Credits and Research

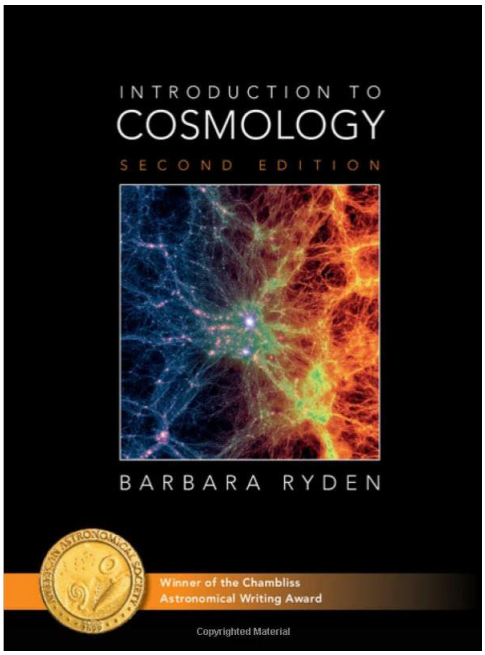
Here's the list of sources I used to put together the "How old is it" video book. These books, videos, and websites also represent resources you can use to do additional research into areas touched on in this video book.

[Music: Puccini - Tosca - E lucevan le stelle]

I used the YouTube Stanford University Cosmology Lectures 1 through 10 (January 14, 2013) by Leonard Susskind extensively. He introduces the study of Cosmology and derives the classical physics formulas that describe our expanding universe. It's the best out there.

STANFORD
UNIVERSITY

https://www.youtube.com/watch?v=P-medYaqVak



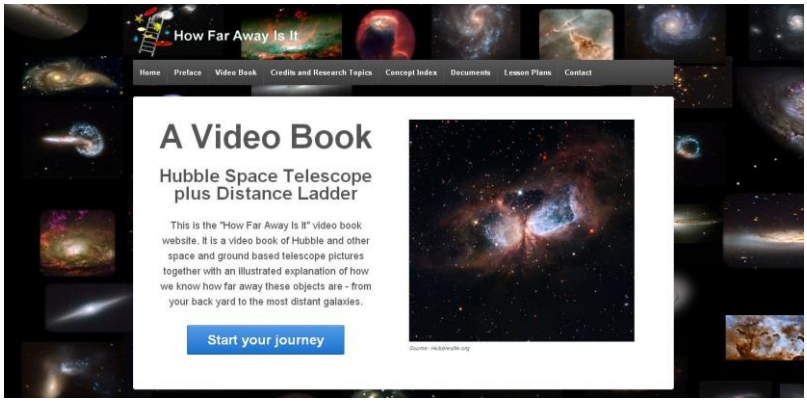
Here is the book I used extensively. The author puts it all together in a very logical order that is easy to follow. But it does have a lot of calculus level math.

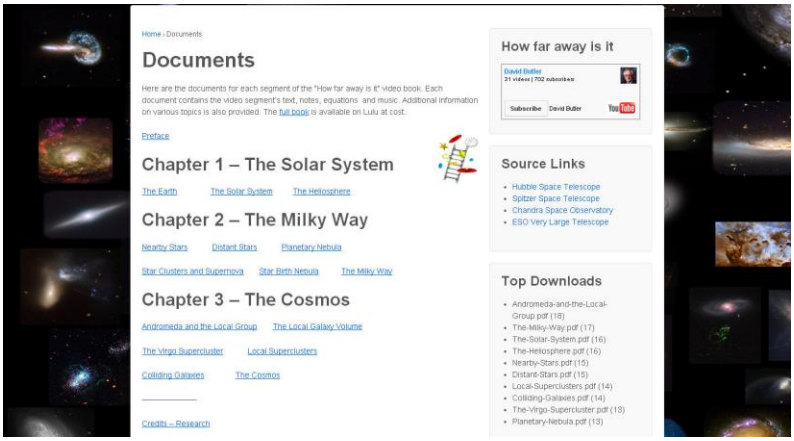
Ned Wright's Cosmology Tutorial

And don't miss Ned Wright's cosmological tutorial site. It is the best site for basic information presented in a straight forward way. His FAQ page is absolutely outstanding.

http://www.astro.ucla.edu/~wright/cosmolog.htm

And don't forget, every How Old Is It video segment has a document with the text, links, music, pictures and notes located on howfarawayisit.com/documents





The following identifies all my sources.

Thanks for watching.

The Universe

Videos

Stanford University Cosmology Lectures 1 through 10 (January 14, 2013) by Leonard Susskind

https://www.youtube.com/watch?v=P-medYaqVak

4K explosion

https://www.youtube.com/watch?v=VqBjsaKQU60

Hubble: Galaxies Across Space and Time

https://www.youtube.com/watch?v=q0P2-qcos90

GN-Z11 video

https://www.nasa.gov/feature/goddard/2016/hubble-team-breaks-cosmic-distance-record

Casimir Effects - Peter Milonni

https://www.youtube.com/watch?v=12yjbyunRdM

CLUES - Constrained Local Universe Evolution Simulation

https://www.youtube.com/watch?v=ulfX_47ovPU

NASA's WFIRST Mission

https://www.youtube.com/watch?v=cxmg-X7Dxug&feature=em-subs_digest

The BaBar Detector

https://www.youtube.com/watch?v=KusaugMR5lU

How Does Fusion Power the Sun?

https://www.youtube.com/watch?v=W1ZQ4JBv3-Y

Hypnotic Solar Explosions 4K

https://www.youtube.com/watch?v=lpzCSZ7Eerc

4K | Universe's Evolution in 8K Fulldome - Illustris Simulation

https://www.youtube.com/watch?v=C1zXumtY6x0

Books & Papers

Introduction to Cosmology by Barbara Ryden, 2017

Cosmology and Controversy by Helge Kragh, 1996

Baryogenesis whitepaper

https://www.astro.umd.edu/~ricotti/NEWWEB/teaching/ASTR688s08/bhupal_termpaper.pdf

Paper-and-pencil cosmological calculator

https://arxiv.org/abs/1303.5961

Friedmann equations

http://zuserver2.star.ucl.ac.uk/~hiranya/PHAS3136/PHAS3136/PHAS3136_files/Cosmo2_34_fried.pdf

Professor Komissarov S.S.Komissarov@leeds.ac.uk lecture on cosmology with equations.

https://www1.maths.leeds.ac.uk/~serguei/teaching/cosmology.pdf

Ohio State course notes

http://www.astronomy.ohio-state.edu/~dhw/A5682/notes4.pdf

A Dynamical Study of the Friedmann Equations

http://cds.cern.ch/record/515592/files/0108066.pdf

Big-Bang Cosmology

http://pdg.lbl.gov/2009/reviews/rpp2009-rev-bbang-cosmology.pdf

Lecture 19 Big Bang Cosmology slides

http://www.pas.rochester.edu/~aran/class/PHY100_10S/lectures/P100_19_BigBang_Cosmology.pdf

Big Bang Cosmology and the Microwave Background

http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-94-2608-08

Big Bang Cosmology slides

http://www.astro.uwo.ca/~basu/teach/ast020/notes/cosmology.pdf

Planck spacecraft measures of CMB

https://en.wikipedia.org/wiki/Planck_(spacecraft)#Results

How inhomogeneous is it graph?

https://ned.ipac.caltech.edu/level5/March03/Freedman/Figures/figure11.jpg

Evidence from Type Ia Supernovae for an Accelerating Universe and Dark Energy

https://arxiv.org/pdf/astro-ph/0307139.pdf

Measuring energy density

http://www-f9.ijs.si/~margan/Articles/vacuum_energy_density.pdf

What's the Energy Density of the Vacuum?

http://www.nicadd.niu.edu/~bterzic/PHYS652/Lecture_10.pdf

Statistics of Caustics in Large-Scale Structure Formation

https://arxiv.org/pdf/1412.5121.pdf

Improved cosmological constraints from a joint analysis of the SDSS-II and SNLS supernova samples

https://arxiv.org/pdf/1401.4064.pdf

Measuring Cosmological Parameters via Expansion

http://www.astronomy.ohio-state.edu/~dhw/A5682/notes9.pdf

Nucleosynthesis Predictions and High-Precision Deuterium Measurements

https://arxiv.org/pdf/1705.03653.pdf

Measurements of the deuterium abundance in quasar absorption systems

https://arxiv.org/abs/astro-ph/9803071

History of CP Violation

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3422684/

Good PowerPoint on inflation

http://www.phys.unm.edu/~gbtaylor/astr422/lectures/22_A422_EarlyUniverse_I.pdf

Websites

Ned Wright's Cosmology Tutorial with a great FAQ section

http://www.astro.ucla.edu/~wright/cosmolog.htm

HyperPhysics

http://hyperphysics.phy-astr.gsu.edu

Gamma Ray Bursts

http://cseligman.com/text/galaxies/lighttravel.htm

https://www.nasa.gov/mission_pages/swift/bursts/cosmic_record.html

http://science.psu.edu/news-and-events/2011-news/Fox5-2011

Cosmology lecture PowerPoint from University College London

http://zuserver2.star.ucl.ac.uk/~hiranya/PHAS3136/PHAS3136/PHAS3136_files/Cosmo2_34_fried.pdf

Wilkinson Microwave Anisotropy Probe

https://map.gsfc.nasa.gov/

GTR version of Friedmann Equations

https://astrobites.org/2011/10/09/general-relativity-friedmann-equations-and-accelerating-expansion-a-quick-overview/

http://hyperphysics.phy-astr.gsu.edu/hbase/Astro/fried.html

The Hubble constant value

https://www.cfa.harvard.edu/~dfabricant/huchra/hubble/

Bound and unbound escape velocity

http://staff.on.br/jlkm/astron2e/AT_MEDIA/CH26/CHAP26AT.HTM

University of Oregon lecture

http://abyss.uoregon.edu/~js/cosmo/lectures/lec05.html

Energy Density of the Vacuum

http://math.ucr.edu/home/baez/vacuum.html

SDSS web layout of the galaxies

http://ircamera.as.arizona.edu/NatSci102/NatSci102/lectures/galaxydist.htm

Dark Energy, Dark Matter

https://science.nasa.gov/astrophysics/focus-areas/what-is-dark-energy

Distance vs Redshift

https://www.eso.org/~bleibund/papers/EPN/epn.html

http://hubblesite.org/image/2014/news_release/2006-52

Host Galaxies of Distant Supernovae

http://supernova.lbl.gov/video.html

Supernova profile

http://www2.lbl.gov/Science-Articles/Archive/sabl/2005/October/04-supernovae.html

Supernovae: The Stellar Route to Understanding Dark Energy

http://hyperphysics.phy-astr.gsu.edu/hbase/Astro/inflat.html#c1

Inflationary Period in Big Bang

https://www.cfa.harvard.edu/news/2011-04

The Best Way to Measure Dark Energy Just Got Better

http://math.ucr.edu/home/baez/vacuum.html

Cosmic Inventory II: Baryonic and Dark Matter

http://hubblesite.org/video/798/news/91-astronomical

The Cosmic Microwave Background

http://planck.cf.ac.uk/science/cmb

http://astronomy.swin.edu.au/cosmos/C/Critical+Density

Critical density calculations.

http://www.astro.ucla.edu/~wright/density.html

Abell 370

http://www.spacetelescope.org/images/heic1711a/

Estimating the Vacuum Energy Density - an Overview of Possible Scenarios Erik Margan

https://en.wikipedia.org/wiki/Observable_universe#/media/File:Observable_universe_logarithmic_illustration.png

2MASS Redshift Survey

https://www.cfa.harvard.edu/~dfabricant/huchra/2mass/

THE COSMIC MICROWAVE BACKGROUND

https://ned.ipac.caltech.edu/level5/Sept02/Kinney/Kinney3.html

High Red Shift Supernovae 1a and Cosmic Acceleration

http://web.physics.ucsb.edu/~jatila/LambdaLabs/

Fractal Structure of Isothermal Lines and Loops on the Cosmic Microwave Background

http://inspirehep.net/record/880036

Ionization of Hydrogen

http://csep10.phys.utk.edu/OJTA2dev/ojta/c2c/ordinary_stars/harvard/ionization_tl.html

Cosmic Inflation

https://ned.ipac.caltech.edu/level5/Glossary/Essay_lss.html

Formation of a group of galaxies

http://cosmicweb.uchicago.edu/group.html

South America Galaxy

https://www.spacetelescope.org/images/potw1323a/

Casimir effect

https://briankoberlein.com/2015/03/06/nothing-but-net/

Evolving the Universe, from the Cosmic Microwave Background to now

https://map.gsfc.nasa.gov/resources/animconcepts.html

CASIMIR EFFECT LINKS

http://www.mit.edu/~kardar/research/seminars/Casimir2010/talks/Konstanz/Casimir.html

iPTF16geu z = 0.4 4.3 bly

https://www.spacetelescope.org/news/heic1710/

SN UDS10Wil

https://www.nasa.gov/mission_pages/hubble/science/sn-wilson.html

SN CL012Car z = 1.28

http://www.spacefellowship.com/news/art38400/hubble-astronomers-use-supernovae-to-gauge-power-of-cosmic-lenses.html

Expansion history graph creator

http://csep10.phys.utk.edu/guidry/darkEnergy/universeEvolRK.html

Hot quark soup that existed at the dawn of the universe

https://www.sciencedaily.com/releases/2015/04/150414125710.htm

Theory provides roadmap in quest for quark soup 'critical point'

https://phys.org/news/2017-01-theory-roadmap-quest-quark-soup.html

BaBar has now discovered *direct* CP violation for B mesons.

http://www2.slac.stanford.edu/tip/special/cp.htm

Scientists Search for Quasar's "Missing" Galaxy

https://scitechdaily.com/scientists-search-for-quasars-missing-galaxy/

pks 1937-101 (qso B1937-1009)

http://simbad.u-strasbg.fr/simbad/sim-id?Ident=%20PKS%201937-101%20

Cosmic Microwave Background

http://astronomy.swin.edu.au/cosmos/C/Cosmic+Microwave+Background

CP Violation in Kaon Decay

http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

NASA's WFIRST Mission

https://www.youtube.com/watch?v=cxmg-X7Dxug&feature=em-subs_digest

Daya Bay Reactor Neutrino Experiment

https://www.bnl.gov/newsroom/news.php?a=111395

Hot quark soup that existed at the dawn of the universe

https://www.sciencedaily.com/releases/2015/04/150414125710.htm

ALAS hunt for dark matter

http://atlas.cern/updates/physics-briefing/chasing-invisible

LISA

https://lisa.nasa.gov/

https://www.youtube.com/watch?v=TsgfnkSJdqs

Supernovae Cosmology Project

http://supernova.lbl.gov/

The High Z SN Search

https://www.cfa.harvard.edu/supernova/home.html

ARP 299 4k photo

http://chandra.harvard.edu/photo/4k_images.html

How Old Are Stars

Molecular Cloud Collapse

https://www.astronomynotes.com/evolutn/s3.htm

http://www.astronomy.ohio-state.edu/~jaj/Ast162/lectures/notesWL14.pdf

https://www.researchgate.net/publication/51989536_The_clustered_nature_of_star_formation_Pre--main-sequence_clusters_inthe_star-forming_region_NGC_602N90_in_the_Small_Magellanic_Cloud

https://arxiv.org/pdf/1307.8445.pdf T-Tauri stars in NGC 602

Protostar Formation

https://pages.uoregon.edu/jimbrau/astr122-2015/Notes/Chapter19.html

https://www.spacetelescope.org/images/potw1607a/

https://www.spacetelescope.org/images/heic1303a/ HBC 1 - 2700 ly

https://www.spacetelescope.org/videos/heic1303a/ Protostar LRLL 54361 – 950 ly

https://apod.nasa.gov/apod/ap090803.html

https://www.spacetelescope.org/images/heic1424a/ XZ Tauri – 450 ly

http://www.astronomy.ohio-state.edu/~ryden/ast162_4/notes14.html

https://www.astro.princeton.edu/~gk/A403/fusion.pdf

https://www.atnf.csiro.au/outreach//education/senior/astrophysics/stellarevolution_mainsequence.html

Becoming a Main Sequence Star

http://www.daviddarling.info/encyclopedia/M/mass-radius_relation.html

http://astro.osu.edu/~ryden/ast162_4/notes14.html mass luminosity relationship

http://www.astro.caltech.edu/~george/ay20/Ay20-Lec7x.pdf

http://hyperphysics.phy-astr.gsu.edu/hbase/Astro/startime.html stellar lifetime calculator

Solar Fusion Rates

http://hyperphysics.phy-astr.gsu.edu/hbase/Kinetic/kintem.html thermal energy

http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/Scheq.html free particle wave function

http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/barr.html#c1 barrier penetration energy

http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/coubar.html coulomb barrier

https://physics.stackexchange.com/questions/73970/with-what-probability-does-nuclear-fusion-occur-at-energies-far-below-the-coulom

http://www.physics.smu.edu/cooley/phy3368/lectures/150225_lecture.pdf Gamow factor

https://wikivisually.com/wiki/Gamow_factor

https://web.njit.edu/~gary/202/Lecture17.html

When Stars Run Out of Hydrogen

http://www.sci-news.com/astronomy/hubble-open-star-cluster-messier-11-07025.html

https://www.e-education.psu.edu/astro801/content/l7_p6.html

http://jthommes.com/Astro/OpenClusters.htm

http://www.astroimages.org/ccd/m67.html M67 HR diagram

https://courses.lumenlearning.com/astronomy/chapter/evolution-from-the-main-sequence-to-red-giants/

https://www.aanda.org/articles/aa/pdf/2018/08/aa32843-18.pdf Gaia DR2 – Observational

http://www.astronomy.com/news/2007/04/how-old-are-stars

http://ftp.lowell.edu/media/content/release_supplements/gyro_background.pdf

http://curious.astro.cornell.edu/our-solar-system/51-our-solar-system/the-sun/birth-death-and-evolution-of-the-sun/167-how-do-you-calculate-the-lifetime-of-the-sun-advanced

Music

Big Bang Cosmological Fundamentals

@00:00 Puccini, Giacomo: Che gelida manina - what a cold little hand La Boheme Act I: Rodolfo's Aria - "Che gelida manina" (Instrumental Version), Sofia Philharmonic Orchestra; from the album "100 Must-Have Opera Karaoke" 2015

@04:34 Beethoven, Ludwig van: Piano Concerto No. 2 in B-Flat Major, Op. 19: II. Adagio; Anton Dikov, Sofia Philharmonic Orchestra; from the album "50 Must-Have Adagio Masterpieces" 2013

@09:41 Borodin, Alexander: Polovetsian Dances from Price Igor; London Philharmonic Orchestra; from the album "The Greatest Classical Masterpieces! (Digitally Remastered)" 2008

@13:26 Tchaikovsky, Pyotr Ilyich: Waltz from Sleeping Beauty from the album Tchaikovsky Peter Ilyich 2009

@16:37 Schubert, Franz: Music to Rosamunde, D. 797_ Ballet Music No. 1_ II. Andante un poco assai; Hermitage Museum Orchestra and Alexander Titov; from the album "Schubert - 100 Supreme Classical Masterpieces: Rise of the Masters" 2011

@22:24 Offenbach, Jacques: Barcarolle (from Tales of Hoffman); from the album "A Calendar of Classics - July" 2007

@25:40 Bach, Johann Sebastian: Double Violin Concerto; Anne-Sophie Mutter, English Chamber Orchestra, Salvatore Accardo; from the album "Essential Adagios" 2010

@33:00 Rimsky-Korsakov: Scheherazade, II, Lento; Berliner Philharmoniker, from the album "Rimsky-Korsakov Greatest Hits" 2005

Big Bang ΛCDM Cosmology

@00:00 Bach, Johann Sebastian: Wachet auf, ruft uns die Stimme, BWV 645 ('Sleepers, awake'); Raymond Agoult and The New Symphony Orchestra of London – from the album "Essential Bach (2CDs)" 2000

@04:46 Offenbach, Jacques: Barcarolle (from Tales Of Hoffman); from the album "A Calendar Of Classics - July" 2007

@09:00 Strauss II, Johann: Waltz on the Beautiful Blue Danube, Op. 314; Peter Guth & Royal Philharmonic Orchestra, from the album "Strauss: Emperor Waltz, Waltz on the Beautiful Blue Danube, Overture to Die Fleidermaus" 1998

@15:05 Bach, Johann Sebastian: Concerto for Violin, Strings and Continuo in E Major, BWV 1042: II. Adagio; Christian Altenburger, German Bach Soloists, from the album "50 Must-Have Adagio Masterpieces" 2013

@21:22 Beethoven, Ludwig van: "The Emperor" Adagio from Piano Concerto No.5 in E Flat Major. Op.73 "The Emperor"; Julia Thornton, from the album "Essential Adagios" 2010

@27:56 Mozart, Wolfgang Amadeus: Symphony No.8 in D, K.48 - 2. Andante; Academy of St. Martin in the Fields and Sir Neville Marriner; from the album "Mozart: The Symphonies, Vol.1 (Complete Mozart Edition)"

@36:21 Puccini, Giacomo: Turandot, Act III: Calaf's Aria - "Nessun dorma" - none shall sleep; (Instrumental Version); Sofia Philharmonic Orchestra; from the album "100 Must-Have Opera Karaoke" 2015

@39:52 Nicolai, Otto: Moon Choir (from The Merry Widows Of Windsor); Otto Nicolai & Bulgarian National Choir, Sofia Philharmonic Orchestra, from the album "66 Must-Have Sensual Classics" 2011

@36:21 Puccini, Giacomo: Turandot, Act III: Calaf's Aria - "Nessun dorma" - none shall sleep; (Instrumental Version); Sofia Philharmonic Orchestra; from the album "100 Must-Have Opera Karaoke" 2015

How Old Are Stars

@00:00 Giordani, Giuseppe: "Caro Mio Ben" - from the album "Meditation: Classical Relaxation" 2010

@06:56 Chopin, Fryderyk: "Prelude in E Minor, Op. 28, No. 4" – from the album "Chopin: The Romantic World Of Chopin's Piano, Vol. 3" 2000

@10:39 Puccini, Giacomo: La rondine: "La rondine, Act I: Doretta's Aria (arr. for flugelhorn and brass band)" - Grimethorpe Colliery RJB Band with Peter Parkes from the album Grimethorpe Colliery Band: Melody Shop (The) 1998

@14:09 Gluck, Christoph Willibald: "Dance Of The Blessed Spirits (from Orpheus and Eurydice)" conductor Herbert Kegel from the album "Meditation: Classical Relaxation" 2010

@24:33 Schubert, Franz: "Andante con moto (from Symphony No. 8)" – Conductor Janos Kovacs; from the album "Meditation: Classical Relaxation" 2010

How old is it - Credits

@00:00 Puccini, Giacomo: Tosca, Act III: Cavaradossi's Aria - "E lucevan le stelle" - and the stars were shining (Instrumental Version); Sofia Philharmonic Orchestra, from the album "100 Must-Have Opera Karaoke" 2015