark matter and how we search for it:
<https://www.youtube.com/watch?v=oPNrcKeqbBM>

Chapter 26: Galaxies

- * Edwin Hubble (6 min, ESA, 2013) HubbleCast #89, on the life and work of Hubble:
<http://www.spacetelescope.org/videos/hubblecast89a/>
- * How Many Galaxies Are There in the Universe (6 min, ESA/Hubble, 2016) HubbleCast #96: on recent counts of galaxies on deep field images:
<https://www.spacetelescope.org/videos/heic1620a/>
- * Virtual Flyby of the Whirlpool Galaxy (1 min, NASA/Hubble, 2019) A flyover of the Hubble image of M51: <https://www.youtube.com/watch?v=ikdXEcmIjgA>
- * Hubble's Contentious Constant (4 min, NASA, 2017) Short discussion of measuring Hubble's constant and on how different measurements now disagree a bit:
<https://www.youtube.com/watch?v=9DDnJmcTRZw>
- * The Most Distant Galaxy Ever Measured (6 min, ESO, 2010) ESOCast #22: How the Very Large Telescope measured the distance to a galaxy formed only 600 million years after the Big Bang: <https://www.eso.org/public/videos/eso1041a/>
- * Grand Design in a Galactic Festoon (6 min, ESA/Hubble, 2007) HubbleCast #11: A nice tour through the detailed Hubble image of the galaxy M74, a beautiful face-on spiral:
<https://www.spacetelescope.org/videos/heic0719a/>
- * Spirals in Nature (4 min, Chandra/NASA, 2012) Looks at how spiral structure forms in a variety of phenomena and compares them to spiral galaxies:
https://www.youtube.com/watch?v=W1TVoD9_vLQ

Chapter 27: Active Galaxies, Quasars, and Supermassive Black Holes

- * A Tour of Centaurus A (4 min, ESA/Hubble, 2011) HubbleCast #46: A visual guide to this relatively nearby active galaxy with a giant black hole at the center and evidence of a recent galaxy collision: <https://www.spacetelescope.org/videos/heic1110a/>
- * A Tour of the Black Hole Jet in M87 (3 min, Chandra/NASA, 2020) Overview of the giant black hole, its jet, the x-rays coming from it, plus the image taken with the Event Horizon Telescope: <https://www.youtube.com/watch?v=gxC2jpugA9g>
- * Merging Galaxies Create Active Galactic Nuclei (2 min, NASA animation, 2013):
<https://www.youtube.com/watch?v=TseB5fKQIHU>
- * Tour of Black Hole Seeds in the Early Universe (3 min, Chandra/NASA, 2016):
<https://www.youtube.com/watch?v=5SKQRrg1mR8>
- * Hubble and Black Holes (9 min, ESA/Hubble, 2011) HubbleCast #43; with Dr. Joe Liske on how Hubble is used to measure the mass of supermassive black holes and study their evolution: <http://www.spacetelescope.org/videos/hubblecast43a/>
- * Most Distant Quasar Found (5 min, ESO, 2011) ESOCast #32, on the discovery of the most distant quasar up to that point: <https://www.eso.org/public/videos/eso1122a/>
- * In the Shadow of the Black Hole (17 min, ESO, 2019) A longer video about the Event Horizon Telescope and its Pioneering Image of the Shadow of the Event Horizon in the Active Galaxy M87: <https://www.eso.org/public/videos/eso1907a/> (See also a 2-min silent version,

with captions giving the essence of the discovery:

<https://www.eso.org/public/videos/eso1907b/>)

- * Inside the Black Hole Image that Made History (11 min, TED, 2019) A discussion with Shep Doeleman, the leader of the Event Horizon Telescope project that made the first image of the M87 black hole: <https://www.youtube.com/watch?v=uyMtsyzXWd4>
- * A Tour of Triplet Black Holes (3 min, Chandra/NASA, 2019) Examines a merger of three galaxies containing supermassive black holes: https://www.youtube.com/watch?v=RNrv_xDdWtE
- * Hubble Detects a Rogue Supermassive Black Hole (3 min, NASA Goddard, 2017) Intriguing observations of 3C186, a quasar that is not in the center of its host galaxy. Discussed ideas for how this could happen, involving the collision of smaller galaxies and merging black holes: <https://www.youtube.com/watch?v=K09zNxtJ1Is>

Chapter 28: Evolution and Distribution of Galaxies

A Flight through the Universe (2 min, Sloan Digital Survey, 2012) A remarkable animation of moving through the galaxies the Survey cataloged; really conveys the huge number of galaxies involved as you fly through: <https://www.youtube.com/watch?v=08LBltePDZw>

How to Find a Galaxy (4 min, PBS, 2016) Short NOVA excerpt on how Geller and Huchra mapped the location of many galaxies: <https://www.youtube.com/watch?v=gAyZbpSW15U>

- * Galaxies Gone Wild (9 min, ESA/Hubble, 2008) HubbleCast #16: A tour through and explanation of 59 new Hubble images of galaxy mergers: <https://www.spacetelescope.org/videos/heic0810a/>
- * Sky Merger Yields Sparkling Dividends (5 min, ESA/Hubble, 2009) HubbleCast #31: New images of NGC 2623, the result of two spirals colliding, yielding bursts of star formation. The object was observed by telescopes sensitive to different wavelength bands: <https://www.spacetelescope.org/videos/heic0912a/>
- * Hubble Snaps Heavyweight of the Leo Triplet (4 min, ESA/Hubble, 2010) HubbleCast # 34: A new image of galaxy M66 shows evidence of a group of three galaxies interacting: <https://www.spacetelescope.org/videos/heic1006a/>
- * Pandora's Cluster (5 min, ESO, 2011) ESOCast #31: New studies, including estimating the dark matter, of Abell 2744, a complex and large cluster of galaxies, show it may have been the result of the collision of 4 smaller clusters: <https://www.eso.org/public/videos/eso1120a/>
- * Crash of the Titans (5 min, ESA/Hubble, 2012) Hubblecast 55: Featuring Jay Anderson and Roeland van der Marel explaining how Andromeda will collide with the Milky Way in the distant future: <http://www.spacetelescope.org/videos/hubblecast55a/>
- * Gravitational Lensing (7 min, Fermilab, 2015) Clear explanation of lensing, with Dr. Don Lincoln: <https://www.youtube.com/watch?v=4Z71RtwoOas>
- * Hubble Extreme Deep Field Pushes Back Frontiers of Time and Space (3 min, STScI, 2012) short report about surveying distant and early galaxies: https://www.youtube.com/watch?v=gu_Vhzh1qGw
- * A Step Closer to our Origin (5 min, ESA/Hubble, 2007) HubbleCast #8: A careful search through the Hubble Ultra-deep Field reveals some very faint, ancient galaxies: <https://www.spacetelescope.org/videos/heic0714a/>

- * Looking Deeply into the Universe in 3-D (5 min, ESO, 2015) ESOCast #72, about using the Very Large Telescope to explore galaxies in the Hubble Deep Field South:
<https://www.eso.org/public/videos/eso1507a/>
 - * The Final Frontier (6 min, ESA/Hubble, 2016) HubbleCast #90 on the Frontier Fields project on the Hubble, studying large clusters of galaxies and the gravitational lenses they form:
<https://www.spacetelescope.org/videos/hubblecast90a/>
 - * Gravity: Nature's Magnifying Glass (2 min, JWST, 2019) How astronomers use gravitational lensing effects to study really distant galaxies:
<https://www.youtube.com/watch?v=2krcAJobiKk>
- When Two Galaxies Collide (2 min, New Scientist, 2008) Computer simulation of two galaxies merging, which stops at various points and shows a Hubble image of just such a system in nature: http://www.openculture.com/2009/04/when_galaxies_collide.html
- * A Tour of a Collision of Four Galaxy Clusters (3 min, Chandra/NASA, 2019) Puts together x-ray and other data to examine a merger of distant galaxy clusters (Abell 1758):
<https://www.youtube.com/watch?v=YQYlmpCIxk>
- A Virtual Universe (4 min, Nature, 2014) Nature (journal) video on an MIT model of a section of universe evolving, with dark matter included):
<https://www.youtube.com/watch?v=SY0bKE10ZDM>

Chapter 29: The Big Bang

- Three Degrees* (26-min, Bell Labs, 1979) An older film about Penzias and Wilson's discovery of the cosmic background radiation, with interesting historical footage (while this is longer than our time limit for short videos, you can show excerpts):
<https://www.youtube.com/watch?v=ttuhcZjSSxc>
- Planck Maps the Dawn of Time (12 min, EuroNews/ESA, 2013) Summary of the work of the Planck mission, featuring interviews with key scientists:
<https://www.youtube.com/watch?v=ytLbP60zVgo>
- * Planck Exposes Ancient Light of Our Universe (1 min, NASA, 2013) How this space telescope can show us the cosmic microwave background radiation:
<https://www.jpl.nasa.gov/video/details.php?id=1206>
 - * Cosmic Inflation (9 min, Fermilab, 2014) Dr. Don Lincoln explains the inflationary hypothesis of cosmology and why it is needed : <https://www.youtube.com/watch?v=0uj0HZ3HLfw>
 - * When Speed Matters (7 min, ESO, 2012) ESOCast #40: The discovery of the acceleration of the expansion of the universe: <https://www.eso.org/public/videos/esocast40a/>
- The Acceleration of the Universe (2 min, Minute Physics, 2012) Dr. Sean Carroll of Caltech explains the acceleration with cartoons: https://www.youtube.com/watch?v=ZDihDaLS_pQ
- The Accelerating Universe (15 min, World Science U., 2019) Nobel Laureate Adam Reiss explains in clear, non-technical terms, how the teams discovered that the expansion of the universe was accelerating: <https://www.youtube.com/watch?v=yrNW73t0y2s>
- Alan Guth Explains Inflation at the Beginning of Time (3 min, World Science Festival, 2012):
<https://www.youtube.com/watch?v=rEXDgpttmyc>
- The Anthropic Principle (7 min, 2012): A section of a program in which Richard Dawkins, a biologist who is a well-known atheist, has a discussion with George Coyne (the chief astronomer from the Vatican Observatory, who is a priest) about the anthropic principle and what it means for belief in God: <https://www.youtube.com/watch?v=lm9ZtYkdkEQ>

Chapter 30: Life in the Universe

Astrobiology: Life Beyond Earth (3 min, California Academy of Sciences, 2018) Interview with Jill Tarter about how our understanding of life out there has changed over the years:

<https://www.youtube.com/watch?v=SUdKLHnJufU>

The Fermi Paradox (6 min each, Kurzgesagt, 2015) Where are all the aliens? – two cartoon summaries of the problem and proposed solutions:

<https://www.youtube.com/watch?v=sNhhvQGsMEc> and

<https://www.youtube.com/watch?v=1fQkVqno-uI>

Making Matter Come Alive (15 min, TED, 2011) TED talk by inorganic chemist Lee Cronin on the origin of life: <https://www.youtube.com/watch?v=unNRCSj0igI>

Hubble Detects a Water Plume on Europa (2 min, NASA News, 2016):

<https://www.youtube.com/watch?v=4QJS9LcB66g>

Geysers on Enceladus: Cold Faithful (3 min, JPL/NASA, 2008) Video with Dr. Torrence Johnson on the Cassini discovery of water geysers coming from Saturn's moon:

<https://www.youtube.com/watch?v=KzVxqmYu90Y>

Interview with Frank Drake about SETI (5 min interview in 2017, covering different ways of searching, what kind of signals we look for, and his thoughts about the search):

<https://www.youtube.com/watch?v=7zreIzRxtoM> (A longer, 40 min interview with Drake from 2012 is at: <https://www.youtube.com/watch?v=HPQz-kdaxNo>)

Where Are All Those Aliens? Interview with Frank Drake (11 min, Closer to Truth, 2017) An interview with Drake in which he explains the Fermi Paradox and gives a variety of reasonable explanations: <https://www.youtube.com/watch?v=AA733aVjk2M>

Why the Search for Alien Intelligence Matters: Jill Tarter TED Talk (21 min, TED, 2009) Her eloquent introduction to SETI; a bit longer than our limit, but worth showing excerpts from:

<https://www.youtube.com/watch?v=EsZGIvRdgTE>

The Story of the SETI Institute, with Frank Drake and Jill Tarter (2012, 2-min introduction):

<https://www.youtube.com/watch?v=xtEh84pTxce>

* Hubble, Exoplanets, and the Search for Life (6 min, ESA/Hubble, 2016) HubbleCast #97: A progress report on our discovery of exoplanets and the search for biosignatures and technosignatures: <https://www.spacetelescope.org/videos/hubblecast97a/>

Breakthrough: Listen Initiative Launch Highlights (5 min, 2015) Yuri Milner is donating \$100 million over 10 years to ramp up several approaches to SETI; features Stephen Hawking, Frank Drake, and others: <https://www.youtube.com/watch?v=f9pqqqhVrgk>

The Drake Equation Explained by Carl Sagan (10 min, Cosmos/PBS, 1979) A (probably not too legal) heartfelt excerpt from the original Cosmos TV series, where Carl Sagan explains and gives values for the factors of the Drake Equation:

<https://www.youtube.com/watch?v=2s1qTUqOv88>

Carl Sagan on Earth as a Pale Blue Dot (6 min, Patrick Nielsen): A very moving contemplation, by the noted popularizer of astronomy, about our role in the cosmos (a perfect film during the conclusion of an Astro 101 class):

<https://www.youtube.com/watch?v=EWPFmdAWRZO>

(Try also the short compilation of his thoughts on our role in the universe: "Humility" (5 min) at: <https://www.youtube.com/watch?v=o8GA2w-qrcg>)

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