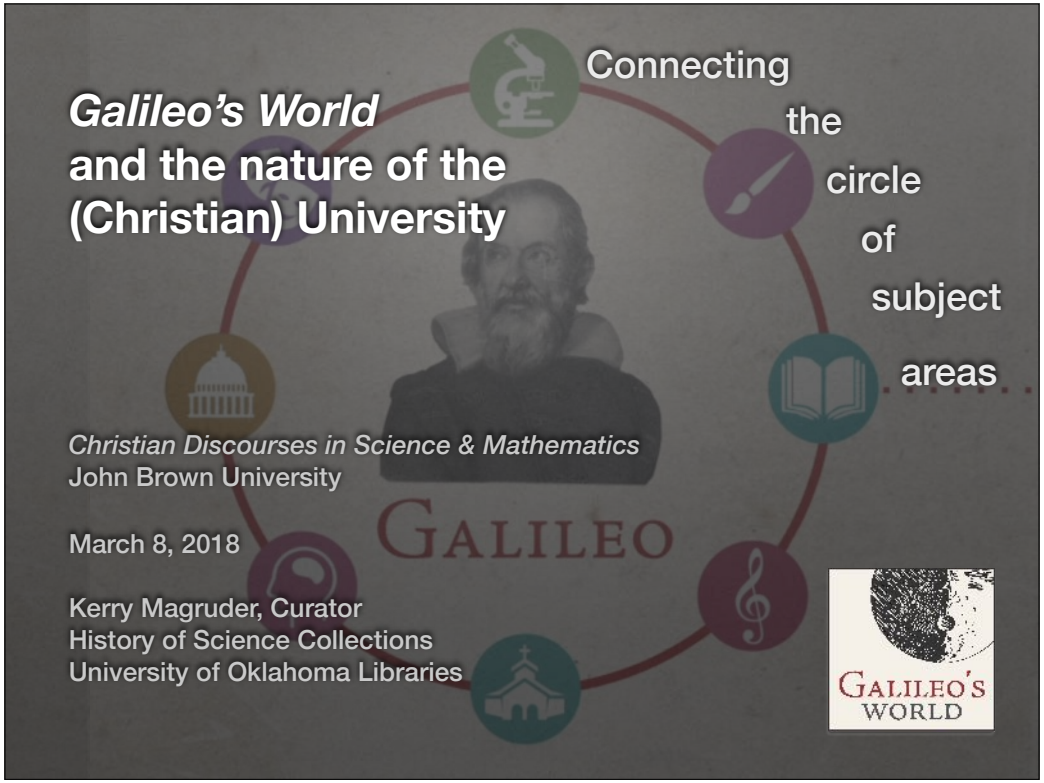
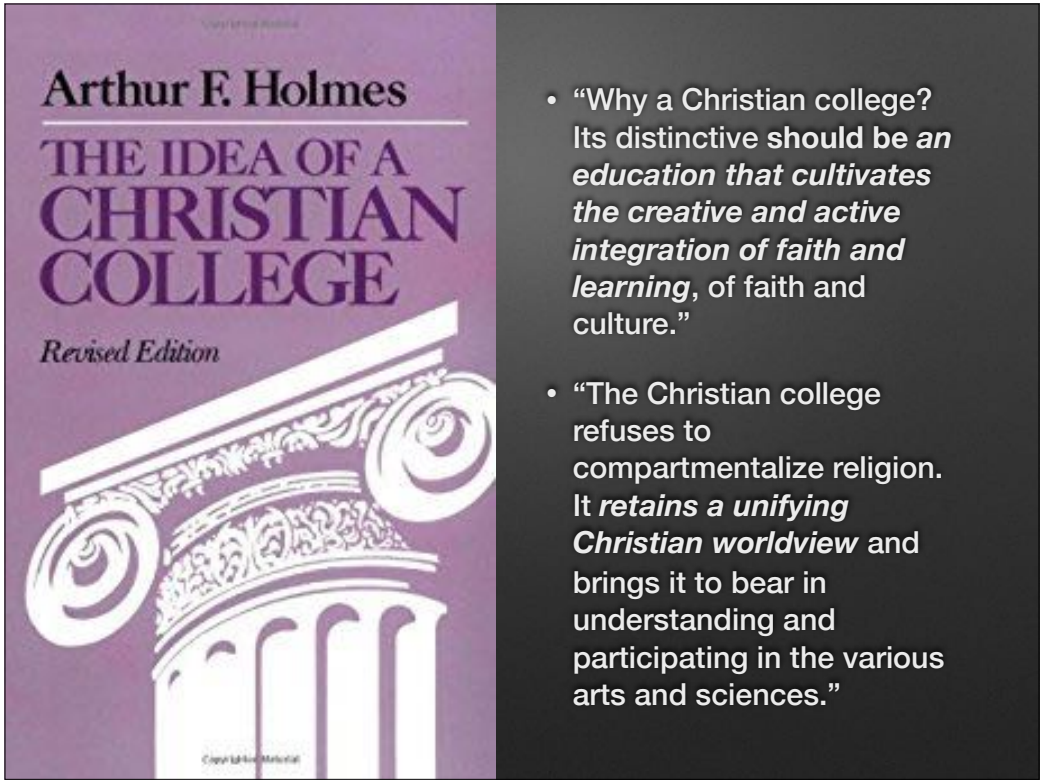


Thank you for inviting me to share with you some lessons learned from Galileo's World about the nature of the Christian University.

ABSTRACT: Any model of Christian education as the integration of faith and learning requires some kind of understanding of the relations between disciplines. In this presentation, we will reflect upon some implications for the Christian university arising from the world of Galileo. What particular aspects of the culture of early modern Florence sparked the creative discoveries and transformations we associate with Galileo and his Tuscan contemporaries? What examples might they offer us, both positive and negative, for the connections between disciplines? Galileo's world illustrates how sparks of creativity arise from certain kinds of interdisciplinary relations and not from others. Healthy traditions promote connections between disciplines that spark creative transformations. We will try to discern how an ideal of mutual service between academic disciplines lies at the heart of a Christian intellectual community. In a Christian education, the disciplines each look upon one another as better than themselves in search of natural, organic, and creative connections.

90 minutes: Take 10 min. intermission before Astronomy and Theology.



In 1975, Arthur Holmes wrote what has become recognized as a classic work on the nature of the Christian college. • Holmes envisioned the distinctive characteristic of a Christian college as "an education that cultivates the creative and active integration of faith and learning…" • By "refusing to compartmentalize religion," a Christian college "retains a unifying Christian worldview." So the Christian college may achieve the ideal of a **UNI**versity, overcoming the fragmentation of large multi-versities.

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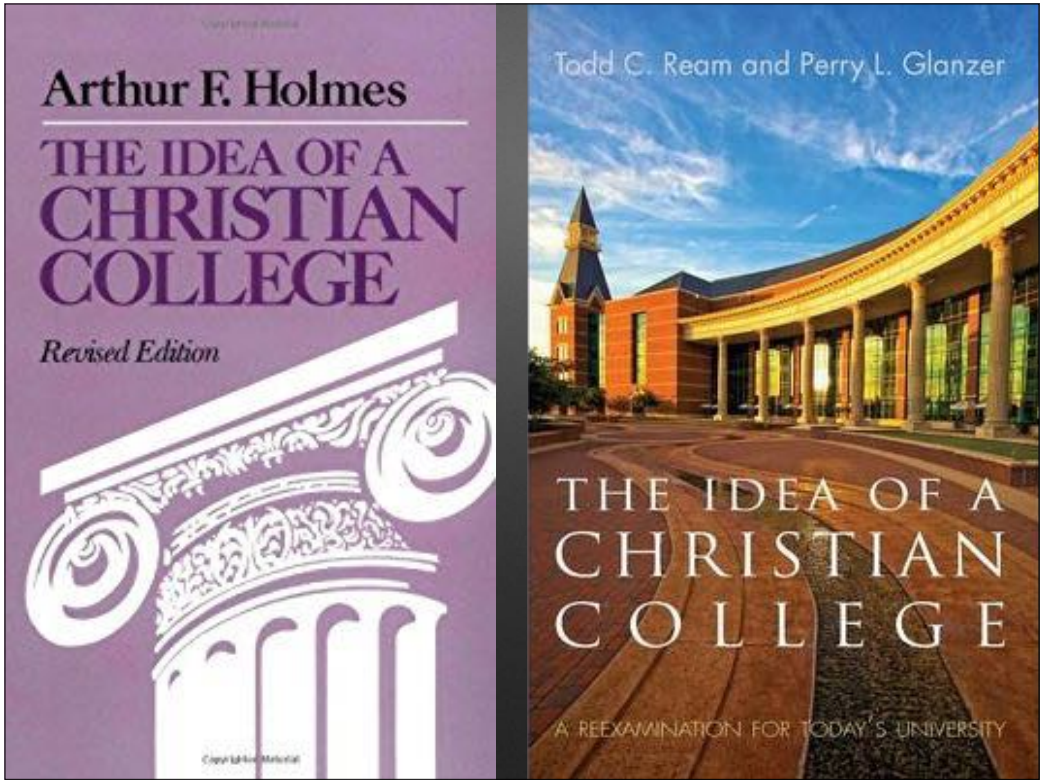
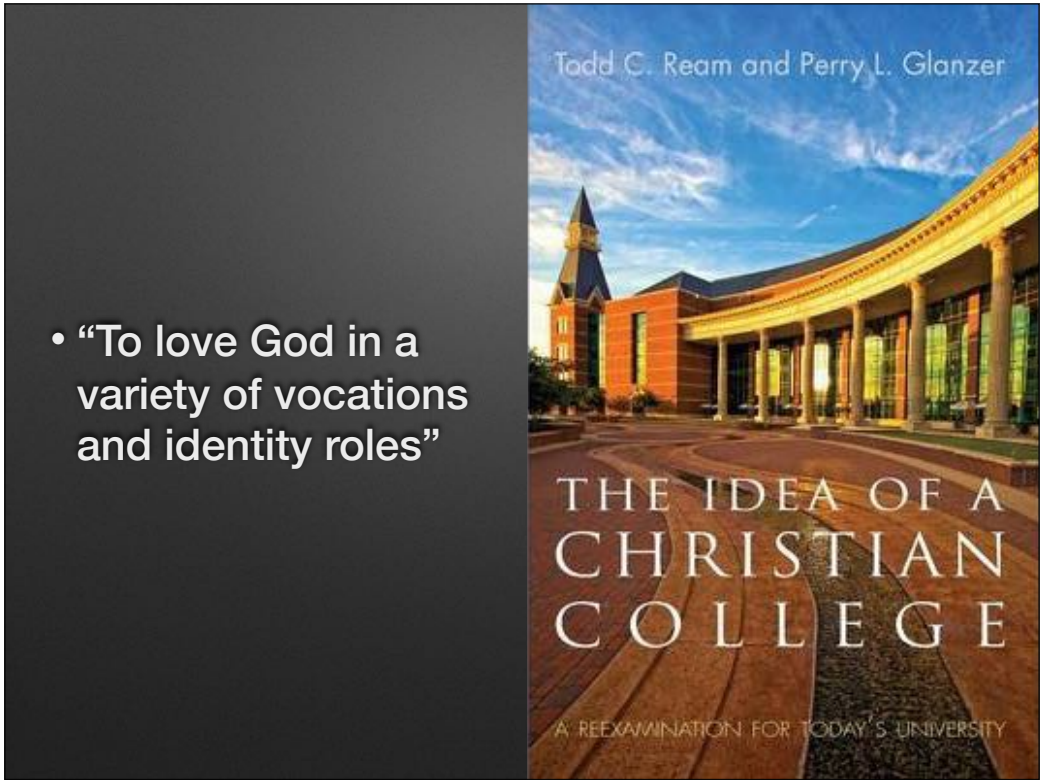
p. 6.

p. 9. A university, not a multiversity.



It's now more than 40 years later. Since Holmes' book first appeared, more and more Christian colleges have become universities. In contrast to colleges, universities, like JBU, support graduate programs, and invest resources in the creation of knowledge, not just its transmission. So Ream and Glanzer have produced a companion for reading Holmes' classic book, extending Holmes' vision to apply to Christian universities.



They argue that our call is “to love God in a variety of vocations and identity roles” (including outside of the church context). The Christian university is composed of multiple disciplines, serving multiple life callings, yet nevertheless sharing a common vision where knowledge and worship of God are at the center of life and learning.

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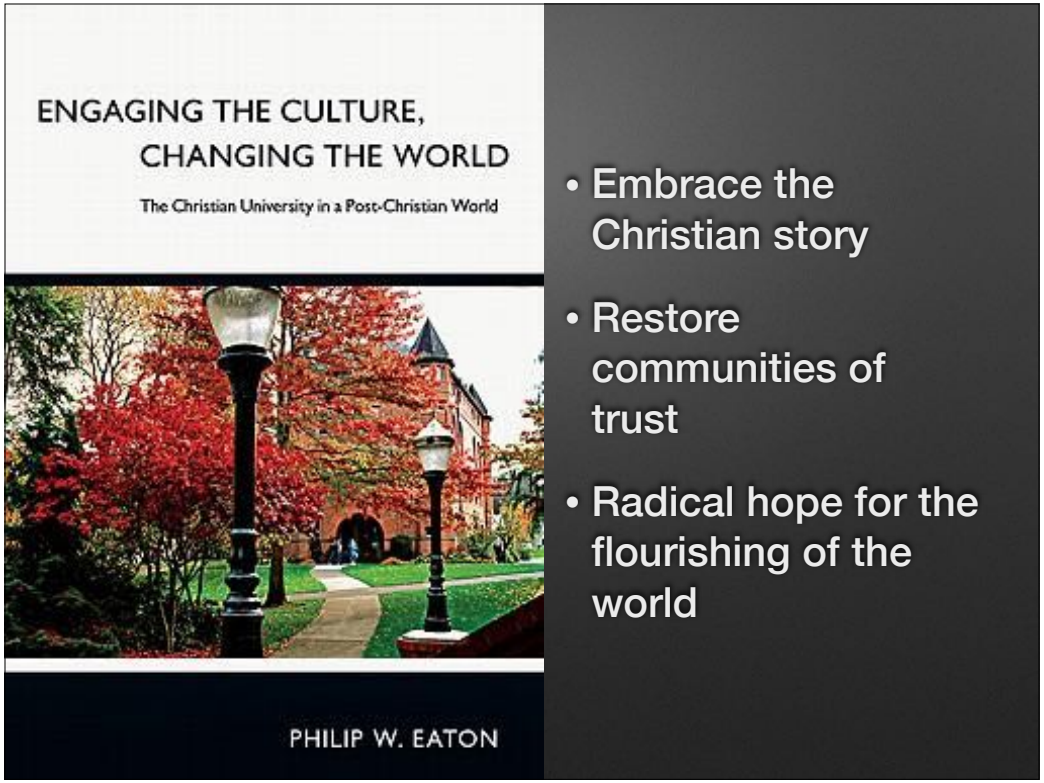
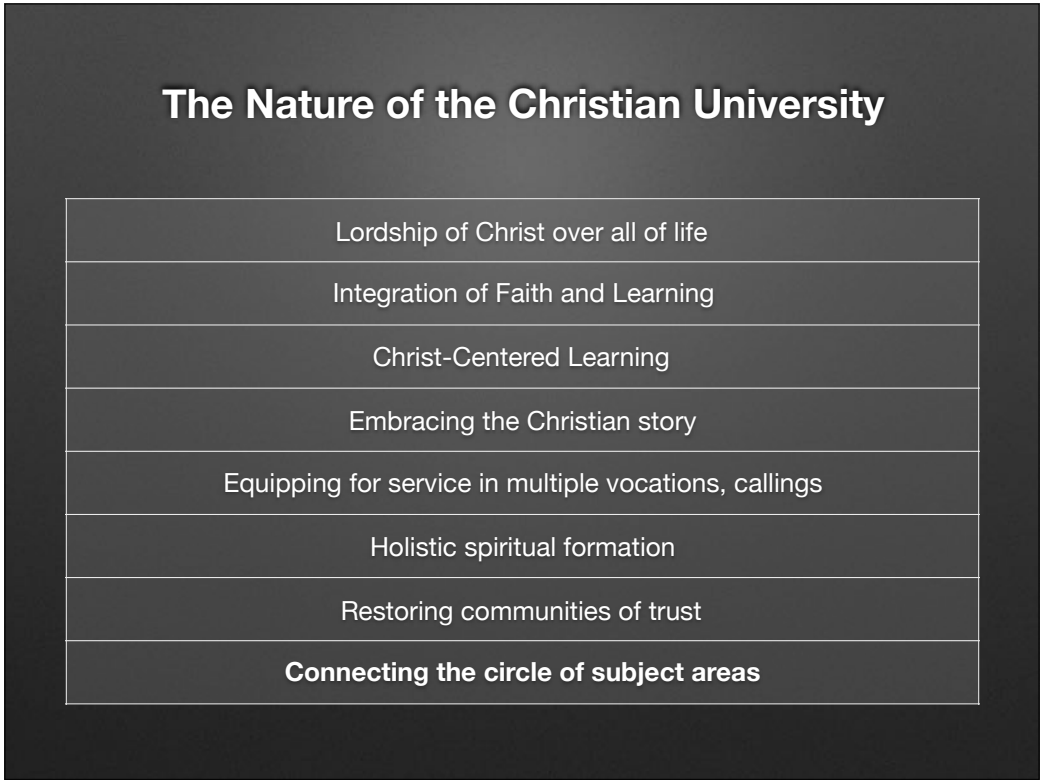
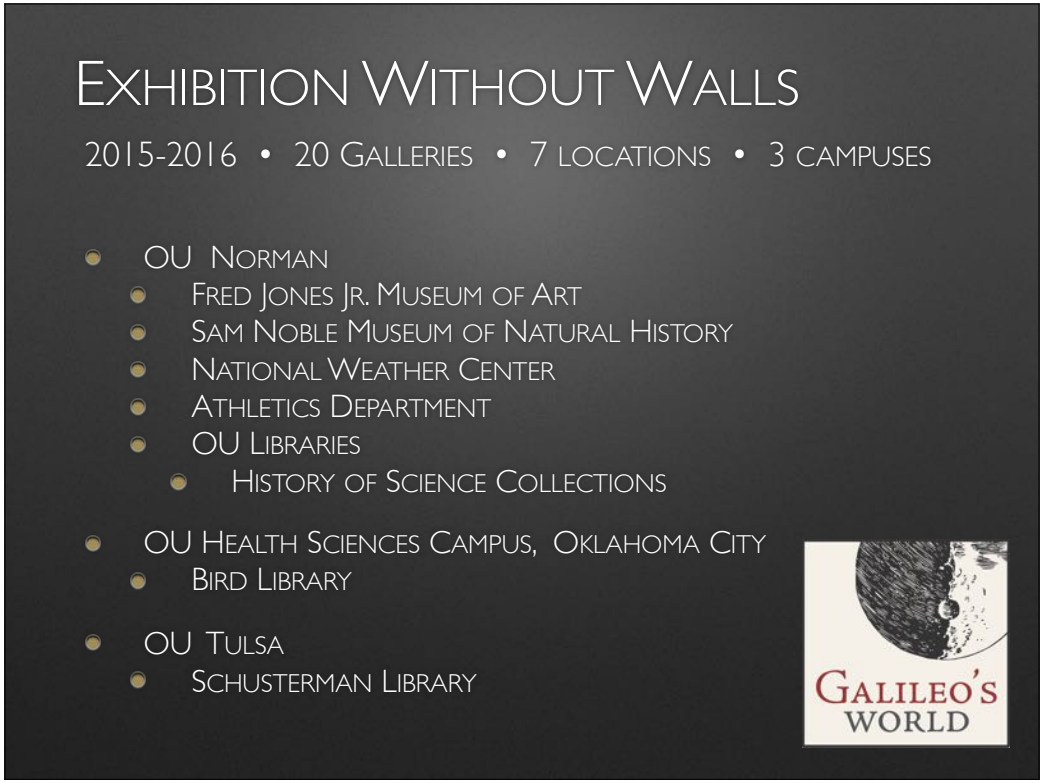
We are called to see our story as part of the larger story of what God is doing.



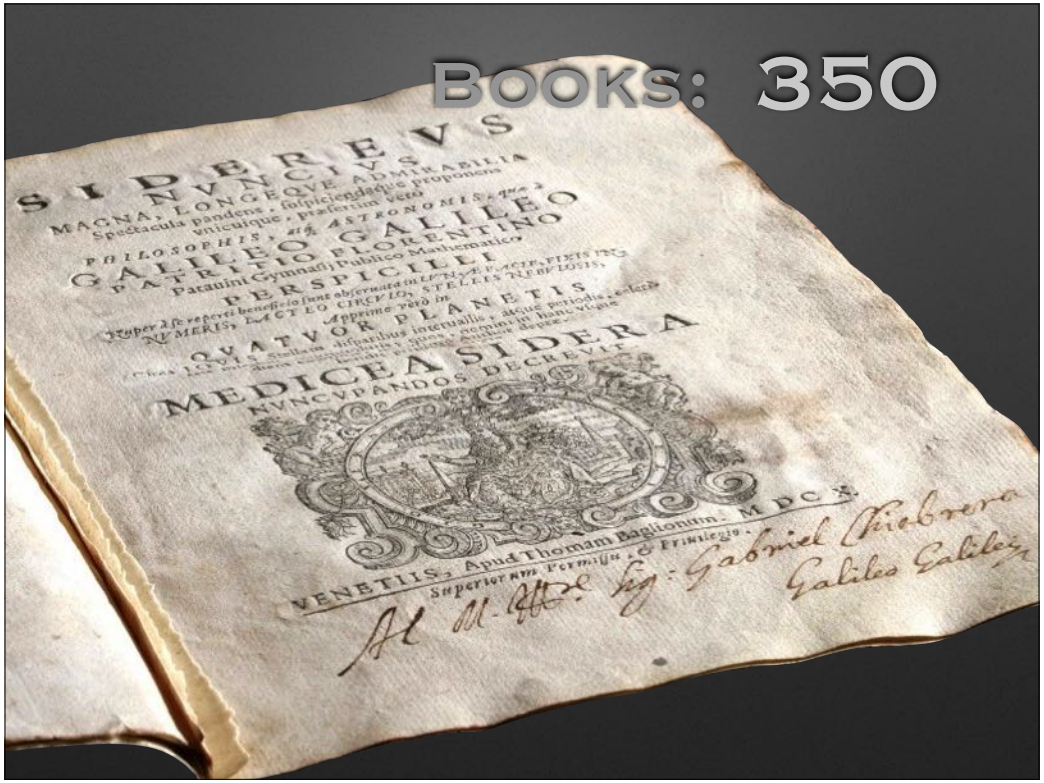
Philip Eaton sees the Christian University in a post-Christian world as a place where we can learn to embrace the Christian story, restore communities of trust, and live out a radical hope for the flourishing of the world.



These and similar books describe the nature of the Christian University in terms of (READ). My remarks assume all these themes as a point of departure. Tonight, I'd like to focus on the integration of faith and learning in a multidisciplinary context • let's call it "connecting the circle of subject areas." This was the theme of the Galileo's World exhibition.

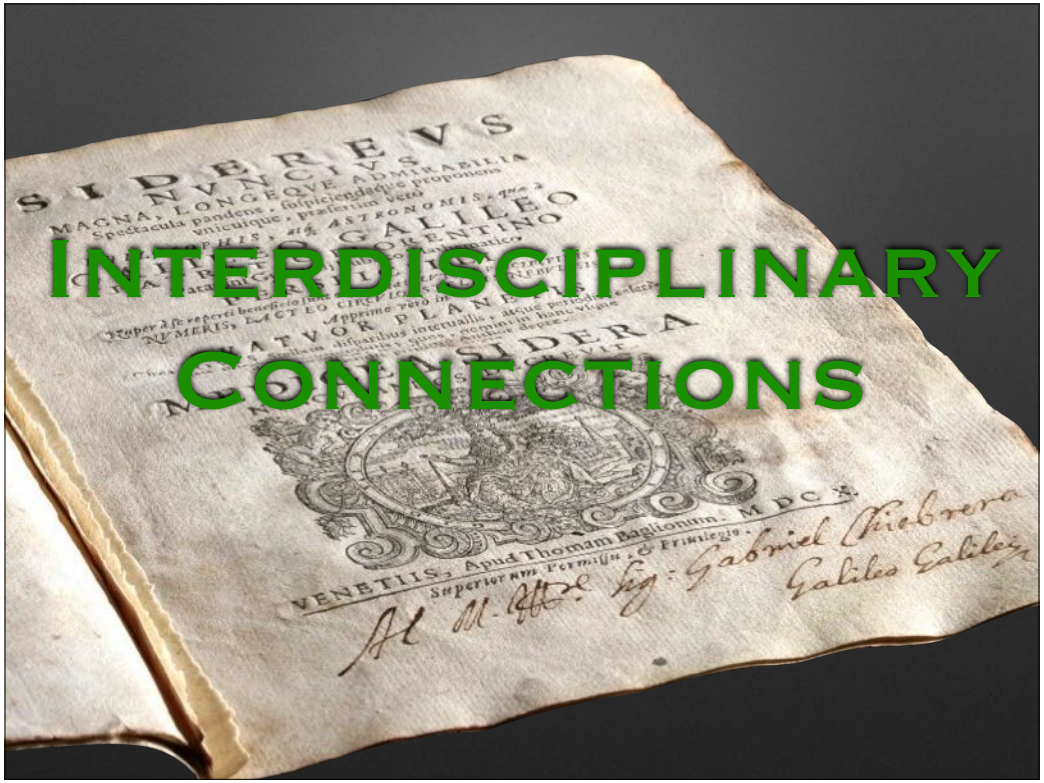


Galileo's World was an exhibition without walls. It appeared over the course of 2015-2016 in 20 galleries in 7 locations across the 3 OU campuses of Norman, Oklahoma City, and Tulsa. With exhibitions at the Museum of Art, Museum of Natural History, the National Weather Center, and the Health Sciences Campus, Galileo's World was designed to overcome the multi-versity syndrome by building bridges across disciplinary divides.



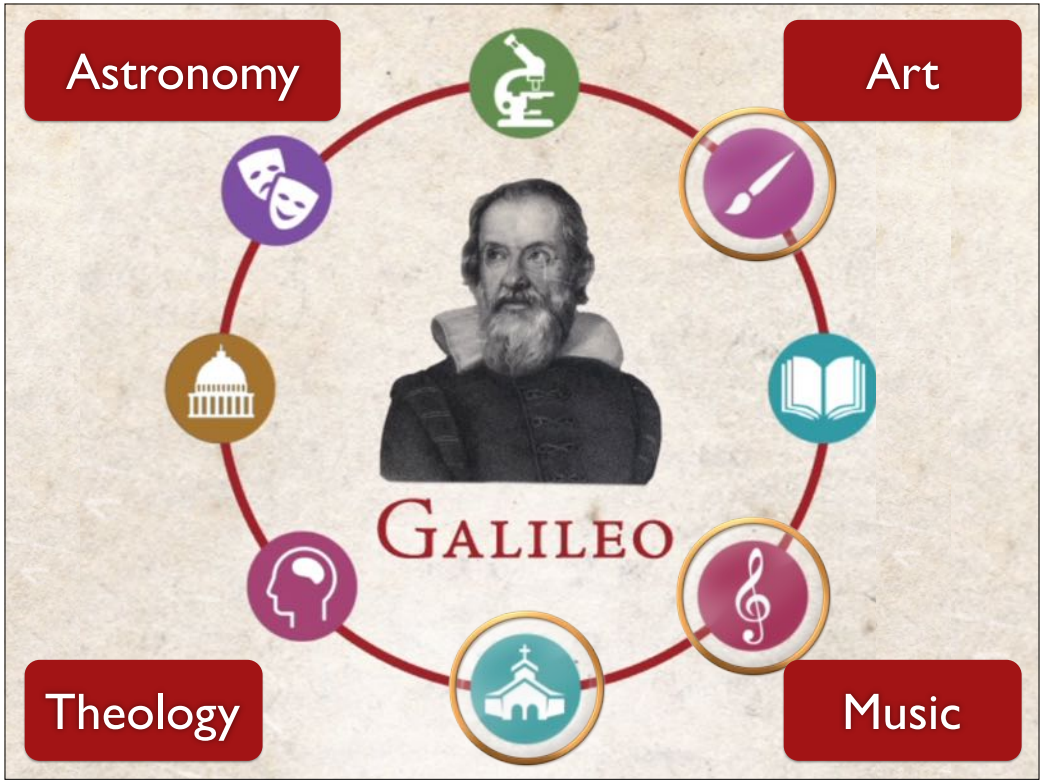
The exhibition featured 350 rare books on display, selected from the vaults of the History of Science Collections and other special collections.

The exhibit included dozens of first editions, by Galileo and others… Every book on display was an original; none were facsimiles. Each book belongs to OU; none were on loan from other institutions.



The books were not dusty tomes sealed up in cases to be admired as treasures. We selected them for display because they tell hundreds of stories • of interdisciplinary connections. The exhibition was about bringing those stories alive to spark creative conversations across the disciplines. That's hard to do in a large research university.

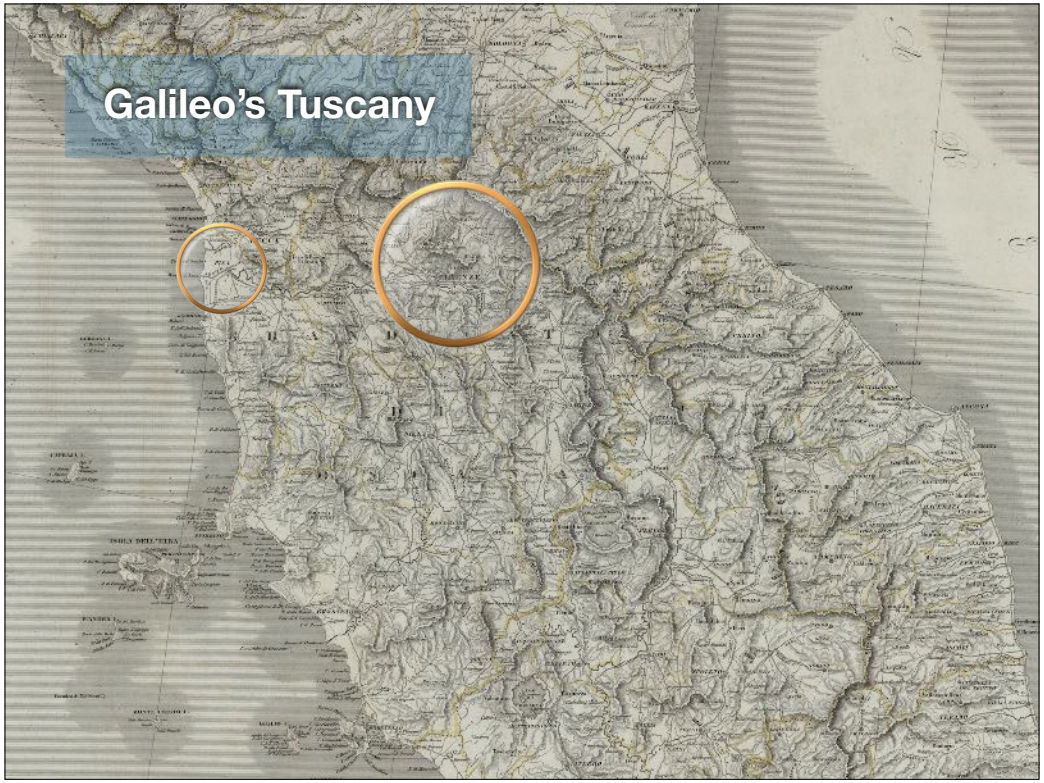
For the library exhibit, on the 5th floor, visitors begin with a brief video in the theater. Before the renovation we undertook for the exhibit, this was my office! But it's much better used as public space, and I'm thrilled that we have something to offer everyone, regardless of age.



The orientation video introduced the idea of the interconnectedness of science and culture which characterized Galileo's World. How do we reconnect the circle of subject areas today? • Three examples we'll look at tonight are how astronomy was related to • art, • music, and • theology. Subject areas like these…

may roll around on the university campus like marbles. If each discipline or subject area is a marble, then how often do we pursue our disciplines in relative isolation, as self-contained studies, despite occasionally bumping into one another?

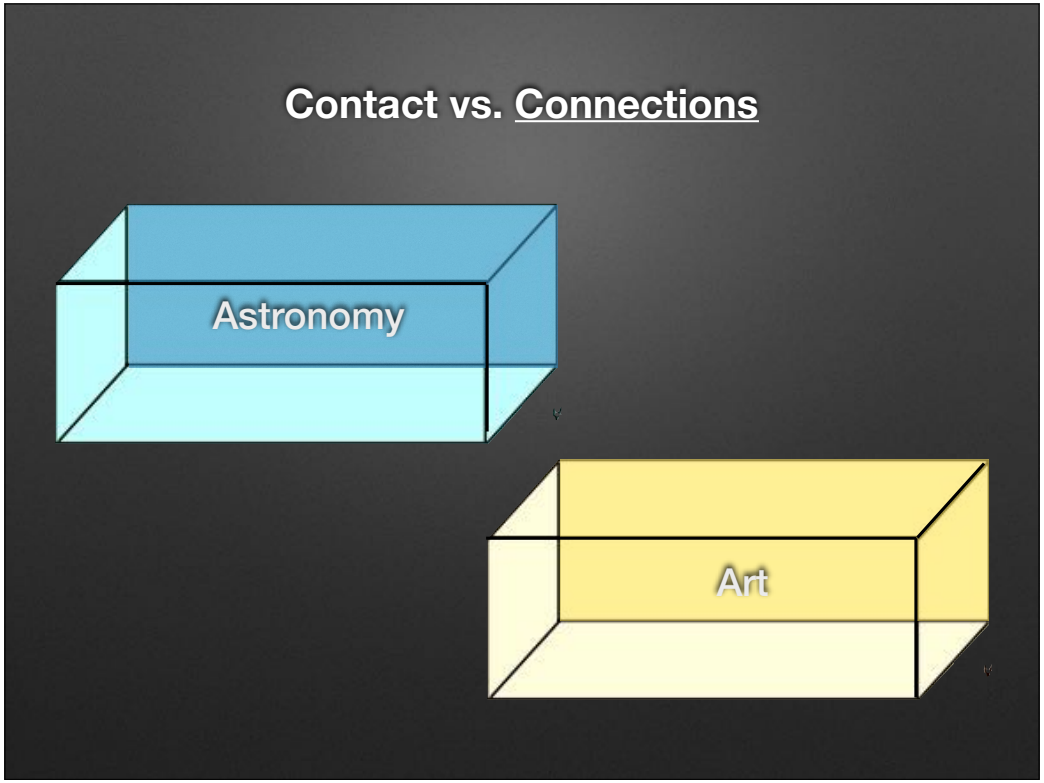
For any two disciplines, bumping into each other doesn’t count as the kind of deep interdisciplinary connection we’re seeking. This is the marble problem, and Renaissance culture in Tuscany found a way to solve it.



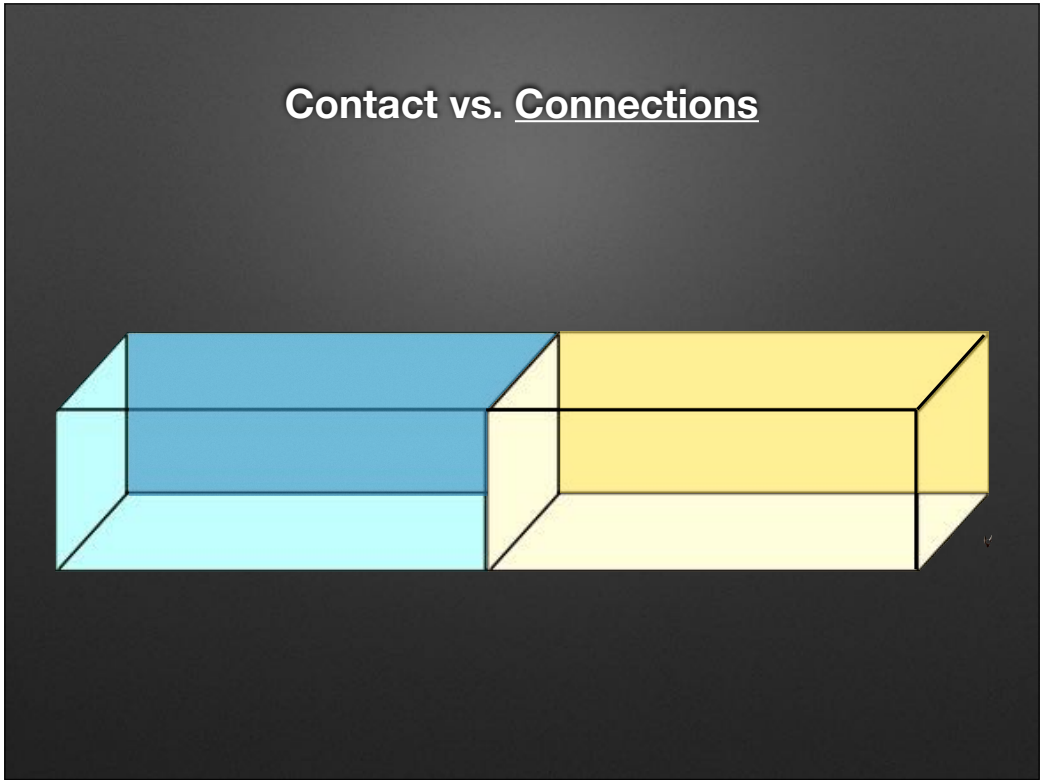
Firenze or Florence is the capital of Tuscany. • To the west, on the delta of the Arno river, is Pisa. This was a special place and time, where science was affected by the surrounding culture in a way that sparked creativity. That special spark of creativity arose from deep and natural interdisciplinary connections, which are evident in Galileo’s science.

What was the secret sauce that made these interdisciplinary connections creative and effective in Galileo's Tuscany? Can we recreate them in the Modern Research University? Can we solve the marble problem?

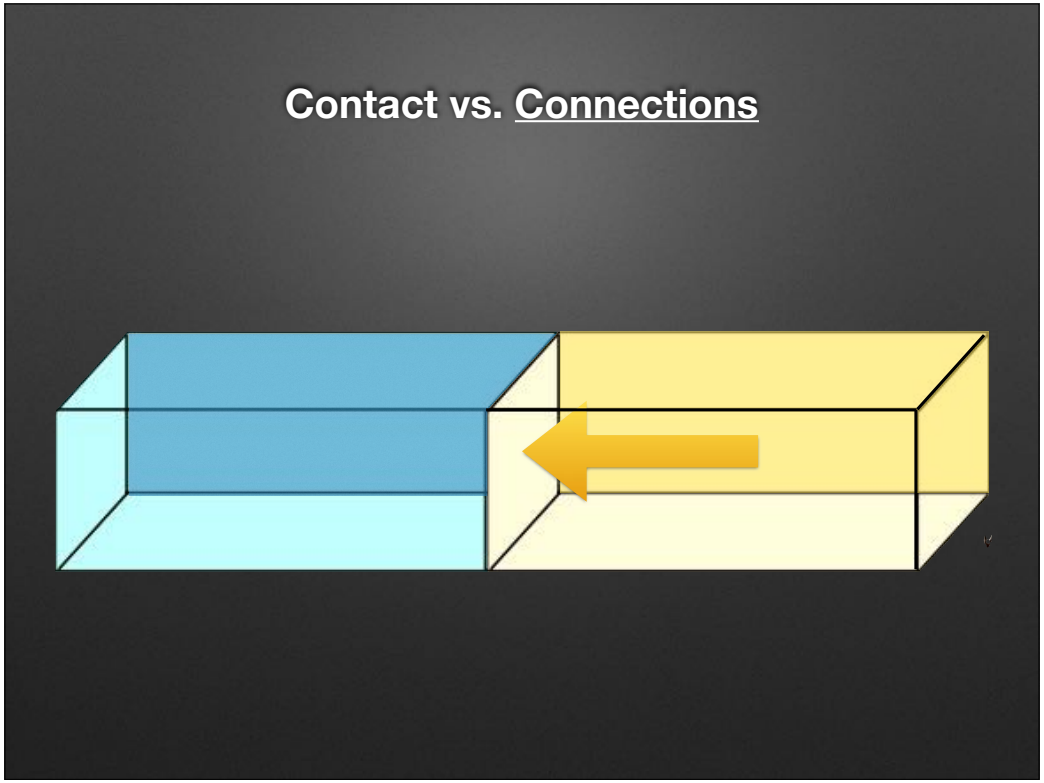
Similarly, can we recreate those special conditions in the Christian University? Research universities and Christian universities face a similar challenge. Do you have the solution to the marble problem? If you can get this right, then Christian universities have an opportunity to become exemplars for large public research universities.



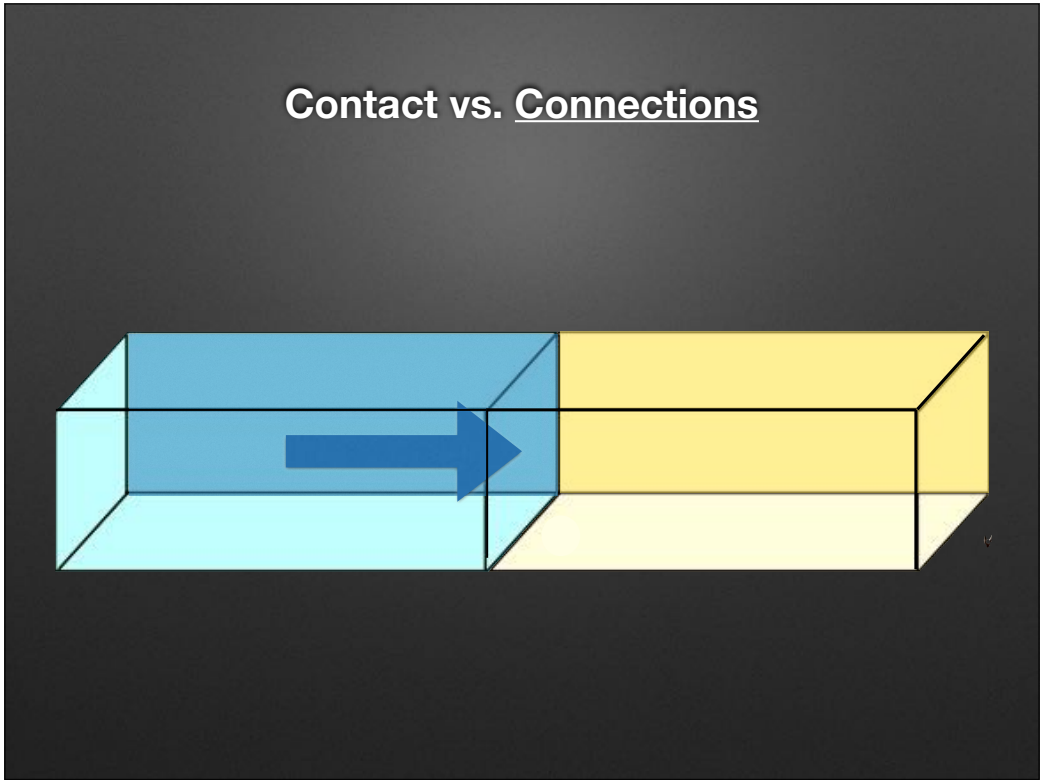
In contrast to the marbles, let's visualize that deeper kind of interdisciplinary connection, of the kind that sparks creativity, by thinking of any subject area as a rectangular box. So here we have two boxes, one represents astronomy and the other represents art. Or instead of astronomy and art, they might represent any two disciplines or subject areas.



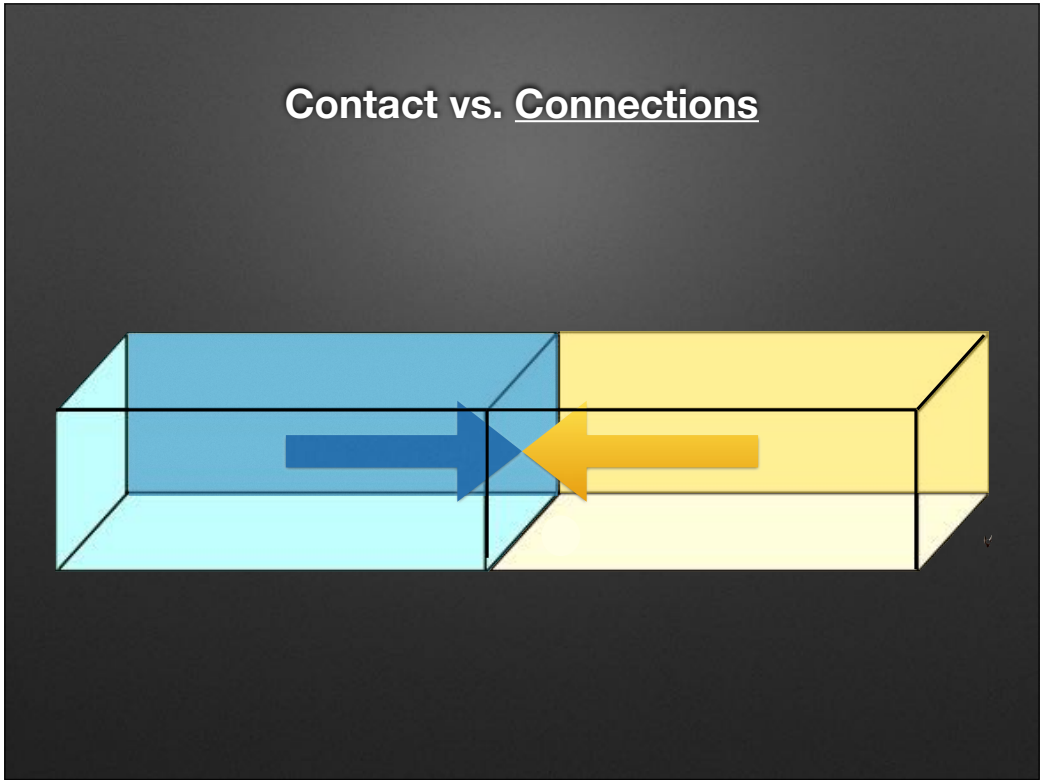
The point of this simple illustration is that, unlike marbles, boxes can be placed side by side. This represents disciplines in relation, becoming connected in some more profound way than just two marbles. Instead of contact at a single point, there's a wider surface area connecting the two. A larger surface where the natural relations between them may play out in a creative fashion.



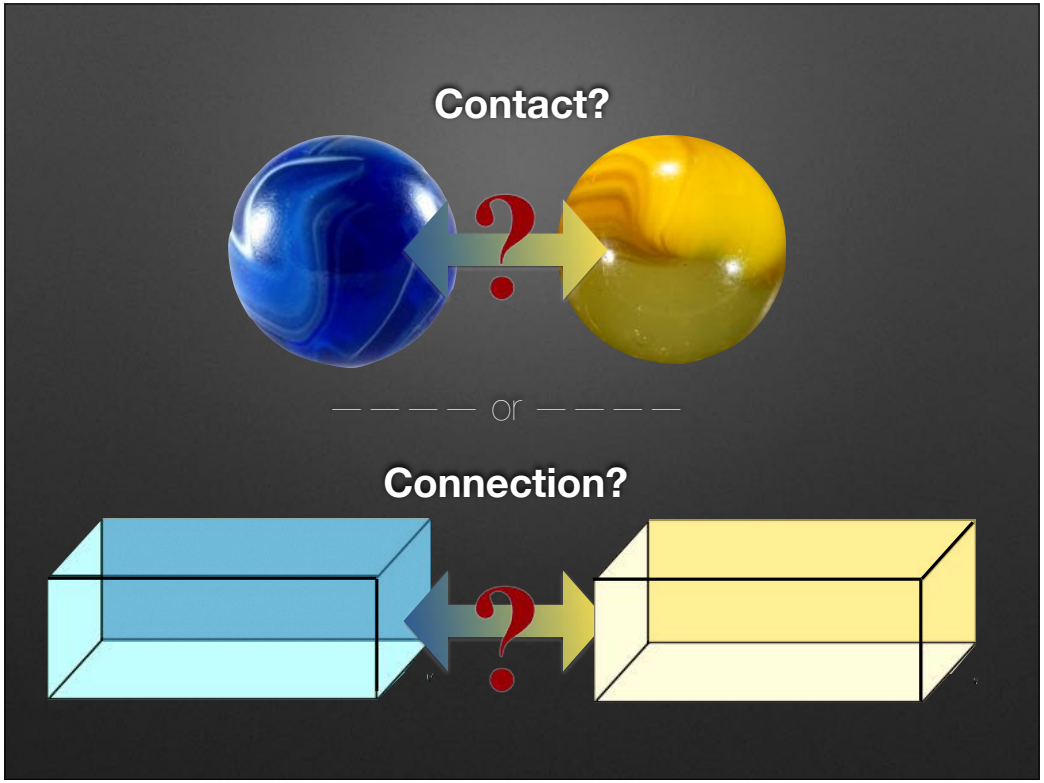
The question that immediately arises is to which box does this connecting surface belong? Does it belong to the yellow box?



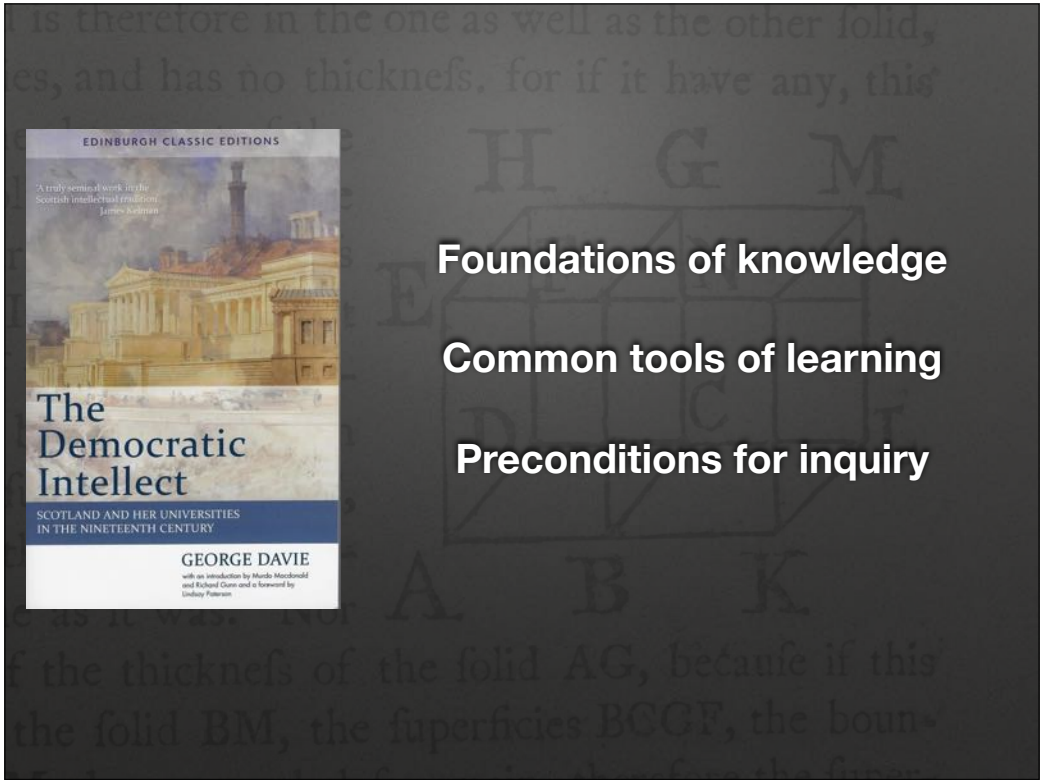
Or to the blue box?



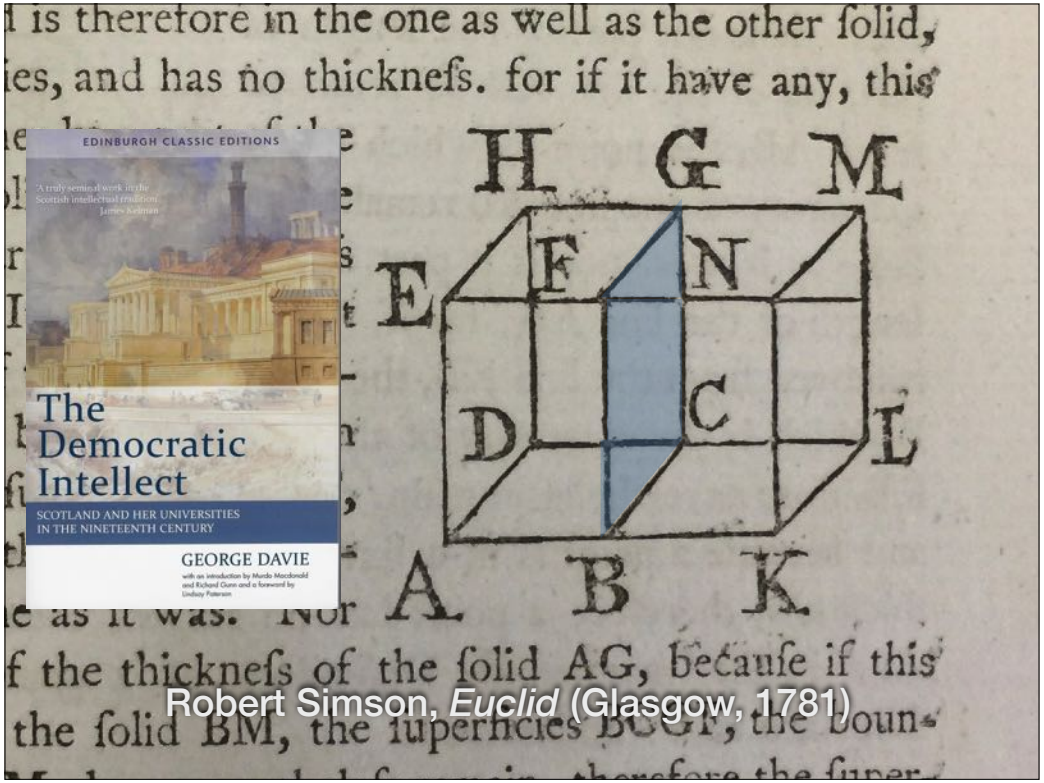
Or to both? For it to be a meaningful connection, it must be both. This side is a common surface, shared equally by both boxes. The connecting surface arises naturally from either box, according to its own nature. Neither box would be a complete box apart from this surface that, as it turns out, can be shared in common. This represents the kind of connecting surface between two disciplines where they meet one another, each on their own ground, in a deeper two-way conversation that sparks creativity in both disciplines.



The marbles and boxes therefore represent two kinds of interaction: mere contact by collision, or a connection through a natural surface area shared in common.

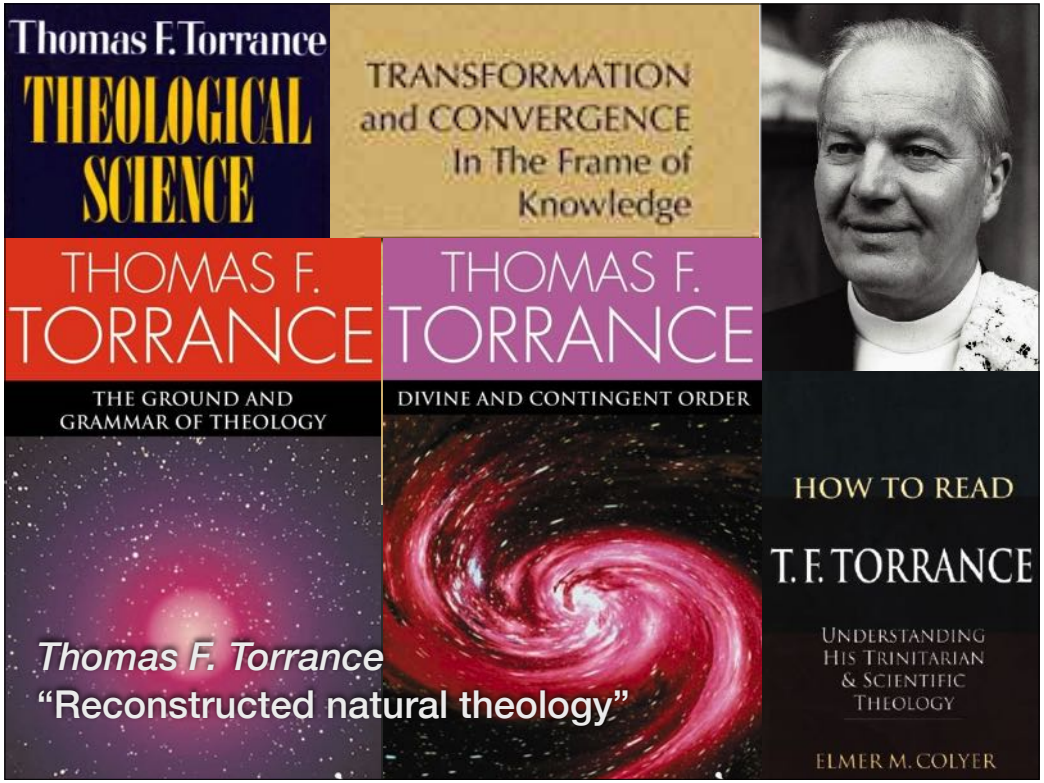


I've taken the boxes model from George Davie, *The Democratic Intellect*. Davie explored the university culture that arose from the Scottish enlightenment, in which disciplines were seen to be connected at a foundational level rather than superficially. • The Scots sought out natural connections based on shared foundations of knowledge, common tools of learning, and shared preconditions for inquiry.

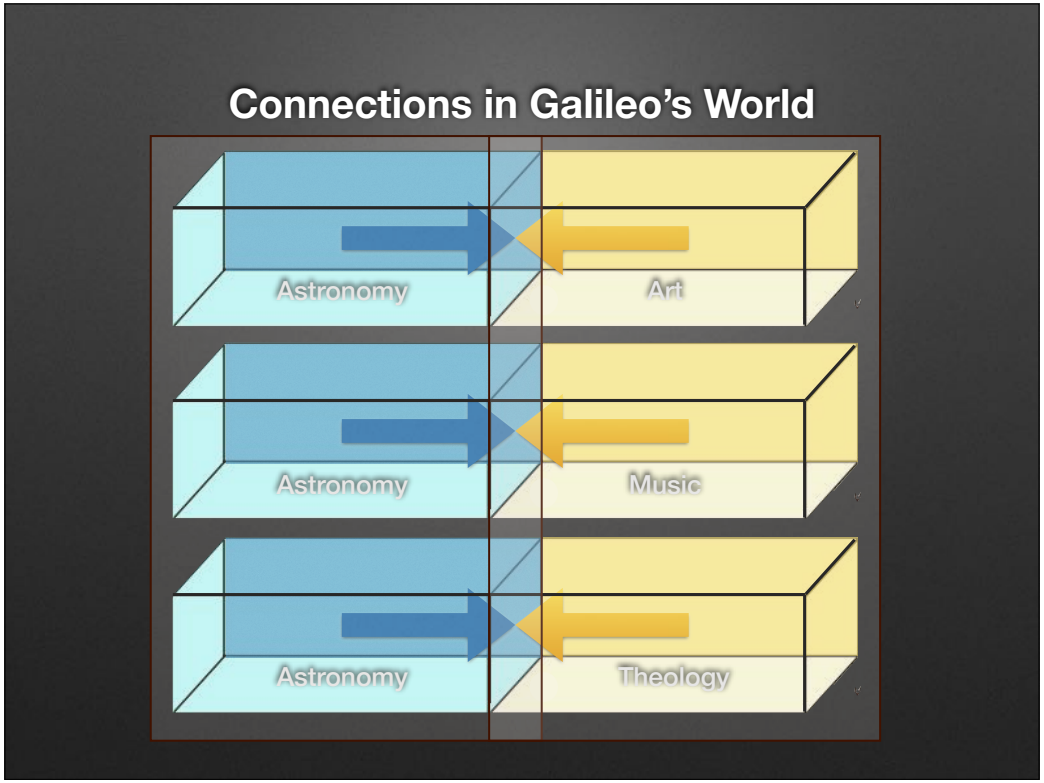


Robert Simson, *Euclid* (Glasgow, 1781)

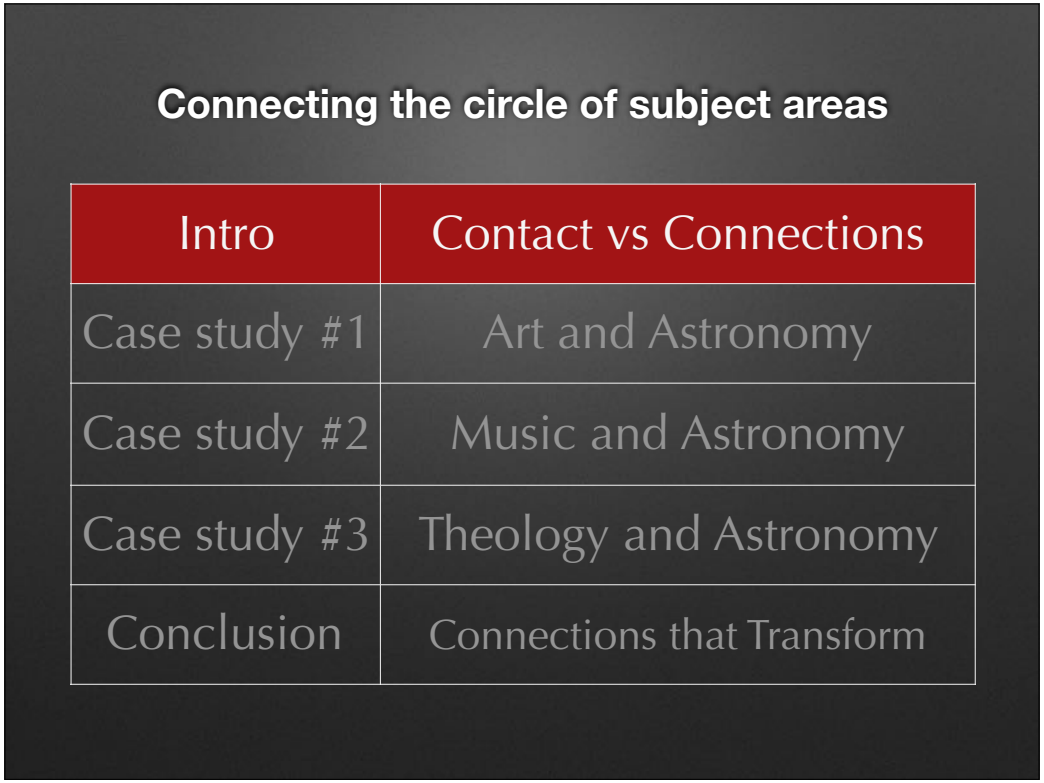
Davie cited the distinctive way Euclid was studied in the Scottish universities. This is an 18th-century edition by Simson that included copious notes. • One of those notes reflected on the connecting surface between two boxes, which arises from either box in a natural way and so belongs equally to both by definition.



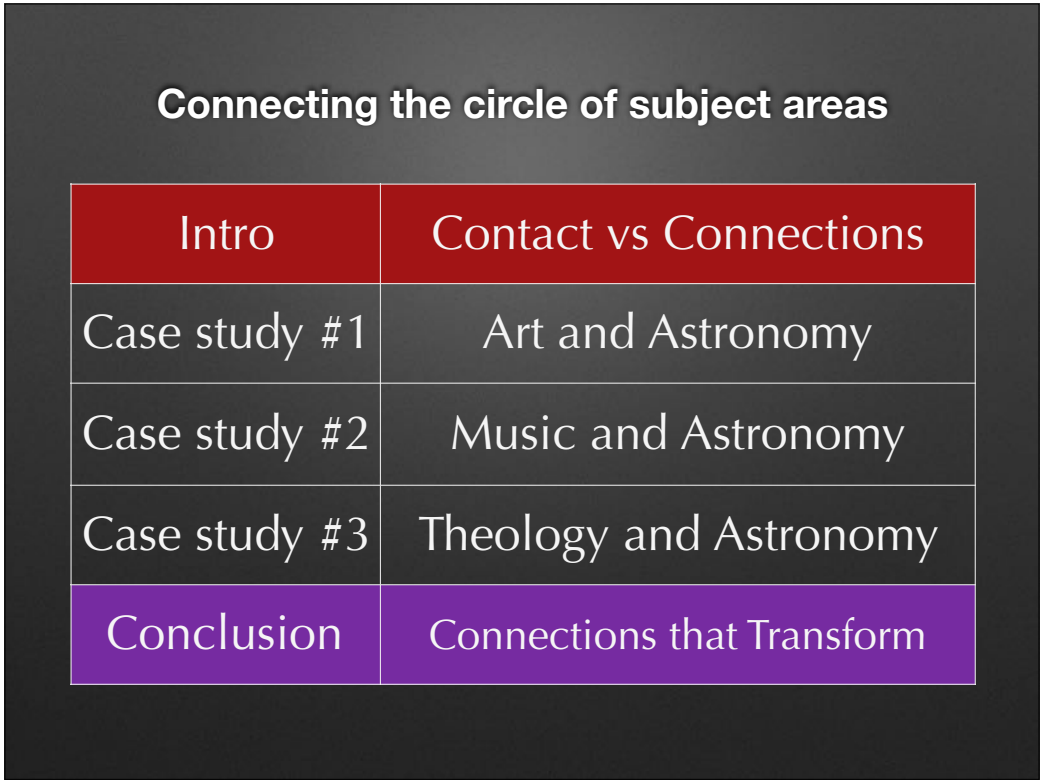
A theologian working in the Scottish tradition who approved of Davie's account was Thomas F. Torrance, who passed away in 2007. Torrance called for a "reconstructed natural theology." Torrance's reconstructed natural theology is not apologetics in the sense of proving theology by means of science, but rather a search for the foundational connections between theology and the natural sciences and other disciplines. So as we explore interdisciplinary connections this evening through some historical case studies, we are taking the first steps toward a reconstructed natural theology in the spirit of Torrance.



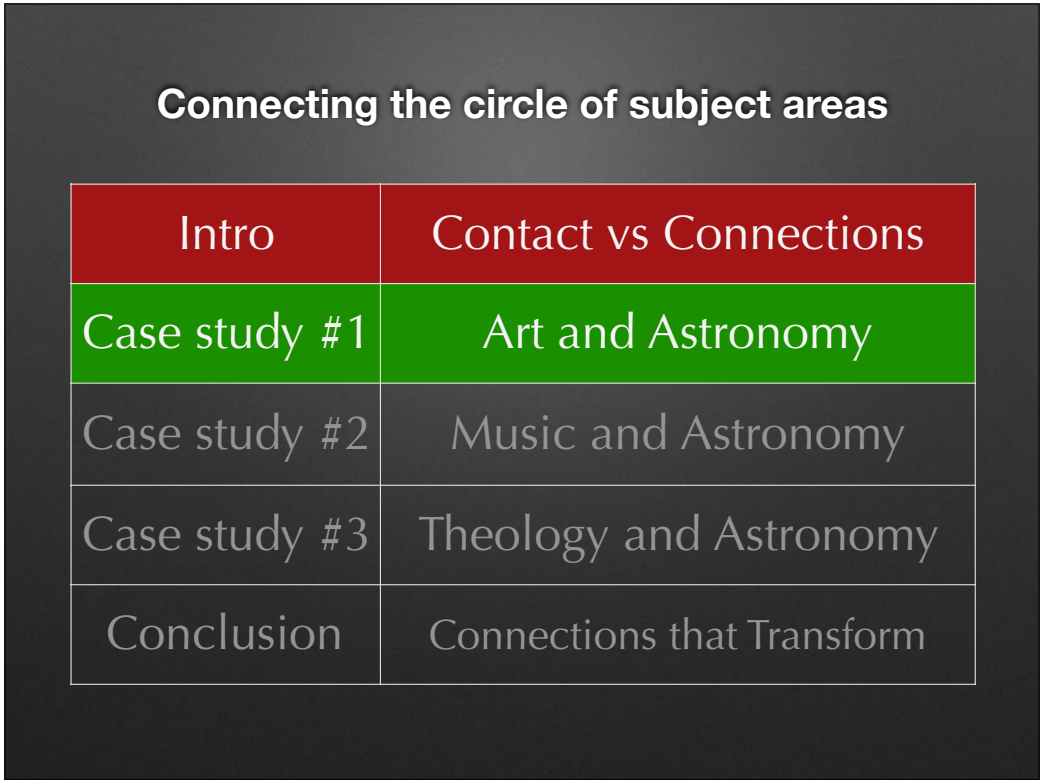
Tonight we'll explore three case studies. • How many of you are interested in astronomy? (Show of hands) Good. We'll use astronomy as the example discipline from the natural sciences. • For cross-disciplinary connections, we'll look in turn at art, music and theology. • In another talk, we might just as easily have chosen literature, health care or engineering.



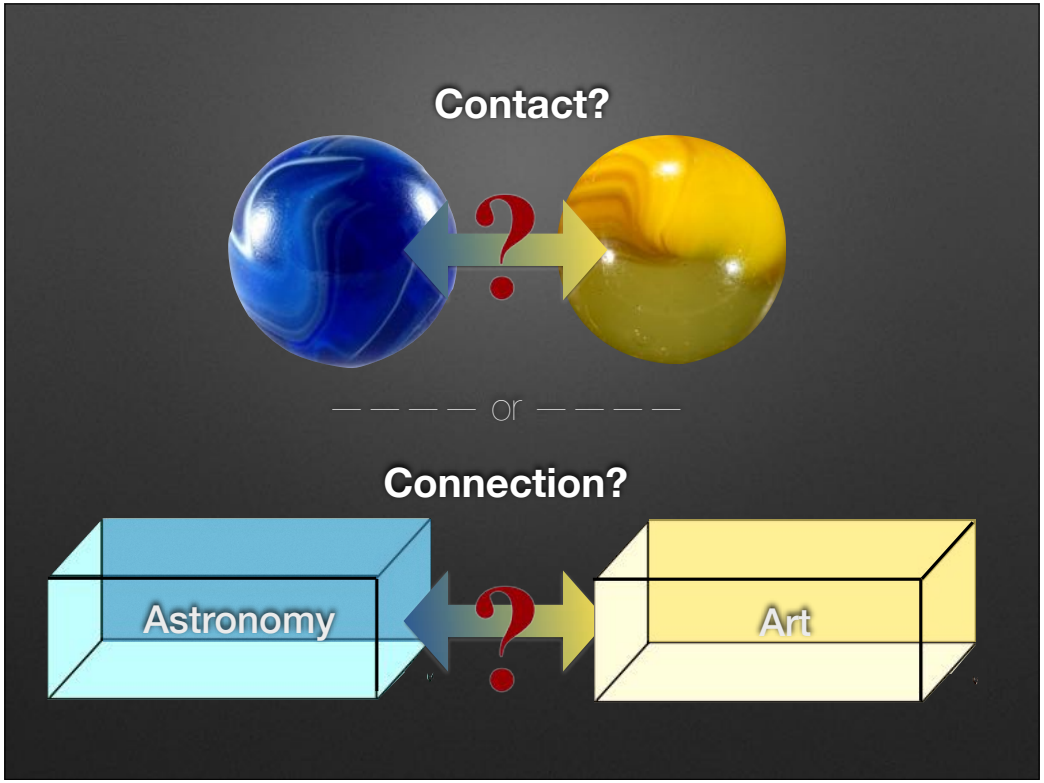
So that's the Introduction. How do we reconnect the circle of subject areas with deeper, natural connections, rather than arbitrary points of contact?



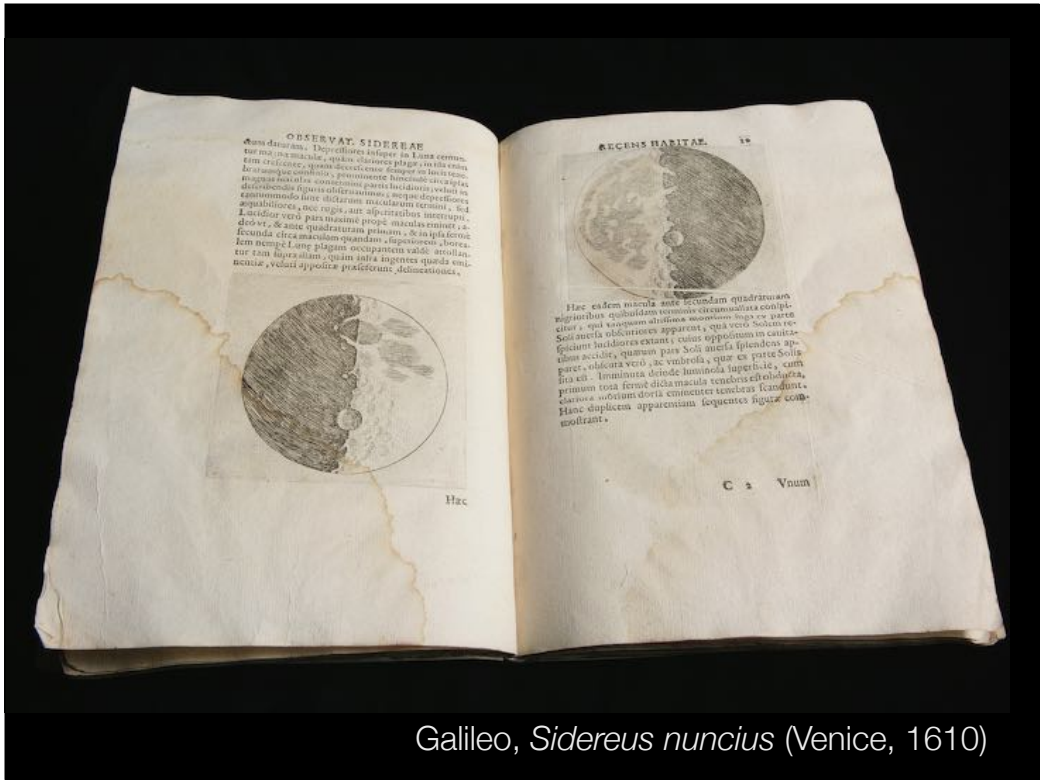
After the three case studies, in the conclusion, we'll revisit how to promote *connections* between disciplines that spark creative transformations, with some theological reflections. Ready?



Let's move on to the first case study, art and astronomy. How many of you are interested in art? Show of hands. How many believe art is connected to science in a meaningful way?



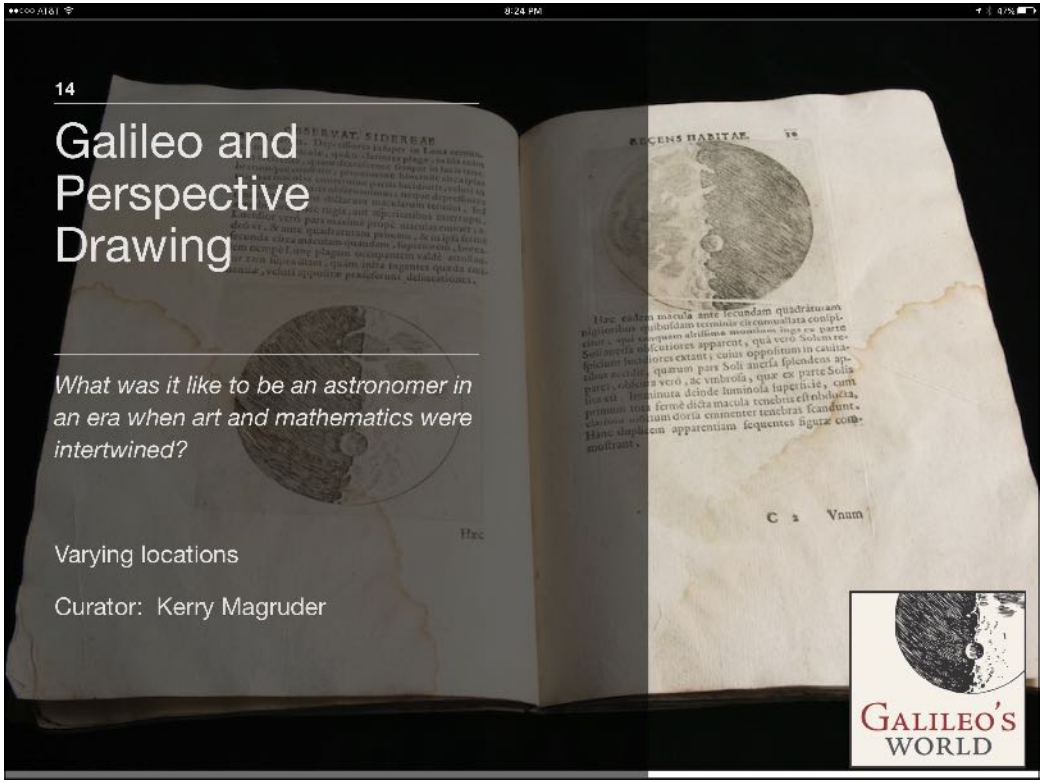
For art and astronomy, which type of relation will we find in Galileo's world? Contact or connection? The collision of marbles or the common surface of the boxes?



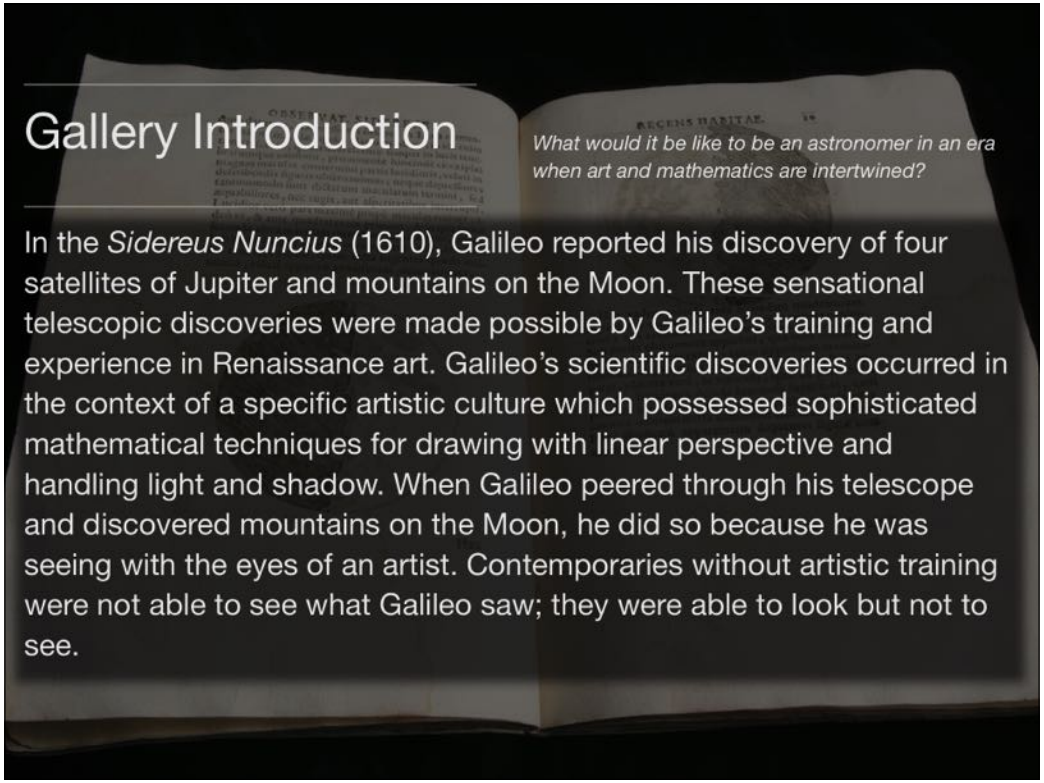
Galileo, *Sidereus nuncius* (Venice, 1610)

This is Galileo's Starry Messenger, the first published report of observations made with a telescope. It made Galileo an international celebrity almost overnight. Galileo discovered four satellites of Jupiter and mountains on the Moon.

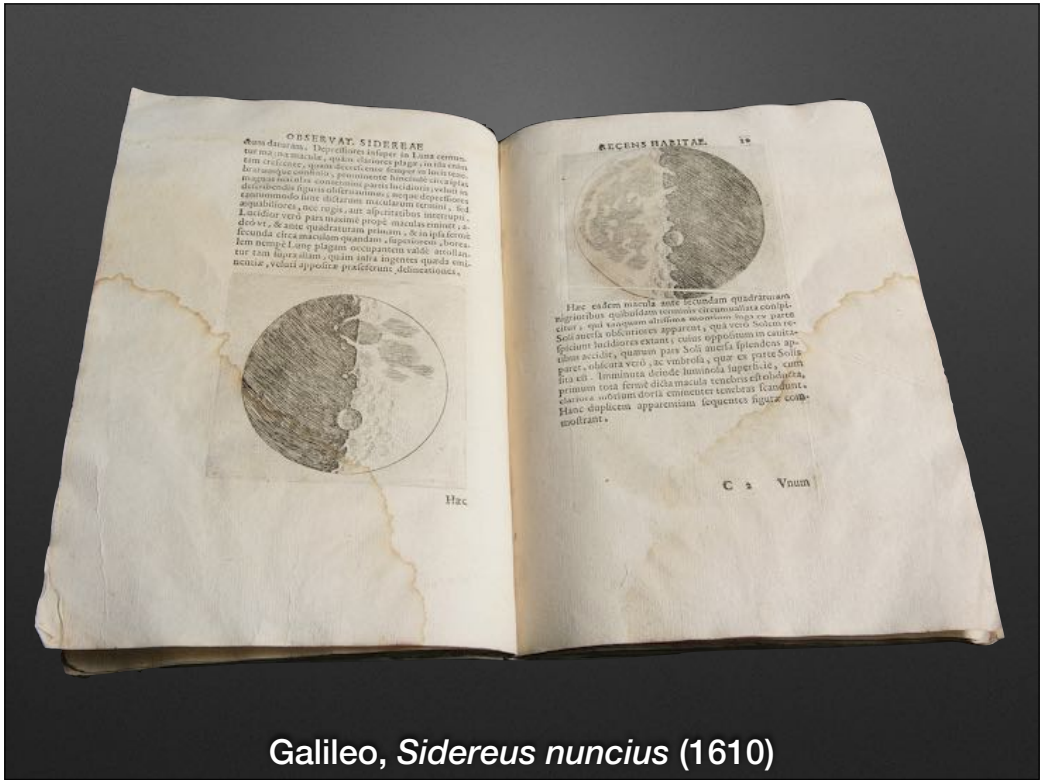
The OU copy was inscribed by Galileo in the lower right corner. The OU copy is the only copy extant with Galileo's handwriting. But this is just one of Galileo's books. Very few libraries in the world contain more than 3 or 4 Galileo first editions; • OU has all 12, and 4 of them contain Galileo's own handwriting.



Of the 20 galleries that made up Galileo's World, one was Galileo and Perspective Drawing. This gallery was devoted to exploring the question: "What was it like to be an astronomer in an era when art and mathematics were intertwined?" This is an iPad screenshot from the Exhibit Guide.



For this gallery, the introduction presents some bold theses. In the Starry Messenger, Galileo reported… (READ)

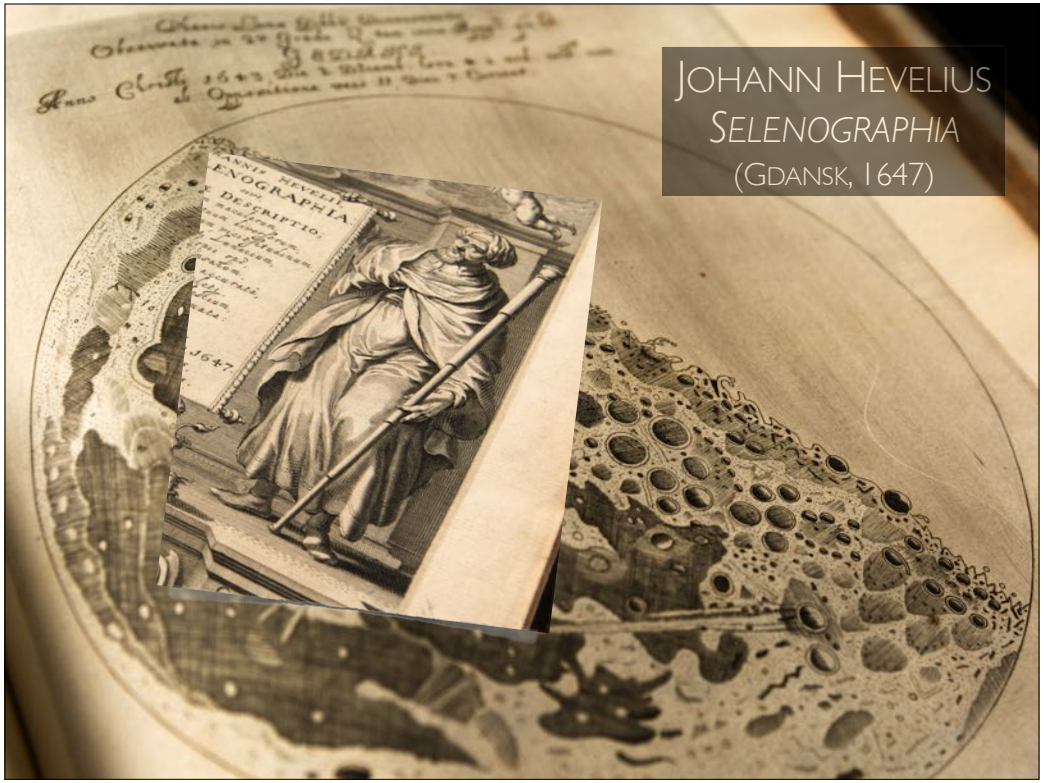


Galileo, *Sidereus nuncius* (1610)

Because lenses at that time were of such poor quality, Galileo's discoveries were made not by optics but by the artistic training of his eyes. Let's explore why this was so.

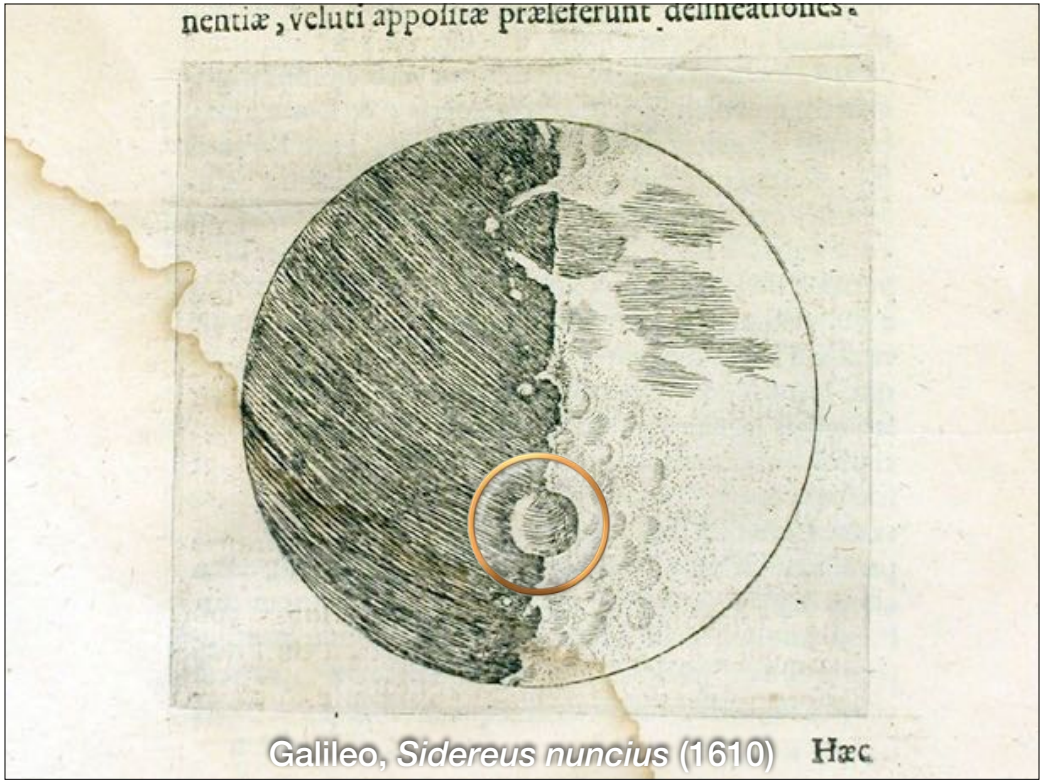
Galileo, *Sidereus nuncius* (1610)

Many people mistake Galileo's engravings of the Moon as attempts to map its surface.



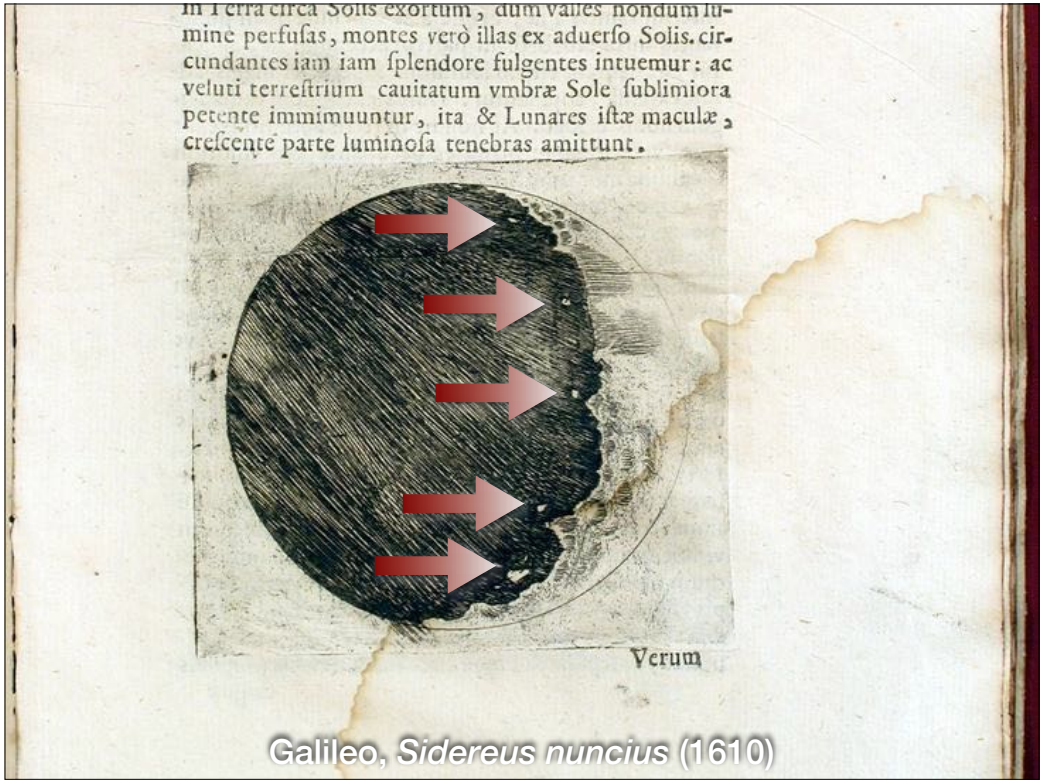
Galileo's book set off the 17th century race for the Moon. Not a race to go there, but a race to map its surface. It's astonishing that this task was accomplished by mid-century — in this comprehensive lunar atlas of Hevelius, less than 40 years after Galileo's initial telescopic discoveries. • Incidentally, for those who might hastily assume Galileo marks a unique staring point of something altogether new, the title page of this volume depicts Galileo in Middle Eastern dress as a tribute to the medieval Islamic optical tradition.

Anyway, this small crater is accurately depicted here. One misinterprets Galileo to accuse him of exaggerating its size…



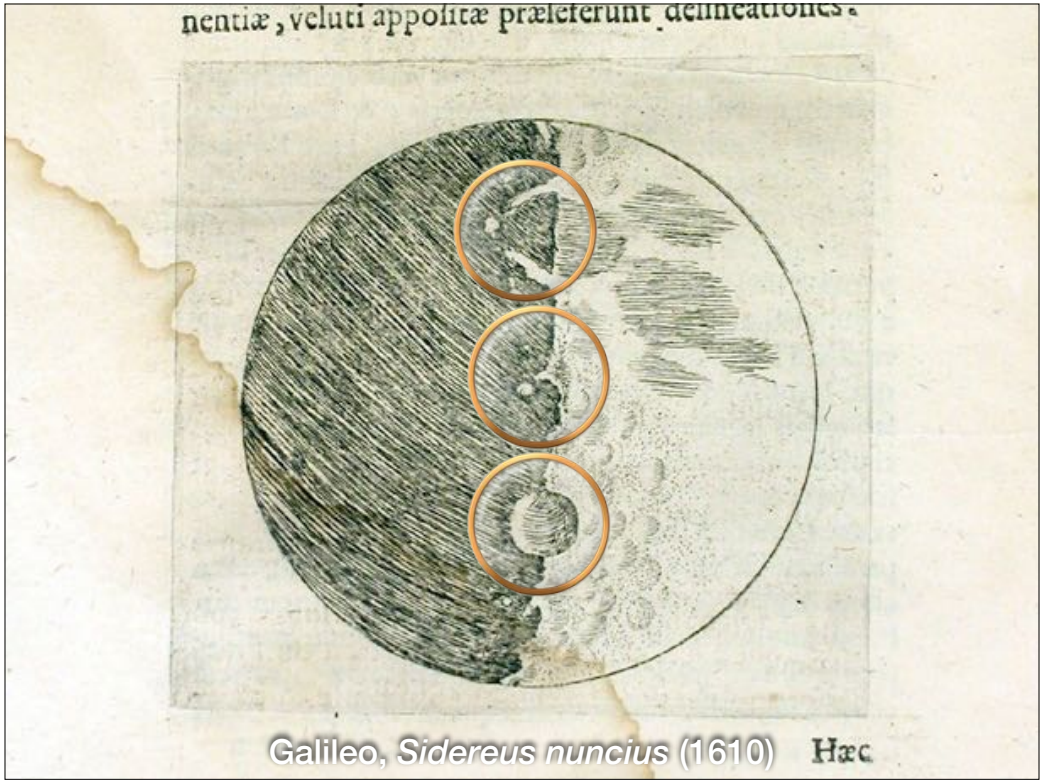
Galileo, *Sidereus nuncius* (1610)

here. In contrast to Hevelius, Galileo's drawing is not a map of the Moon. If not a map, then what was Galileo doing here? • Before the Moon could be mapped, first someone had to demonstrate that there was something there, real surface topography, that could be mapped. The assumption at the time, was that the shading of the Moon was internal, its surface as smooth as a marble.



Galileo, *Sidereus nuncius* (1610)

Galileo countered arguments that the Moon's surface was smooth by teaching us how to see, how to observe the changing play of light and shadow. • The white dots to the left of the shadow line, or terminator, are mountain peaks, standing above the plains that are still in morning darkness.

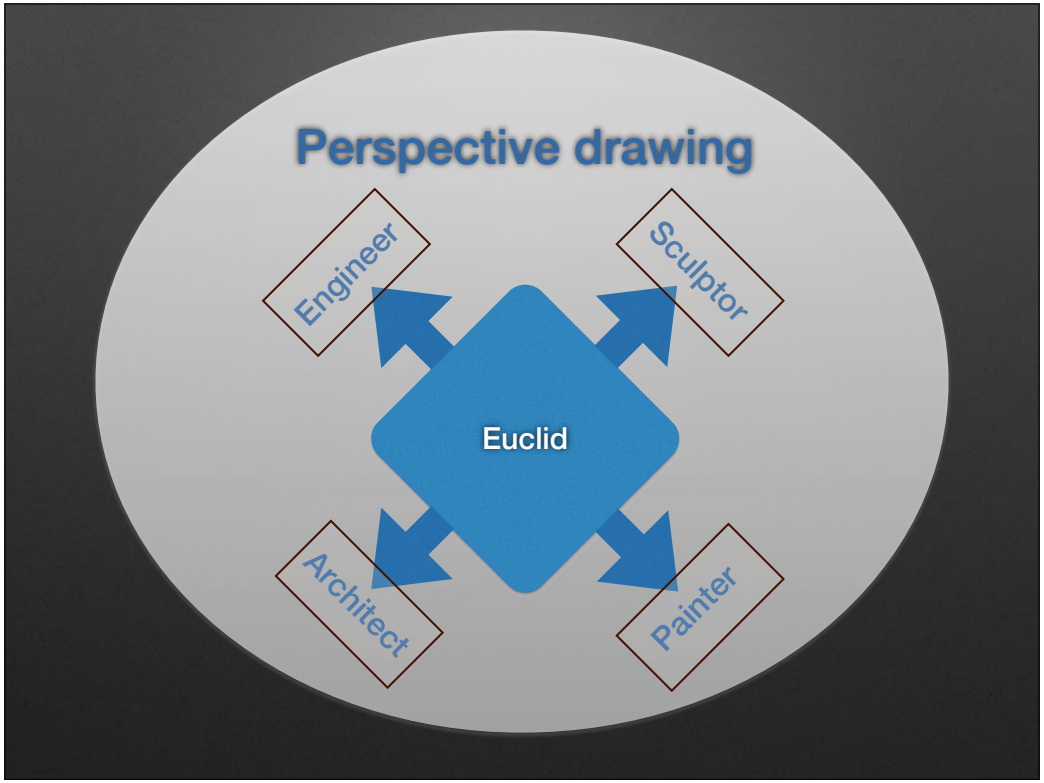


Galileo, *Sidereus nuncius* (1610)

What appears as an isolated peak one night, ❒ may become a chain of mountains the next night, ❒ or converge in a circular structure after that. Galileo was not mapping the moon, or implying that a crater of that size is present in that location, but showing how to detect real lunar topography, contrary to the Aristotelian physicists.• A map of the Moon would be a composite inference from many such observations. The lunar atlas of Hevelius contained observations compiled over 5 years.

How did Galileo learn to see artistically? How did he gain experience in the study of light and shadow? At that time in Tuscany, many young men enrolled in artisan workshops, such as the Academia del Disegno or Academy of Drawing.

In these artisan workshops they would study Euclidean geometry in a hands-on way by acquiring the techniques of perspective drawing. Later in life, Galileo became an honorary member of the Academia del Disegno.



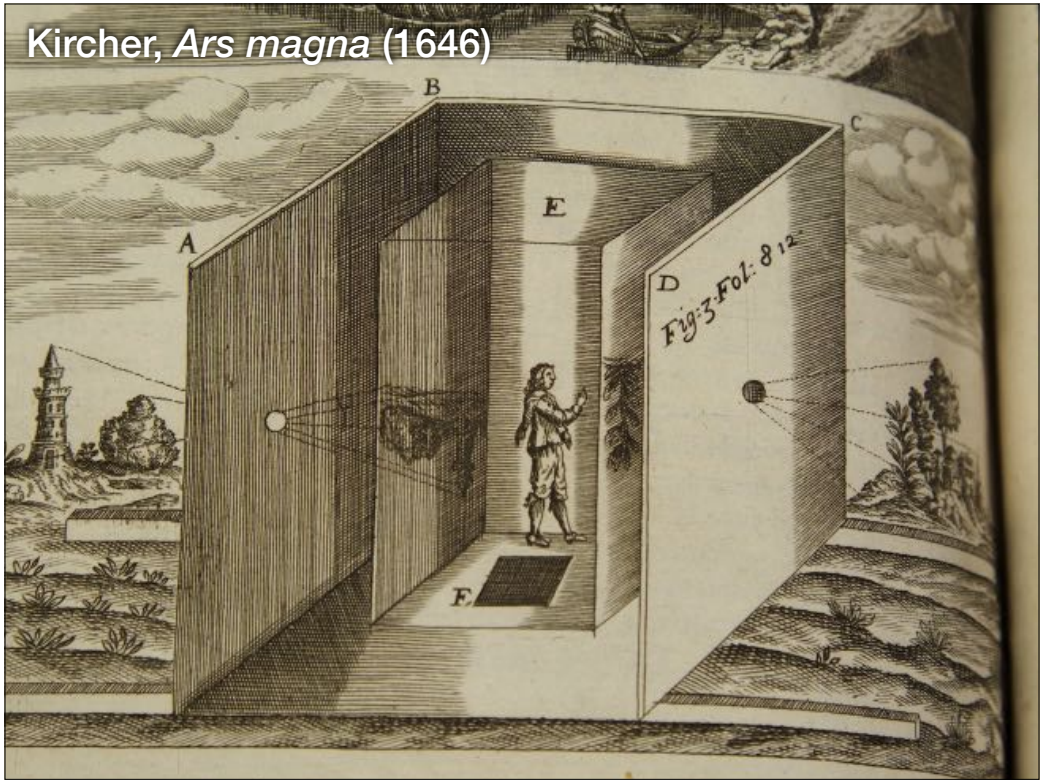
For their capstone project, students in these artisanal workshops would apply their geometrical drawing skills to • a project in art such as a painting or drawing, and go on to become artists. • Or they might craft a sculpture, or make a blueprint, and go on to be sculptors or architects. • Or they might create a design for a complex machine, and go into engineering, as did Galileo. • In artisan workshops, future artists and engineers studied mathematics side by side. This is interdisciplinary education in action, manifesting natural and organic connections between subject areas.

As a young man, Galileo studied in the artisan workshop of Buontalenti, where lessons in geometry were given by Ostilio Ricci. Ricci's lectures there were also attended by Galileo's friend, the painter Cigoli.

This is a painting by Cigoli in Rome, of the Virgin standing on the Moon. • But the Moon shows craters, as it appeared through Galileo's telescope. • Galileo's later secretary, Viviani, recorded that Cigoli stated that Galileo had been his teacher in the art of perspective drawing: "in perspective, Galileo alone had been his master."

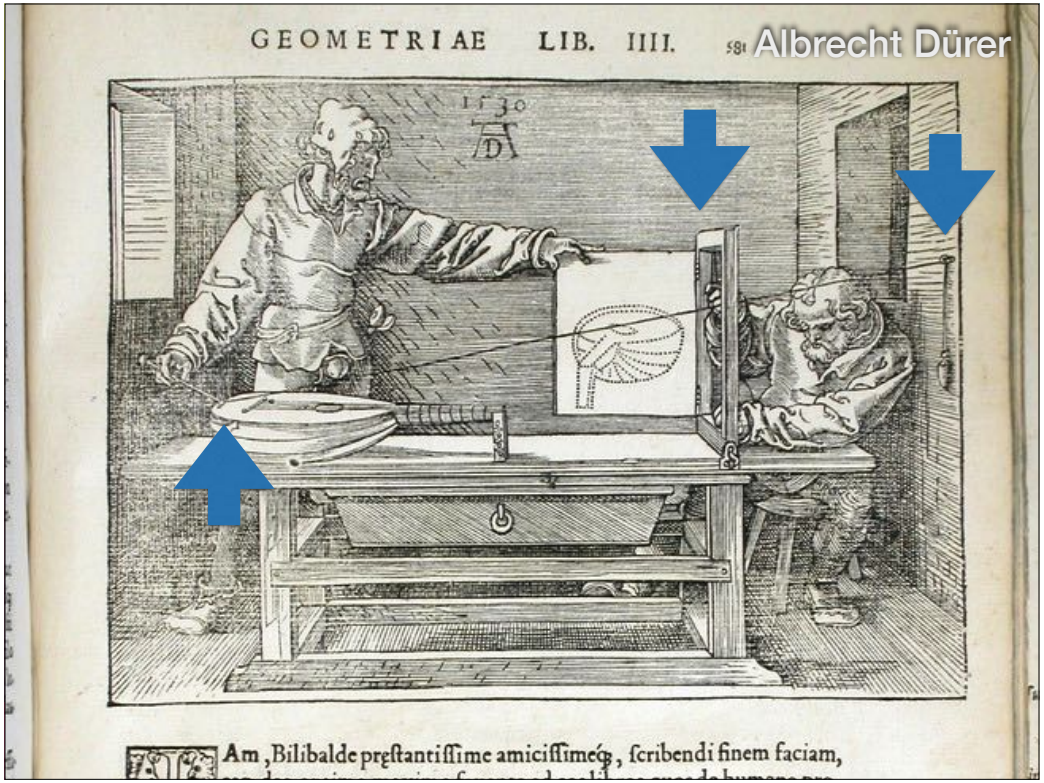
This is the first English translation of Euclid, printed in 1570. In the chapter on the geometrical solids, this copy retains the original pop-ups. Euclid, as studied in the Florentine artisan workshops, was the starting point for optics and perspective.

(Optics combined geometry, experiment, vision and art.)



Euclid worked out the principles of the “camera obscura.” Camera obscura literally means a “dark room.” It consists of a box or container in which light enters via a small hole and projects an image on an opposite wall. The image will be reversed and upside-down, but its proportions will be preserved. Renaissance artists had been familiar with the camera obscura for several hundred years, and it was well-known to astronomers like Kepler and Galileo.

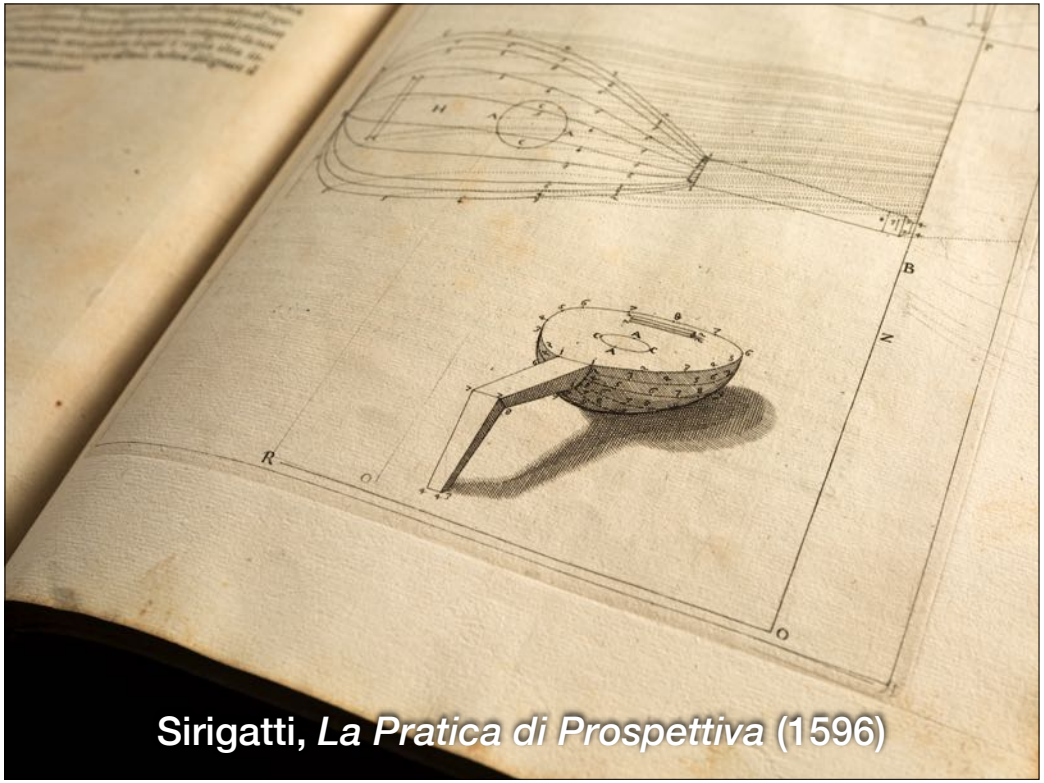
The linear propagation of light in the camera obscura made it possible to draw with true perspective. To aid in perspective drawing, many additional instruments and tools were developed. This geometrical drawing demonstrates true perspective and a mastery of light and shadow. • This and other similar diagrams were drawn by Leonardo da Vinci. They were the only materials ever put in print by Leonardo during his lifetime, appearing in a work on drawing by Leonardo's friend Luca Pacioli. Artists over the following century would practice the techniques and tools of perspective drawing by re-creating geometrical figures like these.



This explanation of perspective drawing comes from a work by Albrecht Dürer, similar in scope to the Pacioli, yet a generation later. Dürer here shows a variation on the perspective drawing technique known as “Alberti’s window.” The artist is creating a drawing of a lute with true perspective by means of • a string running from the object, • through the canvas window, • to the vanishing point on the wall.

Sirigatti, *La Pratica di Prospettiva* (1596)

This beautiful work by Sirigatti, published when Galileo was a young man, brings the tradition of perspective drawing down to Galileo's time. Sirigatti was a member of the Accademia del Disegno, mentioned earlier.



Sirigatti, *La Pratica di Prospettiva* (1596)

The work contains 64 full-page engravings with accompanying exercises, to train artists and engineers. Here is the exercise for the lute, as we saw in Dürer.

Sirigatti, *La Pratica di Prospettiva* (1596)

Here are some exercises similar to the Leonardo drawings in Pacioli. Galileo is known to have worked his way through Sirigatti, practicing the techniques of linear perspective by reproducing these and the other drawings.

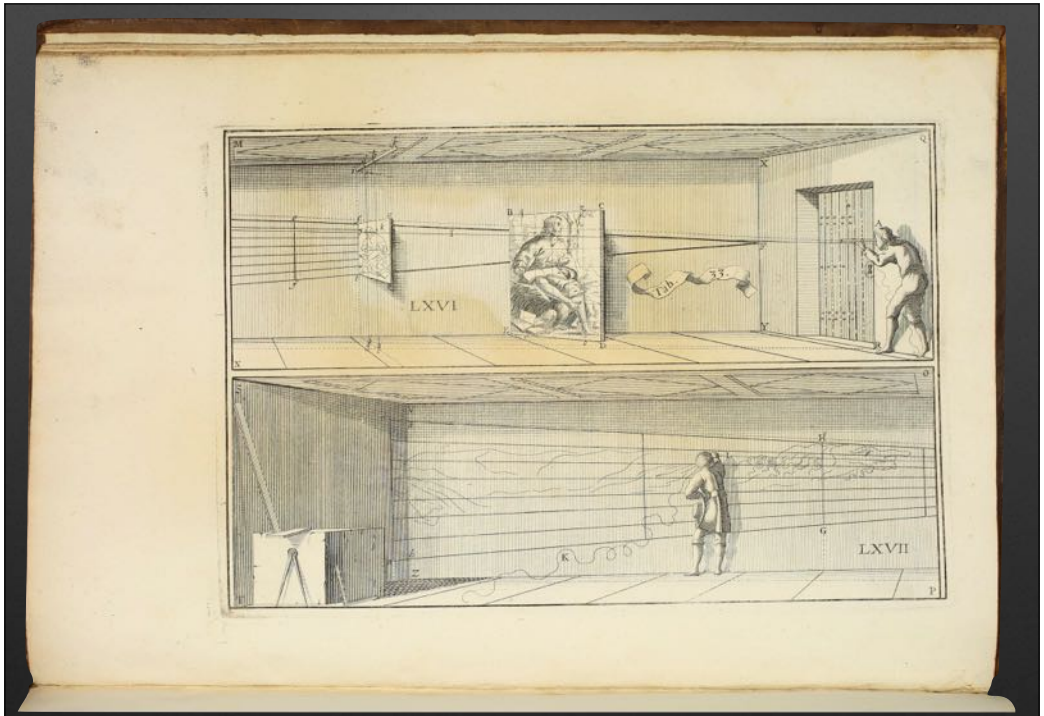
Any young artist or mathematician working his way through Sirigatti, like previous generations working through the exercises of Leonardo or Dürer, would master perspective and the handling of light and shadow (chiaroscuro).

Careful study of the spikes on this ring and the shadows they cast prepared Galileo's eyes to interpret the shadows cast on the Moon by mountains and other topographical features. • Imagine each spike is the same lunar mountain observed at different times under light from different angles. This spiked donut is fantastic!

Thomas Harriot, one of the leading astronomers in England, was observing the Moon at this time and conversing with his friends about the “strange spottedness of the Moon.” He and a friend concluded that the Moon looks like an Apple pie. Why did Harriot not discover the lunar mountains before Galileo? Harriot did not have artistic training in perspective drawing like Galileo; there was as yet no equivalent of Sirigatti in England to help him interpret the “strange spottedness” as shadows cast by mountains. Once Galileo published the Starry Messenger, Harriot quickly agreed, because Galileo taught him how to see.

Jean François Nicéron, *La Perspectiva Curieuse* (Paris, 1663)

During a visit to Florence, Jean François Nicéron met with Galileo's artist friend Cigoli. Cigoli showed Nicéron a perspective drawing tool he had invented. Nicéron later published Cigoli's technique in this book.



Jean François Nicéron, *La Perspectiva Curieuse* (Paris, 1663)

In Florence, Nicéron also viewed examples of anamorphic drawing techniques and Alberti's perspective boxes. This Florentine artistic culture, steeped in the techniques of perspective drawing, was the midwife at the birth of Galileo's telescopic astronomy.

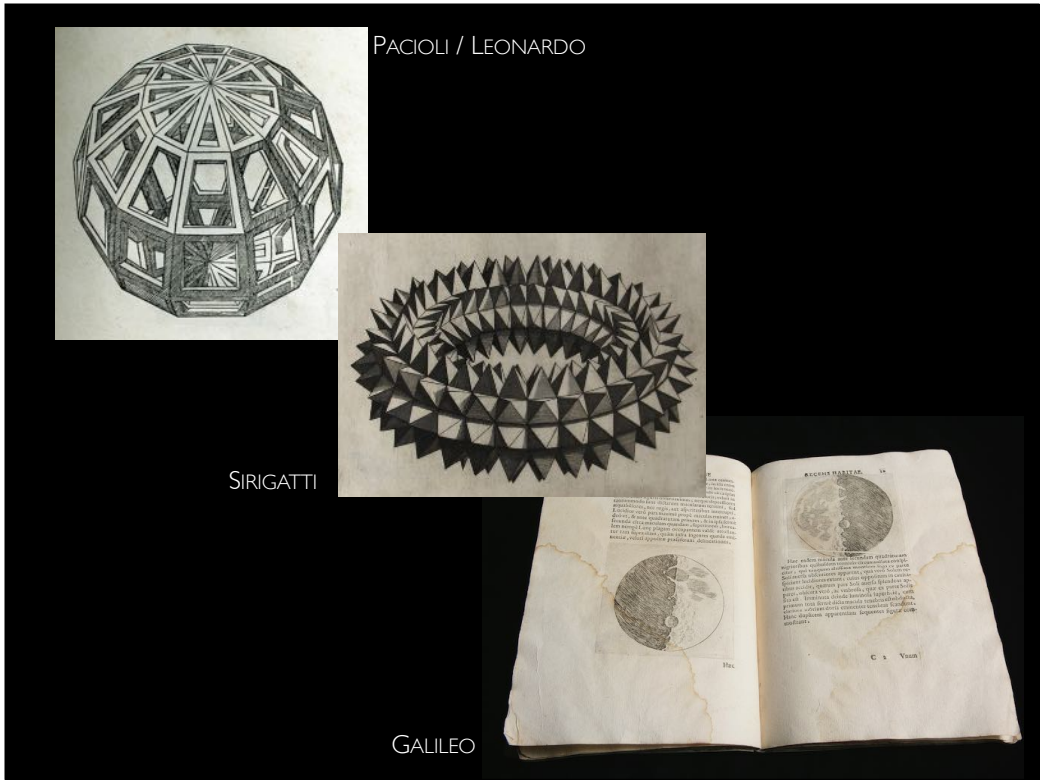
Galileo, *Sidereus nuncius* (1610)

On Galileo's title page, he refers to the telescope

calling it a “perspective tube.” Galileo regarded the telescope as just another tool for perspective drawing.

Galileo, *Sidereus nuncius* (1610)

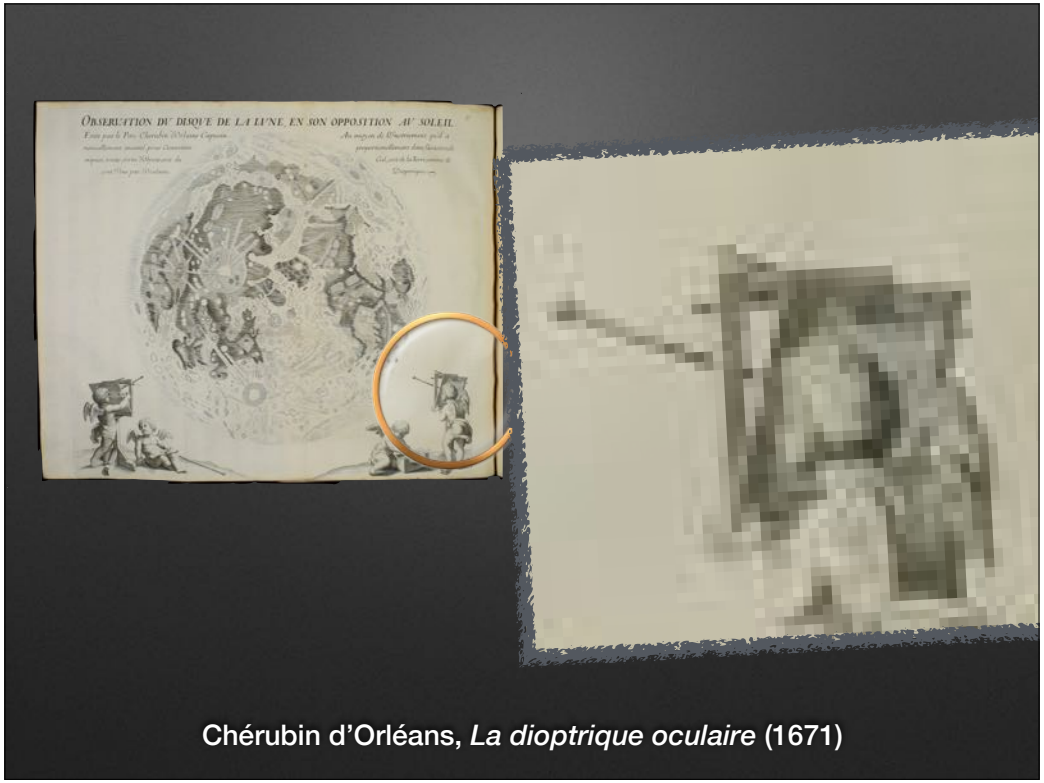
Galileo's years of practice of the principles of light and shadow in perspective drawing, enabled him to interpret the markings appearing in his "perspective tube" as the shadows of mountains protruding up from the surface of the Moon, just like the spiked donut exercise from Sirigatti.



So the most revolutionary astronomical discoveries of Galileo grew out of modes of inquiry and practice initially developed in art for perspective drawing. This sequence – Leonardo, Sirigatti, Galileo – is the background for our story that, to repeat, when Galileo peered through his telescope and discovered mountains on the Moon, he did so only because he was seeing with the eyes of an artist. He made his telescopic discoveries as much through art as through optics.

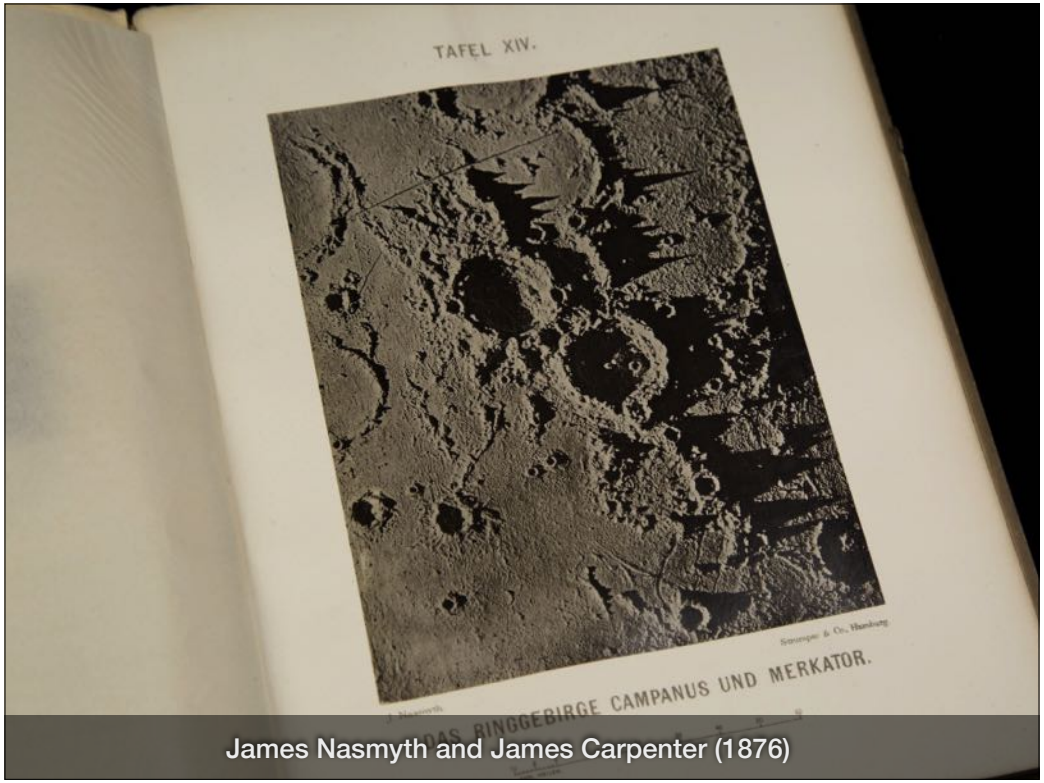
Chérubin d'Orléans, *La dioptrique oculaire* (1671)

A generation after Galileo, D'Orléans provided a comprehensive theoretical and practical discussion of perspective, vision and optics. d'Orléans adopted the lunar map of Hevelius, based on Hevelius' comprehensive telescopic observations. The putti are observing the Moon with telescopes.



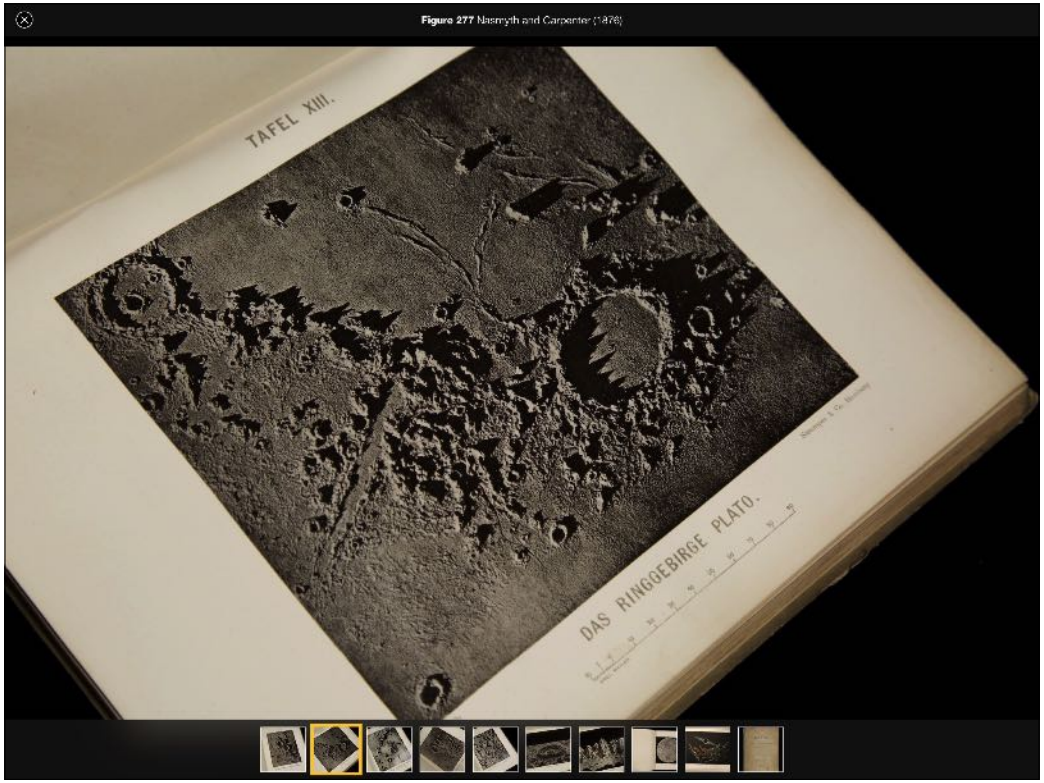
Chérubin d'Orléans, *La dioptrique oculaire* (1671)

This is another page in the same work. Yet on this plate, the putti are observing the Moon not only with the telescope, but with the "pantograph," a perspectival tool devised by d'Orléans. The tradition of perspective that underlay Galileo's discoveries has not yet been forgotten.

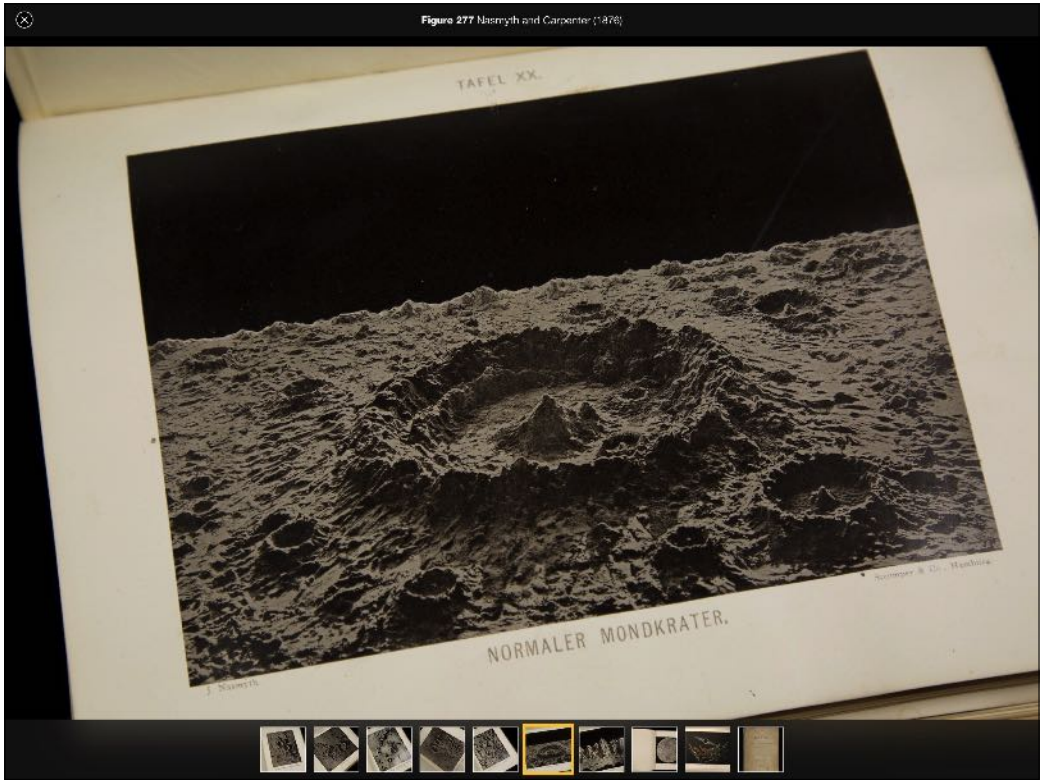


James Nasmyth and James Carpenter (1876)

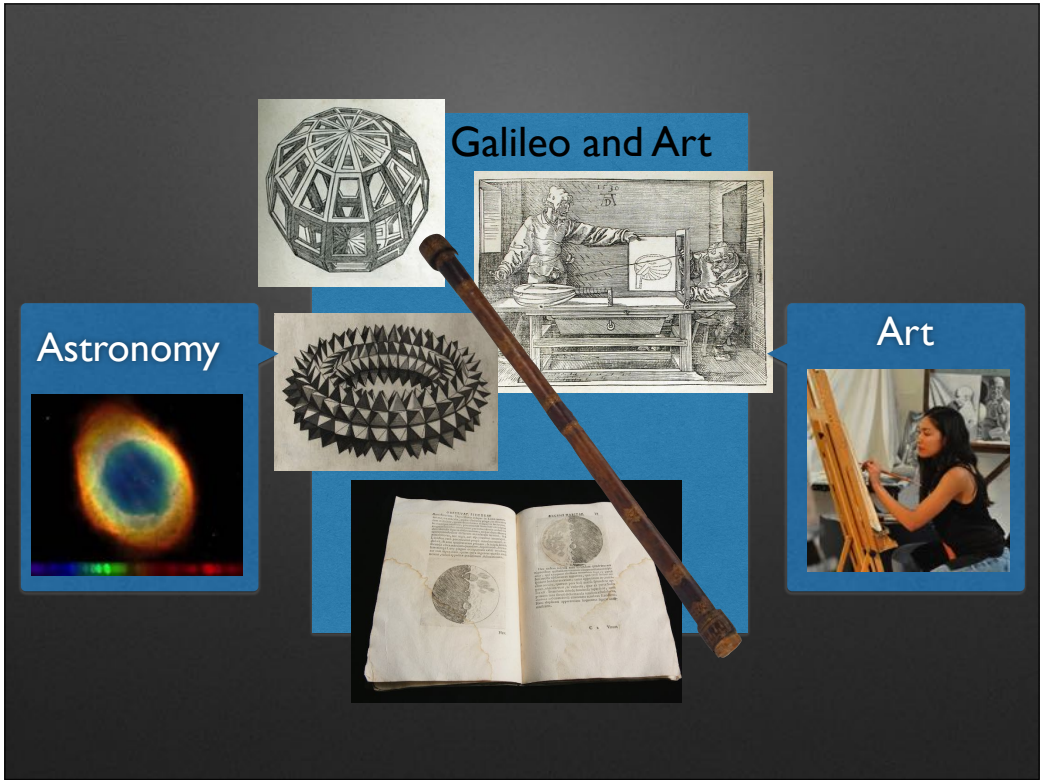
Let’s move forward into the late 19th century. This is not a photograph of the Moon! No Earth-bound telescopes could discern such detail. Nasmyth was a Scottish engineer best-known for inventing the steam hammer. He combined avid interests in astronomy and photography. Carpenter was an astronomer at the Greenwich Observatory. Together they constructed plaster models of the lunar surface. They photographed these plaster models using raking light,



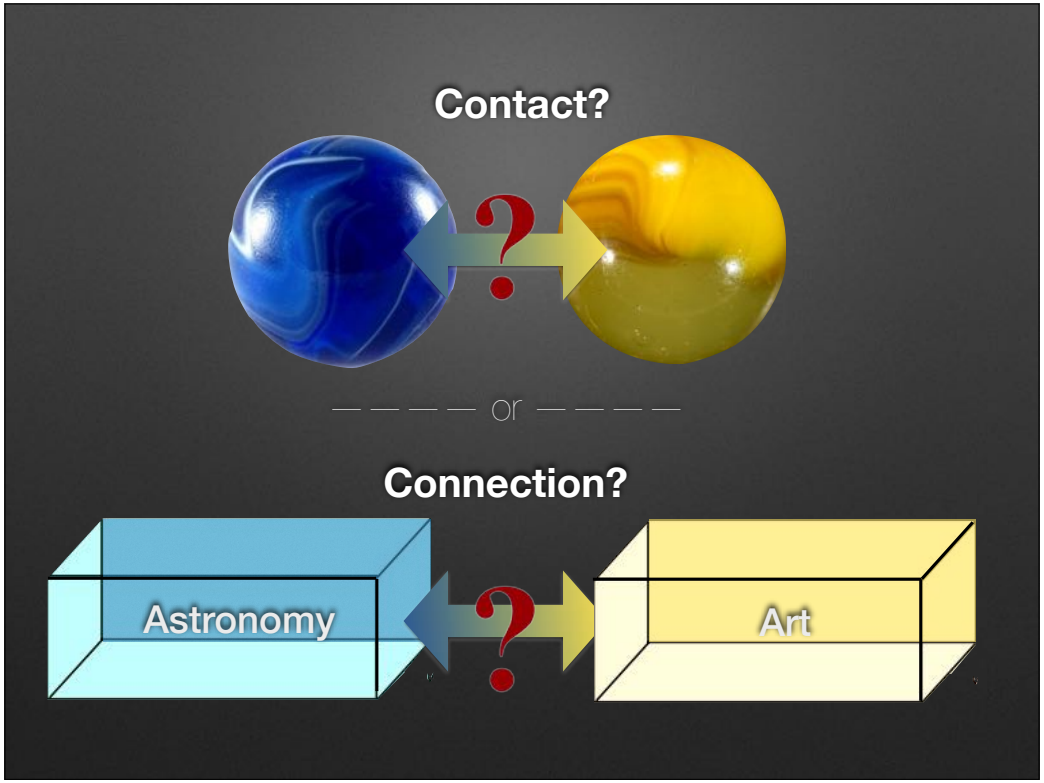
With light rays coming from oblique angles, they were able to simulate shadow effects on the surface of the Moon. In this British achievement in astronomy, we see that a productive combination of art and astronomy did not end with Galileo.



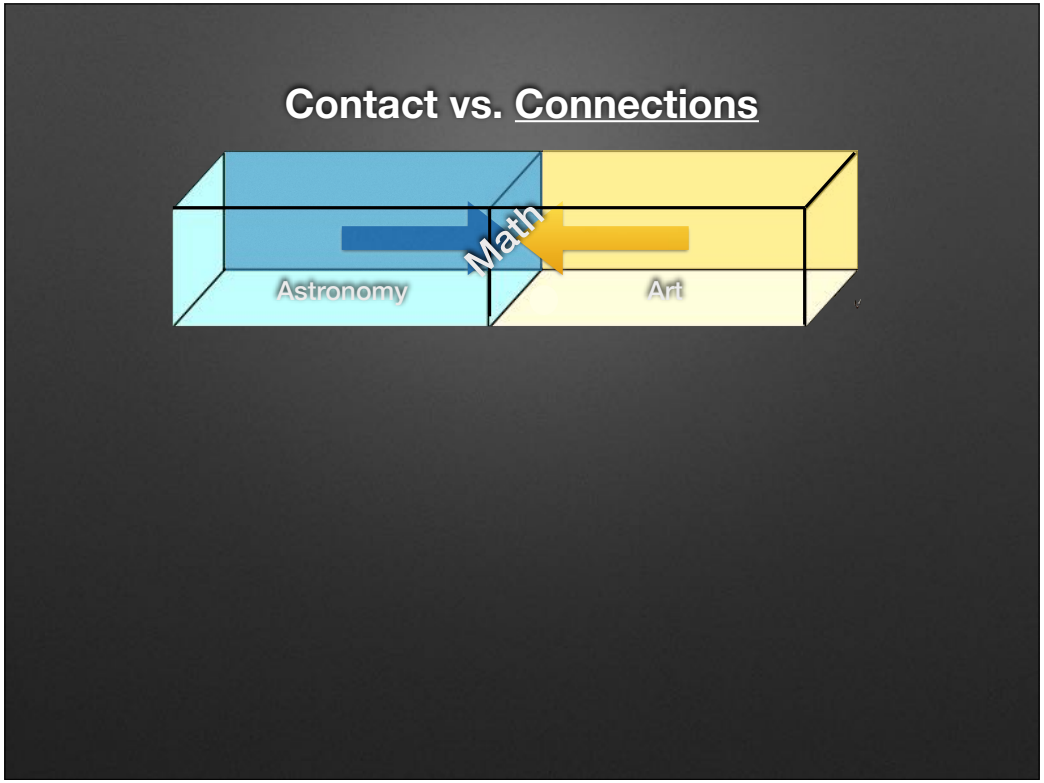
The shadows Galileo observed on the Moon revealed topographical relief. In the controlled conditions of their photographic laboratory, Nasmyth and Carpenter recreated the same effects in detail which Galileo had originally taught us to understand.



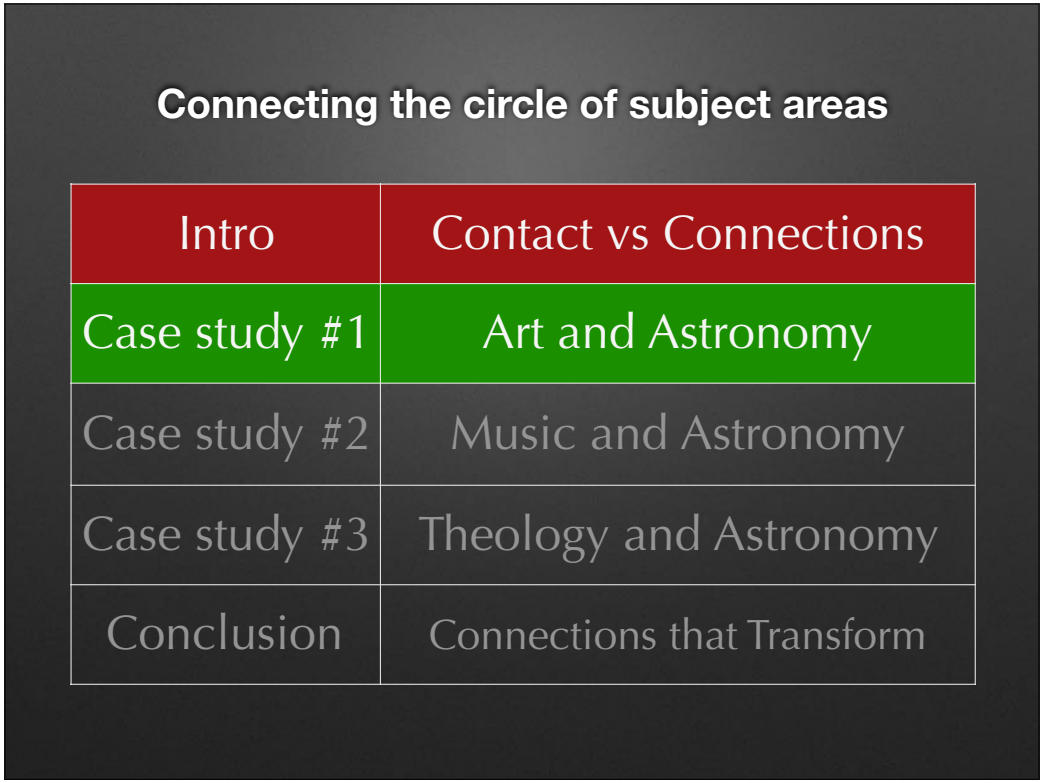
If Thomas Harriot, Nasmyth or Carpenter were to join your faculty here at JBU, do you think they would advise students from personal experience that those who are interested in • astronomy and art have reason to discover one another, and to explore how each has a perspective that can be meaningful to the other?



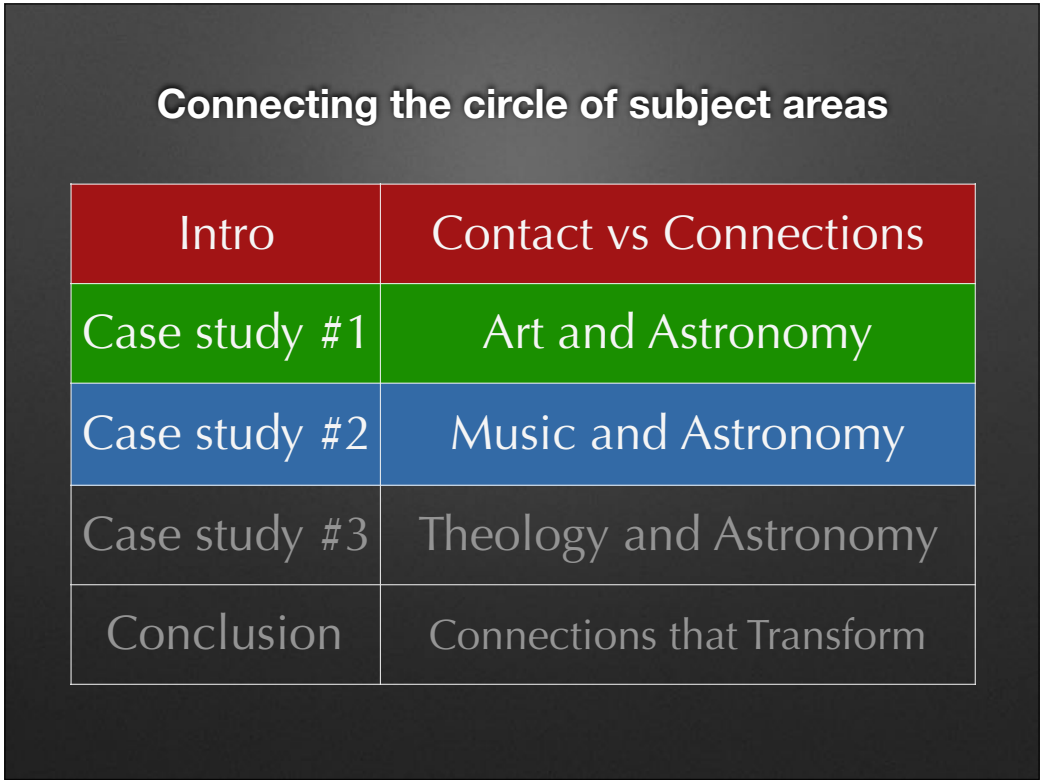
So with art and astronomy, is it a relation of contact or connection? Marbles or boxes? Hmm???



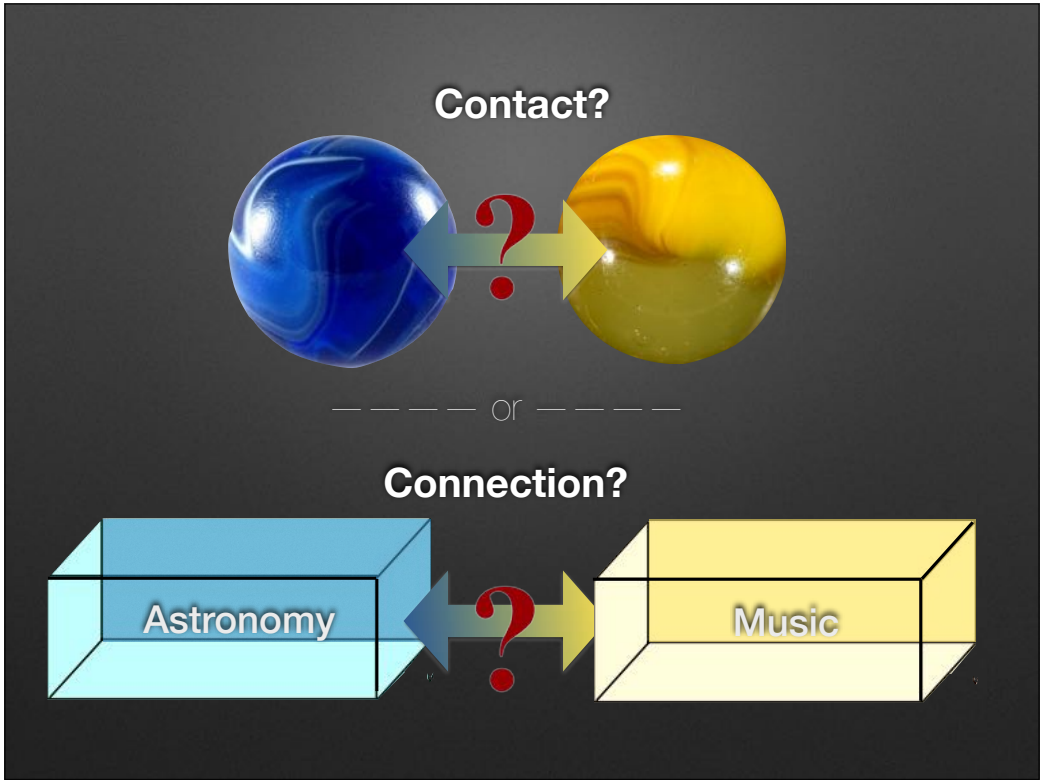
In Galileo's World, art and astronomy were connected by the mathematics of perspective drawing, which gave art and astronomy a large enough surface area for creative interplay. Perspective drawing belonged equally to both.



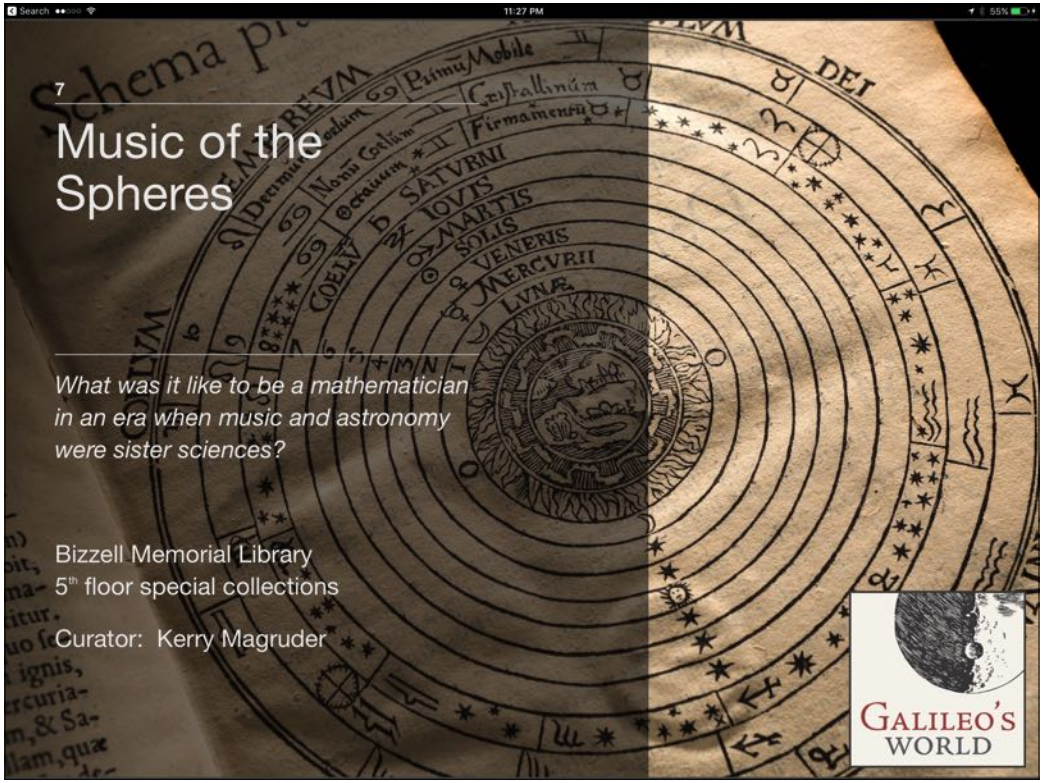
So we've seen that perspective drawing turned out to be just what was needed for Galileo to use his "perspective tube" to discover mountains on the Moon.



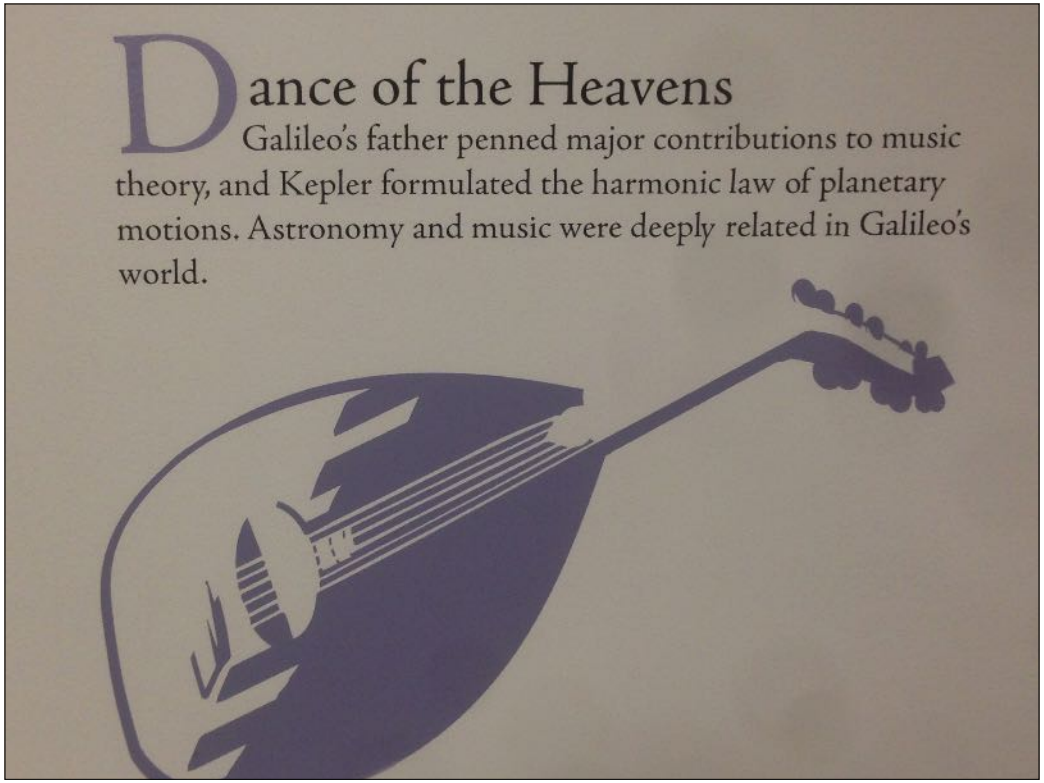
Now let's turn to our second case study, music and astronomy. How many of you are interested in music? Show of hands. How many believe music is connected to science in a meaningful way?



In Galileo's world, will we see music and astronomy merely in contact or more deeply connected? Colliding marbles, or boxes sharing a common surface?



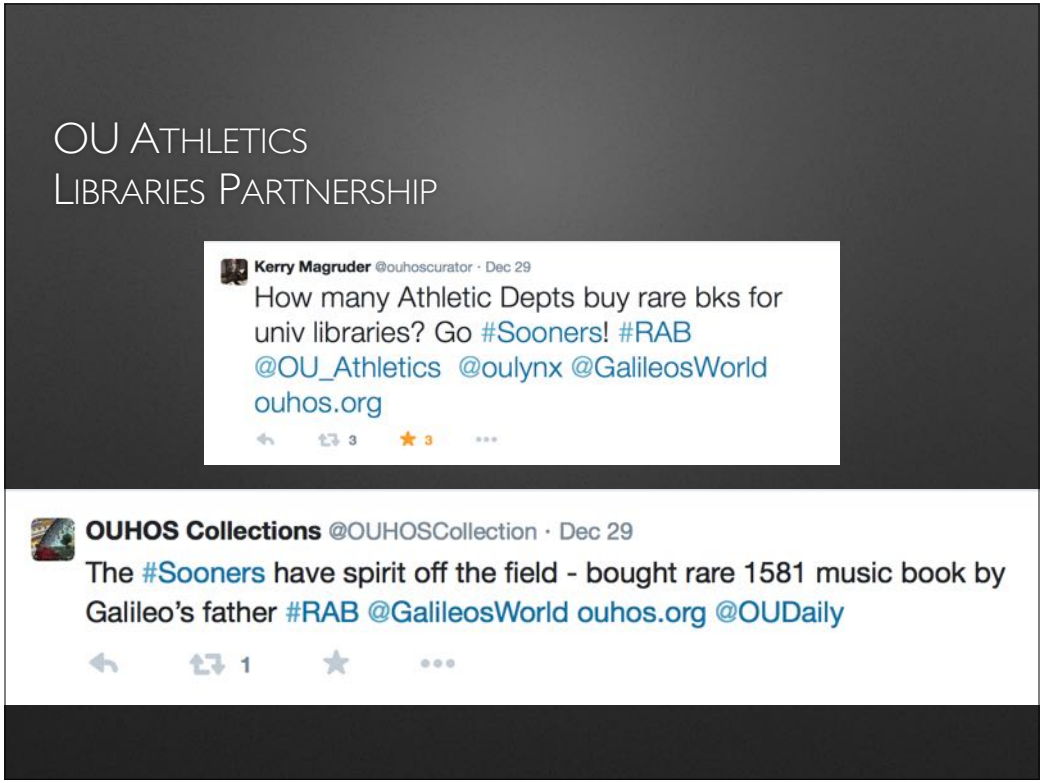
This screenshot from the iPad Exhibit Guide is for the Music of the Spheres gallery. The prompt for reflection is: What was it like to be a mathematician in an era when music and astronomy were sister sciences?



The first section in the Music of the Spheres gallery is Dance of the Heavens. A wall graphic reads: "Galileo's father penned major contributions to music theory, and Kepler formulated the harmonic law of planetary motions. Astronomy and music were deeply related in Galileo's world." Let's explore this a little more.

Vincenzo Galilei, *Dialogo* on Ancient and Modern Music (1581)

The first book encountered in this gallery is a book on music theory by Galileo's father. Galileo's father Vincenzo was a leading composer of music for the lute. This work profoundly influenced the birth of Italian opera. Galileo also played the lute, and gave public lectures on the acoustics of the lute. Galileo quoted his father's book in his later works.



By the way, during the Sooner's recent desperate bowl games, tweets like these may have been overlooked in Norman among the general despair, confusion and sorrow, but (read).

Out of the 350 original rare books on display, 3 were purchased with the assistance of the OU Athletics Department: a manuscript in 2012, Sirigatti in 2013, and Vincenzo Galilei in 2014.

So to thank the Sooners we created a gallery on sports: What would Coach Galileo say? If you remember their generosity, I hope you can root for the Sooners at least once next season. At least if they're not playing the Razorbacks. But back to music…

In Fall of 2015, OU Prof Gene Enrico presented a public lecture on: Vincenzo Galilei and the Birth of Italian Opera.

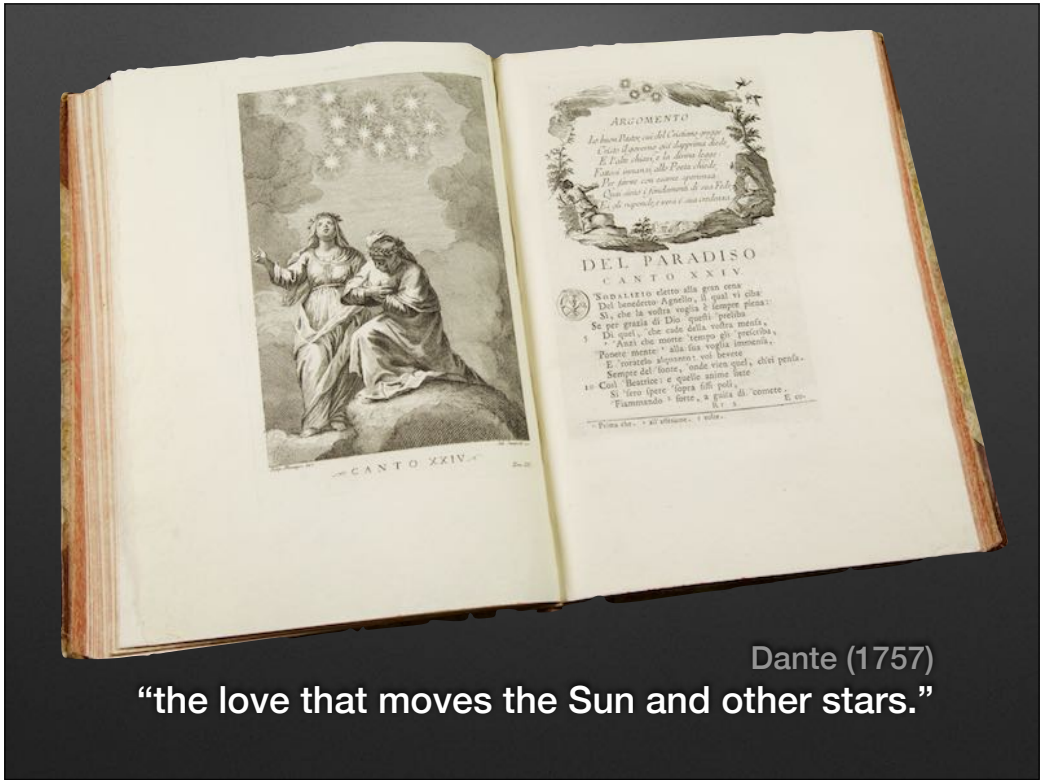
The following week, the School of Music presented an opera by Monteverdi. Monteverdi's opera, about Orpheus and the Harp, reflects Vincenzo's influence. The students who participated in this performance will remember Galileo's World decades from now not for the science, but for the music.

————-

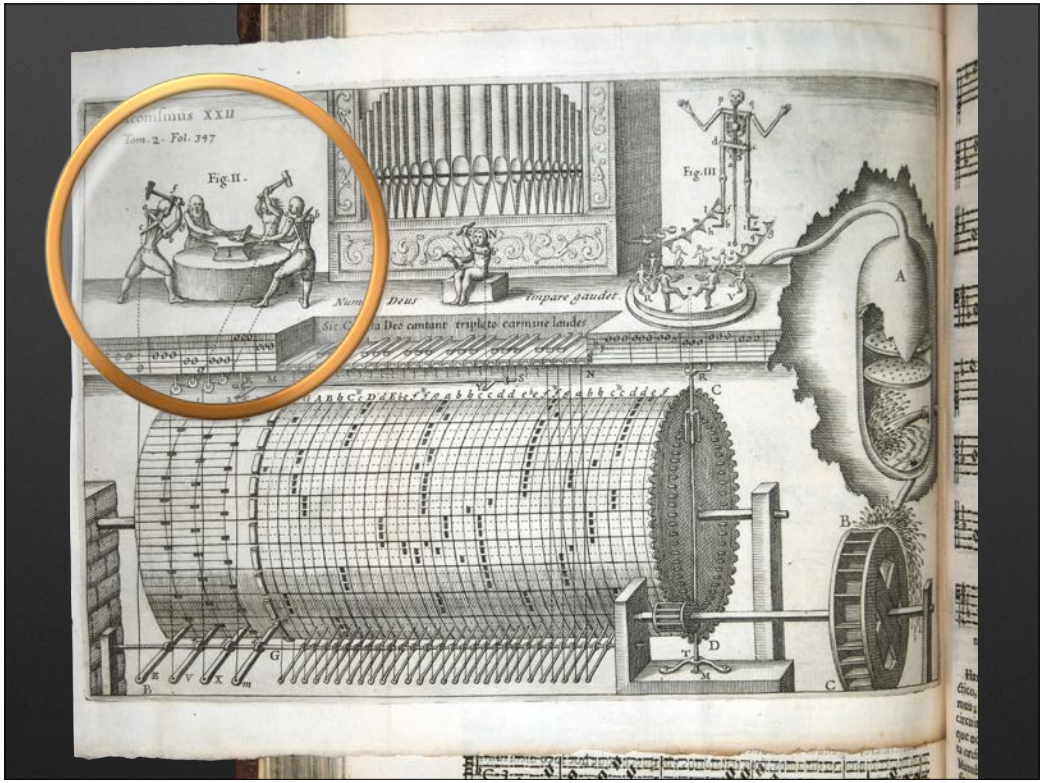
(Mathematics is not just for mathematicians. The history of science is not just for scientists, but embraces both music and astronomy together.)

This is our functioning replica of Galileo’s inclined plane in the New Physics gallery. When Galileo conducted his inclined plane experiments to demonstrate the law of free fall, he measured the times of the balls to • “within a 10th of a pulsebeat.” Can you measure time to the 10th of your pulsebeat? I cannot, but I’m not a musician. Galileo’s friends who were not musicians, were not able to successfully replicate the experiment. Even with a stopwatch it’s still difficult to replicate today! So Galileo’s science was made possible because of his experience in music even on the level of basic sensory perception.

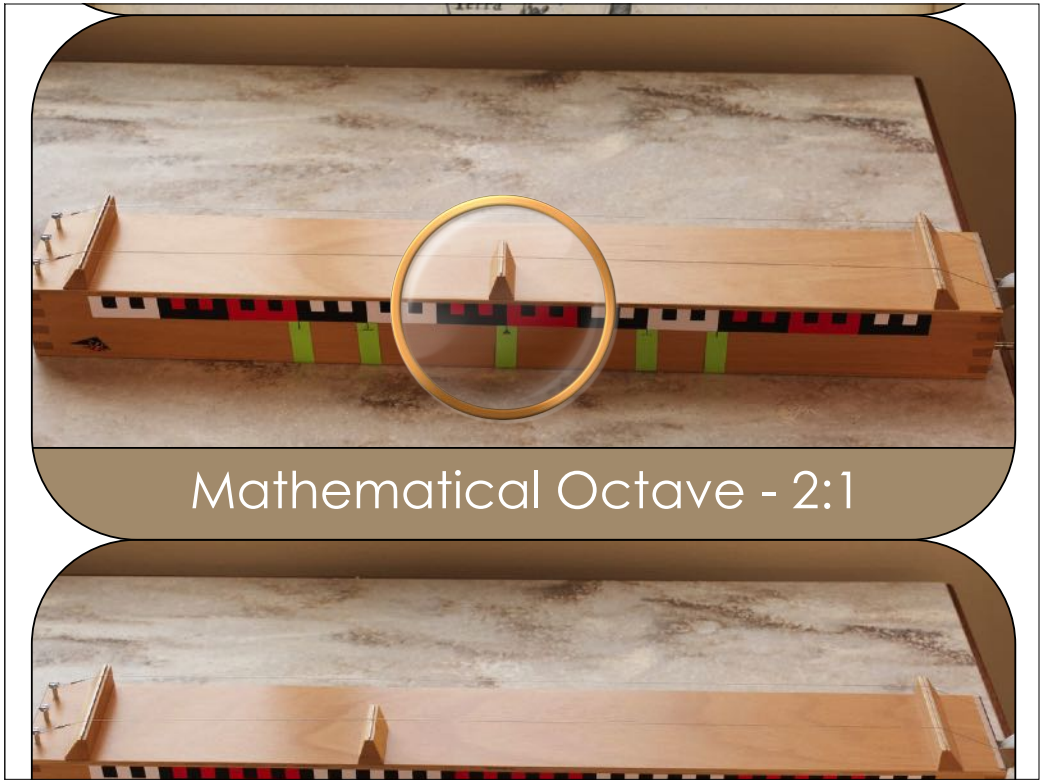
In the Music of the Spheres gallery, we explore the manifold relations between music and astronomy. This is the Nuremberg Chronicle, • showing the transparent, concentric celestial spheres that medieval and Renaissance writers believed turn in place, creating the music of the spheres.



The idea of the music of the spheres was pervasive, in science and literature and wider culture. This is the first edition of Dante’s collected works. The last line of the Divine Comedy concludes that the celestial spheres turn • by “the love that moves the sun and other stars.” Galileo gave lectures on Dante and could recite his poetry at length, by heart.

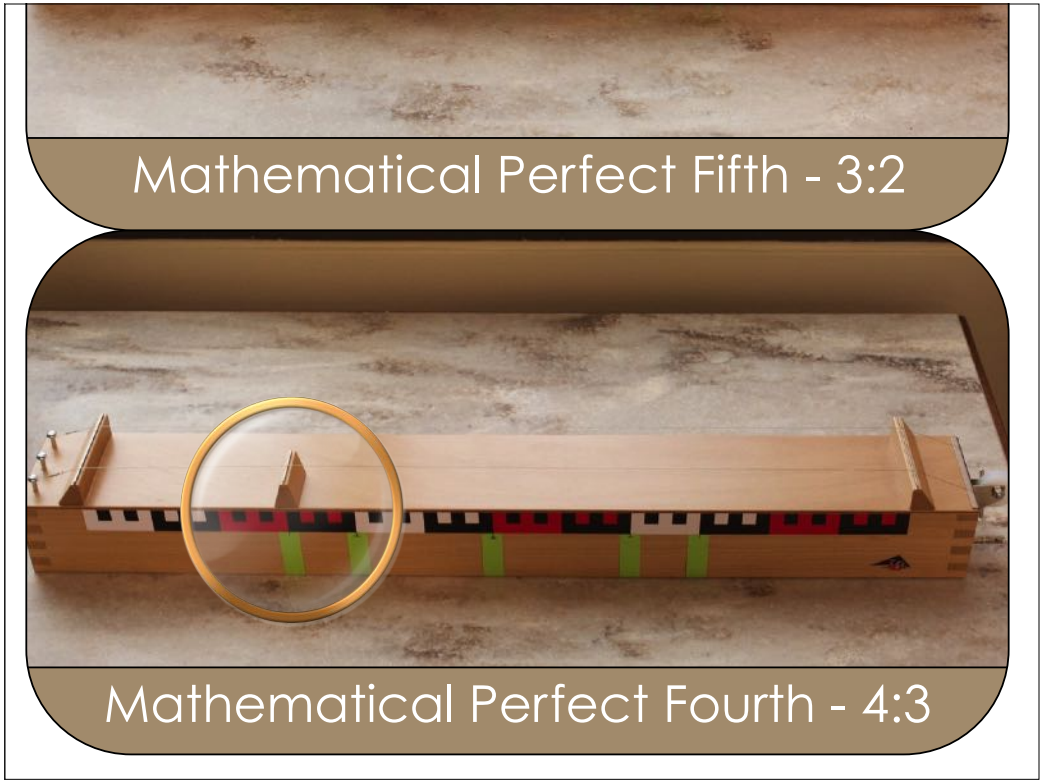


The idea that music and astronomy are somehow intrinsically related, that they are sister sciences, goes back to the ancient Pythagoreans. According to legend, after hearing blacksmiths at work, Pythagoras arrived at the idea that the musical scale consists of whole number ratios. For the ancient Pythagoreans, the universe is a musical scale. • This is a depiction of a water-driven organ from a work on music, published a generation after Galileo. In Galileo's world, every musical instrument is a sign in miniature of the mathematical harmony of nature.

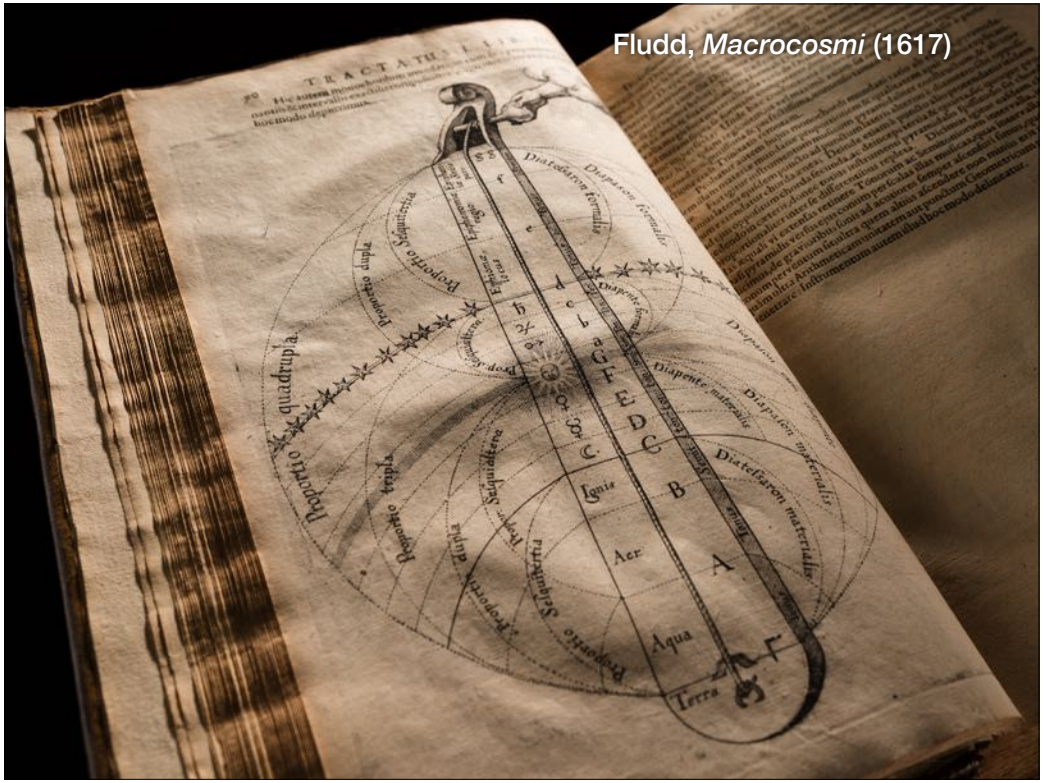


This is a two-string duochord. If a bridge divides the first string into two equal halves, then the long string and the half string are an octave apart.

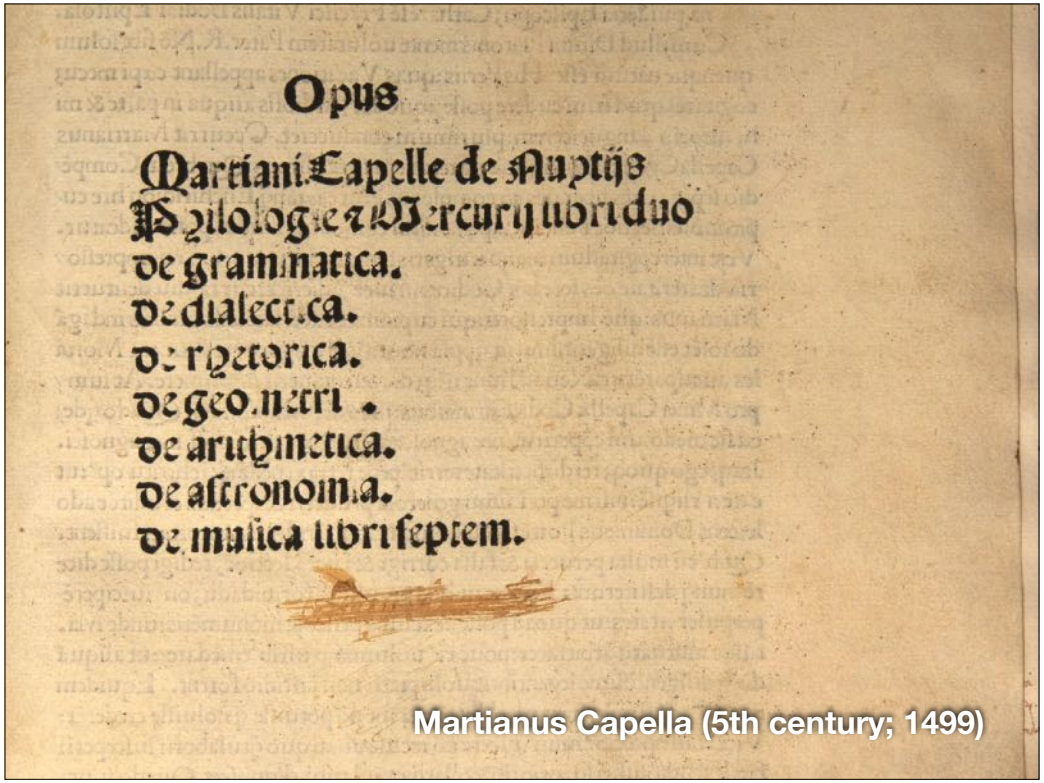
Divide the string into three equal segments, and the 2/3rds string and the original string produce the harmony called a perfect fifth.



Divide the string into four equal segments, and the 3/4ths string and the original string produce the harmony called a perfect fourth.

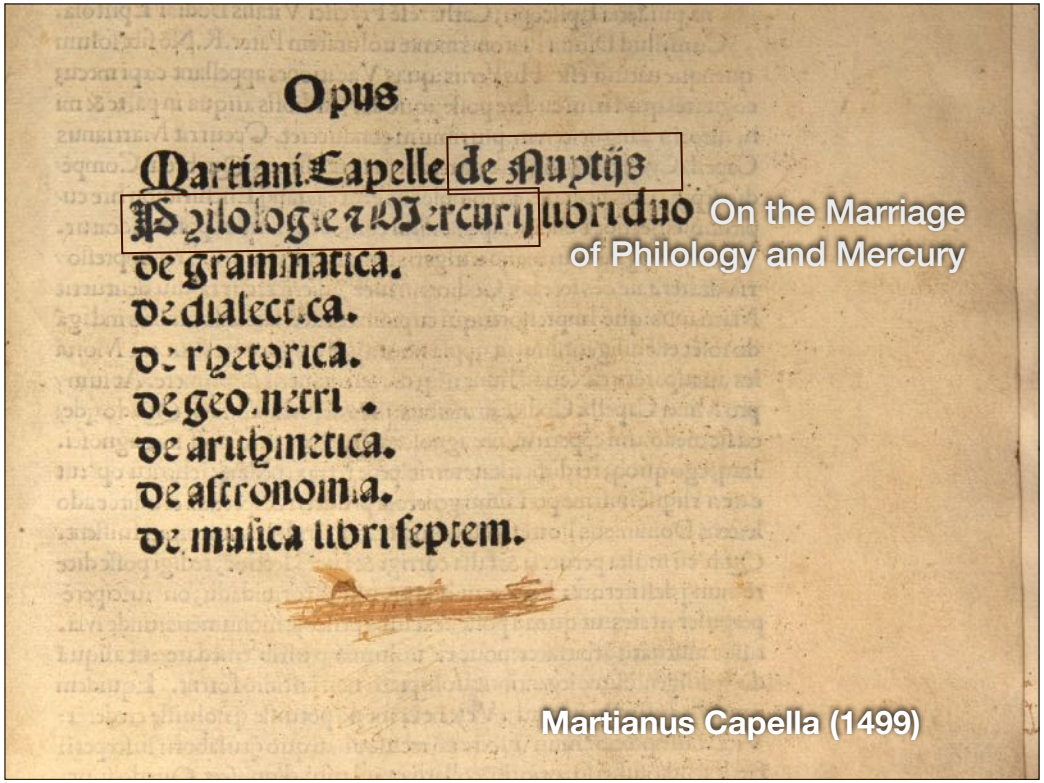


The link between astronomy and music was also pervasive in medicine. Robert Fludd was a London physician contemporary with Galileo. This page depicts the universe itself as a musical instrument, a monochord. The universe can only be understood through music. Likewise an understanding of medicine depends upon the physician's comprehension of both astronomy and music. At this point, is anyone surprised that Galileo received university training as a physician and moved in medical circles for most of his life? (The relations between astronomy, music and medicine would require another lecture!)

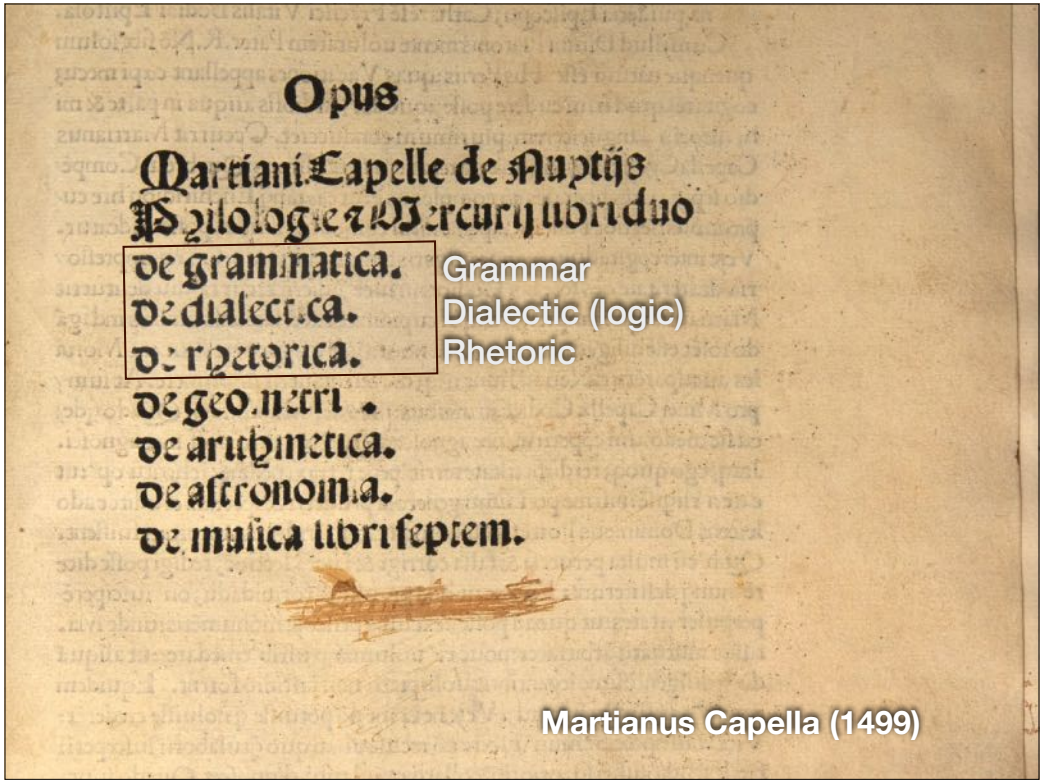


Martianus Capella (5th century; 1499)

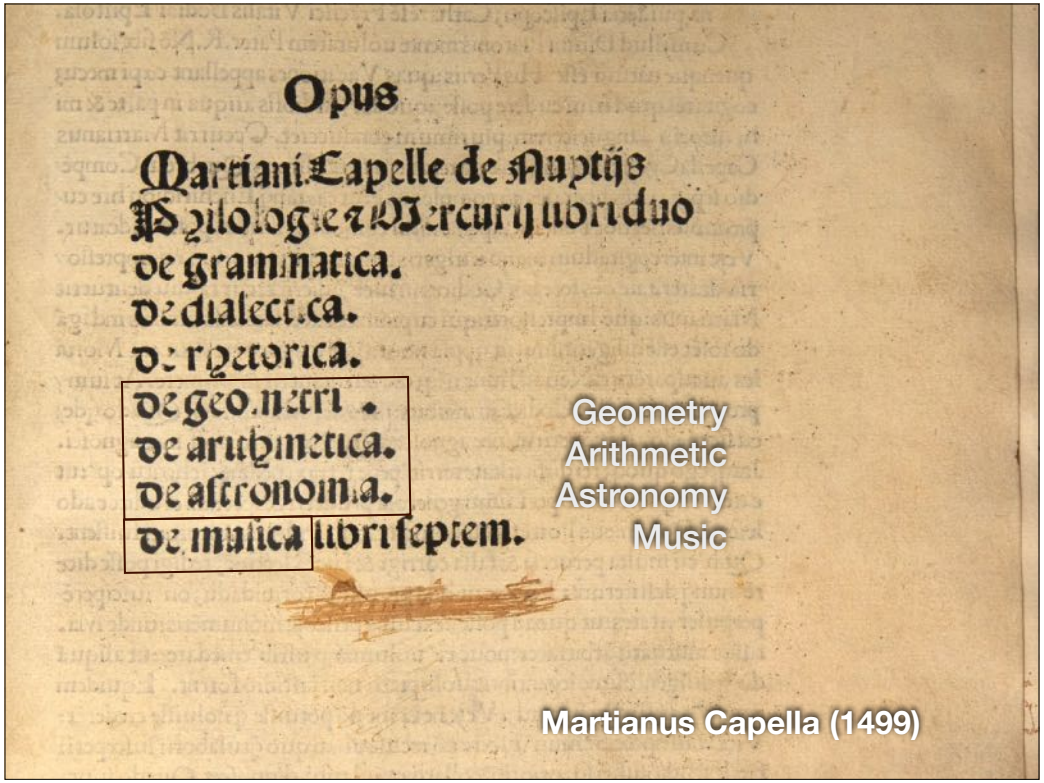
The linkage between astronomy and music established by the Pythagoreans became institutionalized in the liberal arts tradition. Let's go back to Martianus Capella, who lived in the Roman empire in the 5th century. In this book, Capella described the seven liberal arts, i.e., the education appropriate to a free citizen rather than a slave. In this book Capella also argued that Venus goes around the Sun instead of the Earth, a hypothesis Galileo would finally prove many centuries later.



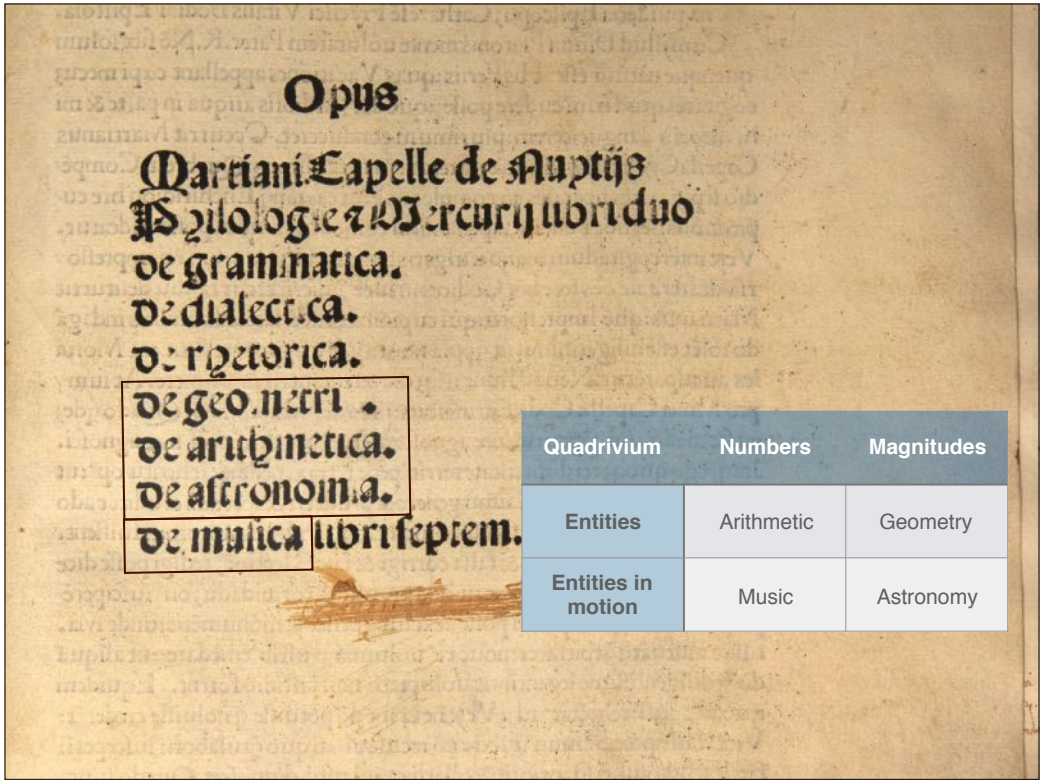
The strange title, The Marriage of Philology and Mercury, refers to a wedding of the most learned goddess and the swiftest god. C. S. Lewis described it as the joining of speech and insight, as if our thoughts and language were as agile as a little ball of mercury rolling around on a sheet of glass.



The first three liberal arts are grammar, how to write well; logic or dialectic, how to think well; and rhetoric, how to speak well. These three later became known as the trivium, and were the basis of study in grammar schools.

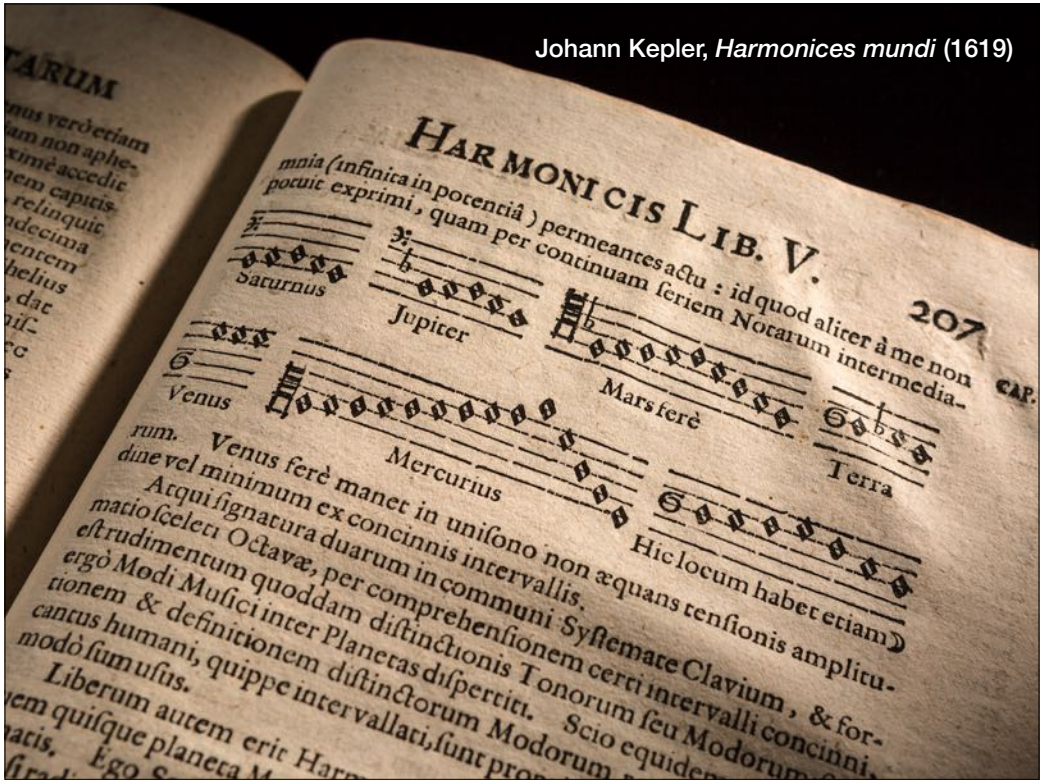


Next come the last four liberal arts, beginning with geometry, then arithmetic, astronomy, and music. Later known as the quadrivium, they were studied at the university level. These last four liberal arts are all mathematical sciences.



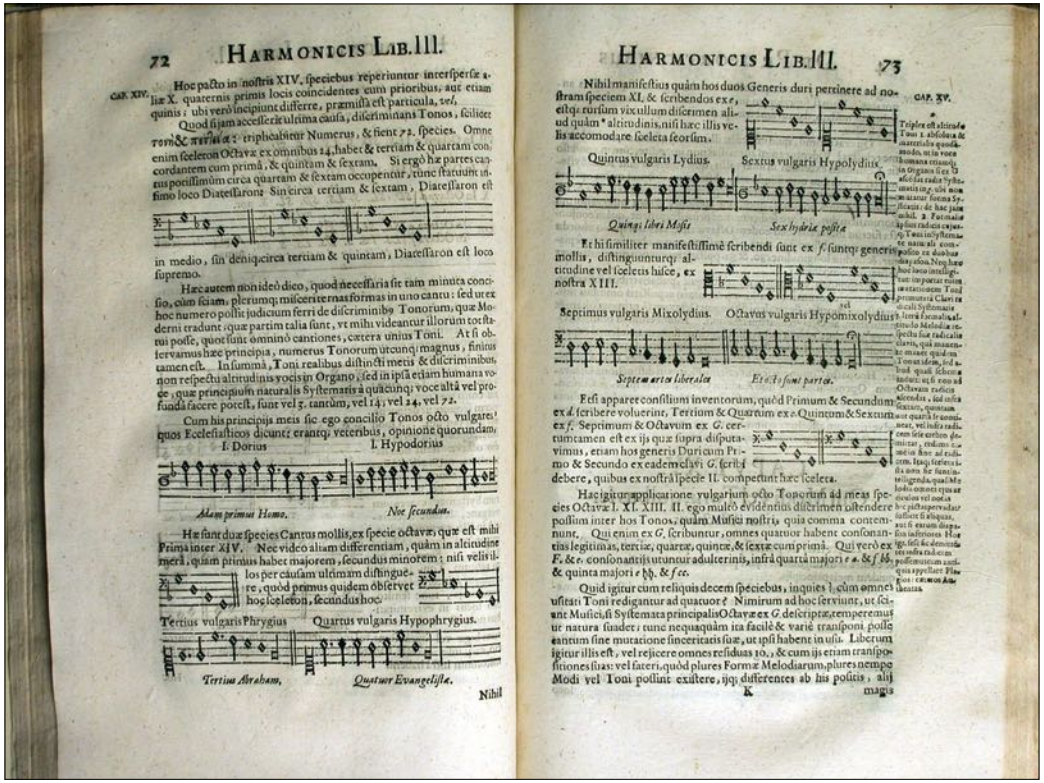
Quadrivium	Numbers	Magnitudes
Entities	Arithmetic	Geometry
Entities in motion	Music	Astronomy

Arithmetic • is the study of numbers; while geometry is the study of magnitudes, like lines and circles. • If numbers are put in motion, we then have music, a branch of arithmetic. If circles are put in motion, we then have astronomy, a branch of geometry. So music and astronomy, for the liberal arts tradition as for the ancient Pythagoreans, are sister sciences. This was not just metaphor, but understood as inherent in the nature of reality. So it also functioned as a heuristic, a way of thinking: a discovery in one area should lead to a corresponding or analogous discovery in the other area.



Johann Kepler, *Harmonices mundi* (1619)

The most astonishing example of music guiding astronomical inquiry in this liberal arts tradition may be Kepler's Harmony of the Universe, published in 1619. This book marks the first time all three of Kepler's laws of the motion of the heavens were presented together. But what is fascinating is that Kepler was thinking musically. He articulated the three laws in the form of musical notation. The liberal arts tradition of rich interdisciplinary between music and astronomy fostered a radical mental leap from a musical mode of thinking to astronomical discovery.



72 HARMONICIS LIB. III.

CAP. XIV. Hoc pacto in noſtris XIV. ſpeciebus reperiuntur interſperſæ aliæ X. quaternis primis locis coincidentes cum prioribus, atq; etiam quinis; ubi verò incipiunt differre, præmiſſa eſt particula, *vel*, ſcilicet τονικὴ διαφορὰ: tripheabitur Numerus, & fient 72. ſpecies. Omne enim ſceleton Octavæ ex omnibus 24 habet & tertiam & quartam concordantem cum primâ, & quintam & ſextam. Si ergò hæ partes cantus poſtiſſimùm circa quartam & ſextam occupentur, tunc ſtatuim infimo loco Diateſſaron: Sin circa tertiam & ſextam, Diateſſaron eſt

in medio, ſin denique circa tertiam & quintam, Diateſſaron eſt loco ſupremo.

Hæc autem non ideò dico, quod neceſſaria ſit tam minuta concioſio, cùm ſciam, plerumq; miſceri ternas formas in uno cantu: ſed ut ex hoc numero poſſit judicium ferri de diſcriminibo Tonorum, quæ Moderni tradunt; quæ partim talia ſunt, vt mihi videantur illorum toſtui poſſe, quoe ſunt omninò cantiones, cætera unius Toni. At ſi obſervamus hæc principia, numerus Tonorum utcunq; magnus, finitus tamen eſt. In ſummâ, Toni realibus diſtincti metis & diſcriminibus, non reſpectu altitudinis vocis in Organo, ſed in ipſâ etiam humana voce, quæ principium naturalis Syſtematis a quācunq; voce altâ vel profundâ facere poteſt, ſunt vel 3. tantùm, vel 14, vel 24, vel 72.

Cum his principiis meis ſic ego concilio Tonos octo vulgares! quos Eccleſiaſticos dicunt; erantq; veteribus, opinione quorundam,

I. Dorius I. Hypodorius

Adam primus Homo. *Noe ſecundus.*

Hæ ſunt duæ ſpecies Cantus mollis, ex ſpecie octavæ, quæ eſt mihi Prima inter XIV. Nec video aliam differentiam, quàm in altitudine meræ, quàm primus habet majorem, ſecundus minorem: niſi velis il-

los per cauſam ultimam diſtinguére, quòd primus quidem obſervet hoc ſceleton, ſecundus hoc.

Tertius vulgaris Phrygius Quartus vulgaris Hypophrygius.

Tertius Abraham. *Quatuor Evangeliſtæ.*

Nihil

HARMONICIS LIB. III. 73

CAP. XV.

Nihil manifeſtius quàm hos duos Generis duri pertinere ad noſtram ſpeciem XI. & ſcribendos ex *e*, eſtq; rurſum vix ullum diſcrimen aliud quàm * altitudinis, niſi hæc illis veſtis accomodare ſceleta ſeorſum.

Tripleti eſt altitudo Toni 1. abſoluta & mutabilis quodammodo, ut in voce humana etiamſi in Organo ſies ab eo ſat radix Syſtematis tuæ, ubi non mutatur forma Syſtematis: de hac jam ubi. 2. Formalia ipſa ſunt radicia cujuſq; Toni in Syſtemate nam ali compoſito ex duobus ubi dicam. Vtrq; hæc hoc loco intelligetur importare totam variationem Toni primarii a Claris radicali Syſtematis

Quintus vulgaris Lydius. Sextus vulgaris Hypolydius

Quinq; libri Moſis *Sex lydiæ poſitæ*

Et hi ſimiliter manifeſtiſſimè ſcribendi ſunt ex *f* ſuntq; generis mollis, diſtinguuntur q; altitudine vel ſceleris hiſce, ex noſtra XIII.

Septimus vulgaris Mixolydius. Octavus vulgaris Hypomixolydius

Septem artes liberales *Et octo ſunt partes.*

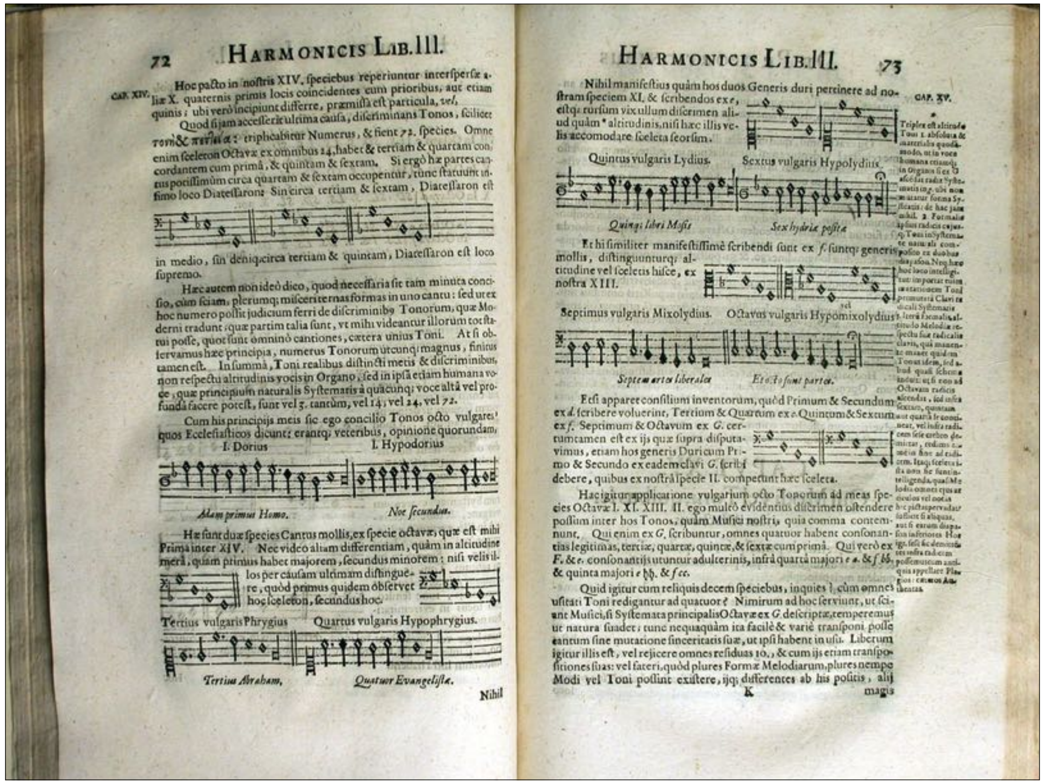
Eſt apparet conſilium inventorum, quòd Primum & Secundum ex *d* ſcribere voluerint, Tertium & Quartum ex *e*, Quintum & Sextum ex *f*, Septimum & Octavum ex *G*. certumtamen eſt ex ijs quæ ſupra diſputavimus, etiam hos generis Duricum Primo & Secundo ex eadem clave *G.* ſcribi debere, quibus ex noſtrâ ſpecie II. competunt hæc ſceleta.

Hac igitur applicatione vulgarium octo Tonorum ad meas ſpecies Octavæ I. XI. XIII. II. ego multò evidentius diſcrimen oſtendere poſſum inter hos Tonos, quàm Muſici noſtri, quia comma contemnunt. Qui enim ex *G.* ſcribuntur, omnes quatuor habent conſonantias legitimas, tertiæ, quartæ, quintæ, & ſextæ cum primâ. Qui verò ex *F. & e.* conſonantijs utuntur adulterinis, infrà quartâ majori *e a.* & *f bb.* & quinta majori *e bb.* & *f cc.*

Quid igitur cum reliquis decem ſpeciebus, inquies? cùm omnes uſitati Toni redigantur ad quatuor? Nimirum ad hoc ſervient, ut ſciant Muſici, ſi Syſtemata principalis Octavæ ex *G* deſcripta, temperemus ut natura ſuader; tunc nequaquàm ita facilè & variè tranſponi poſſe cantium ſine mutatione ſinceritatis ſuæ, ut ipſi habent in uſu. Liberum igitur illis eſt, vel rejicere omnes reliquas 10., & cum ijs etiam tranſpoſitiones ſuas: vel fateri, quòd plures Formæ Melodiarum, plures nempe Modi vel Toni poſſint exiſtere, ijq; differentes ab his poſitis, alij

K magis

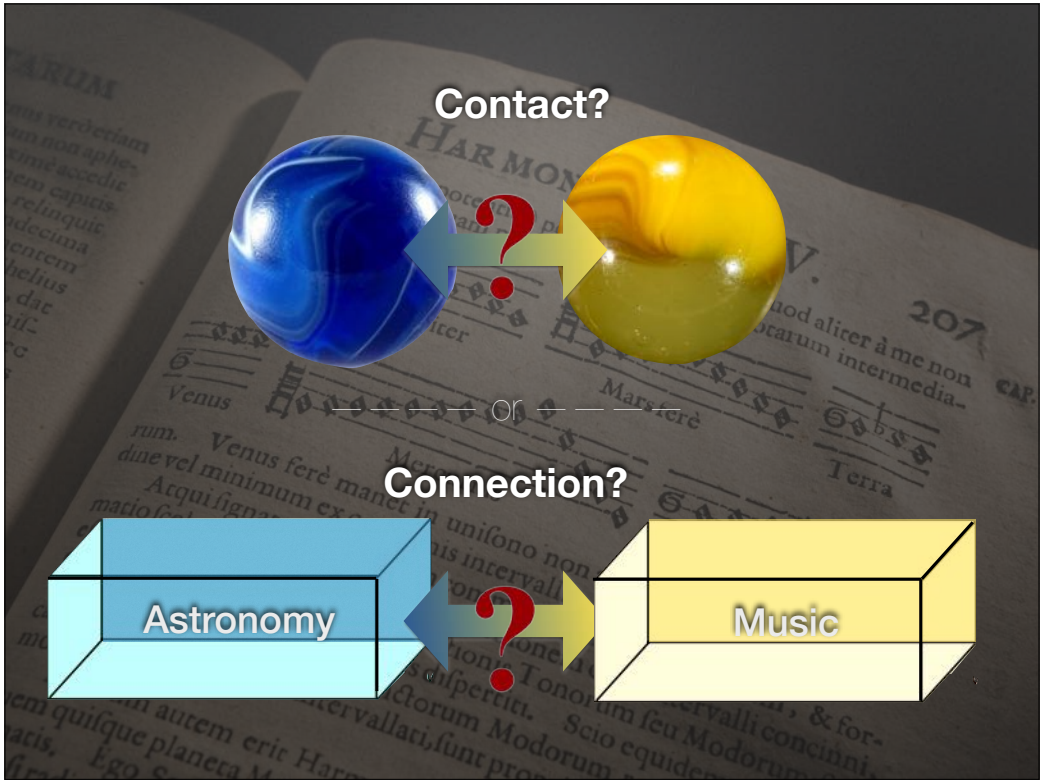
Kepler achieved a synthesis of his new astronomy with recent polyphonic musical theory. Citing Vincenzo Galilei, among others, Kepler demonstrated that the motions of the planets consisted of precisely the same harmonic ratios as the latest tuning of musical scales. The beauty of music provided the context of discovery for what we call Kepler's "third law."



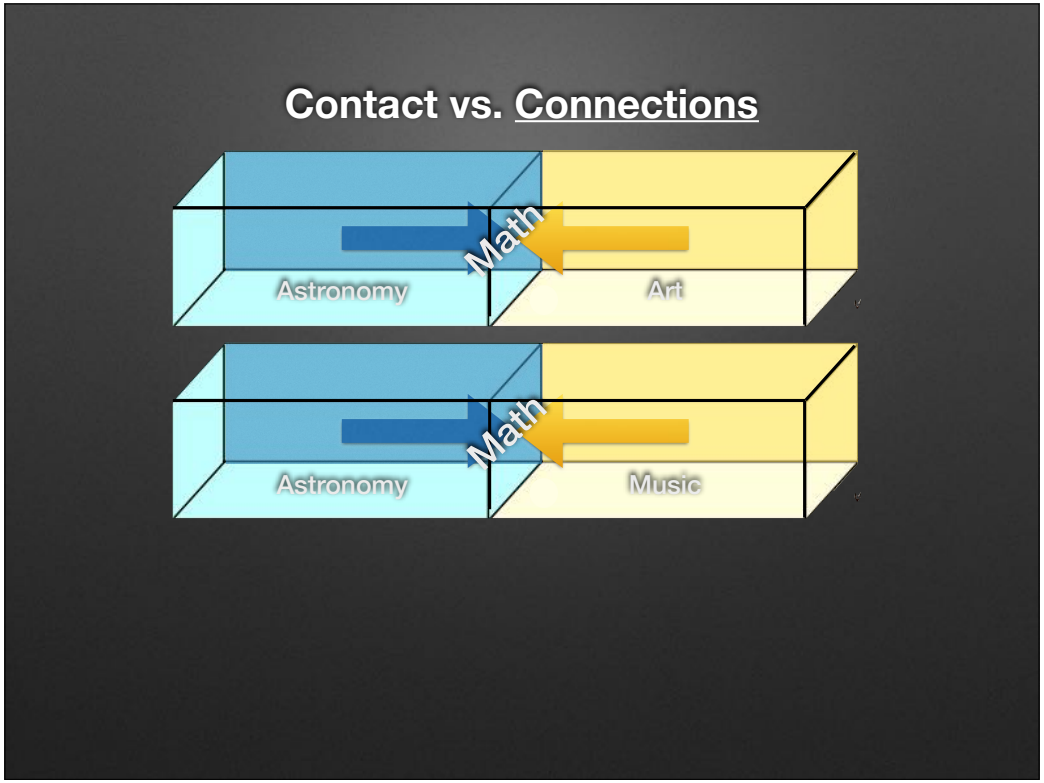
Jonathan Annis, an OU graduate student in music composition, has composed a suite for harp, flute and oboe entirely based upon musical themes from Kepler's book. Jonathan arranged the themes, but they're all from Kepler's musical description of the universe as a cosmic dance. •[listen]

We hope to perform the entire suite sometime this year, and make a recording available as an open educational resource. Jonathan is creating a score of his arrangement annotated so that musicians and astronomers alike can understand how Kepler was thinking.

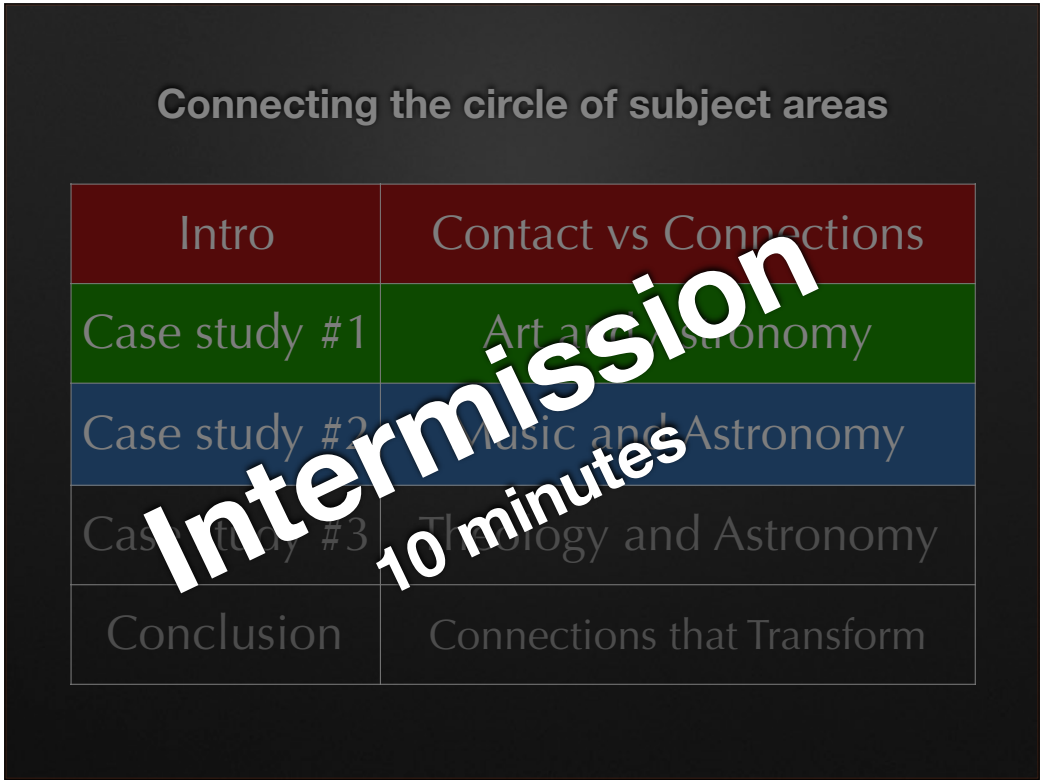
So Kepler's musical mode of thinking led him to formulate his harmonic law. • That harmonic law still governs the motions of planets, stars and galaxies. Does this kind of interdisciplinarity, or connections between subject areas at a profound, creative level, count as ….



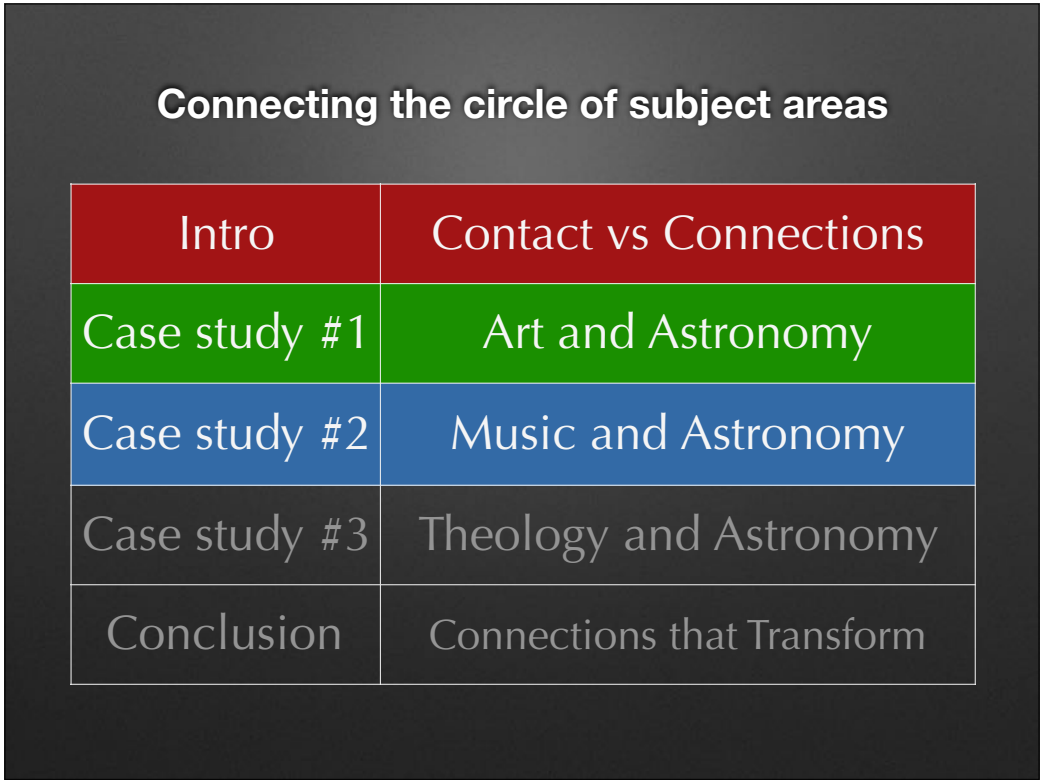
contact? Or connection?



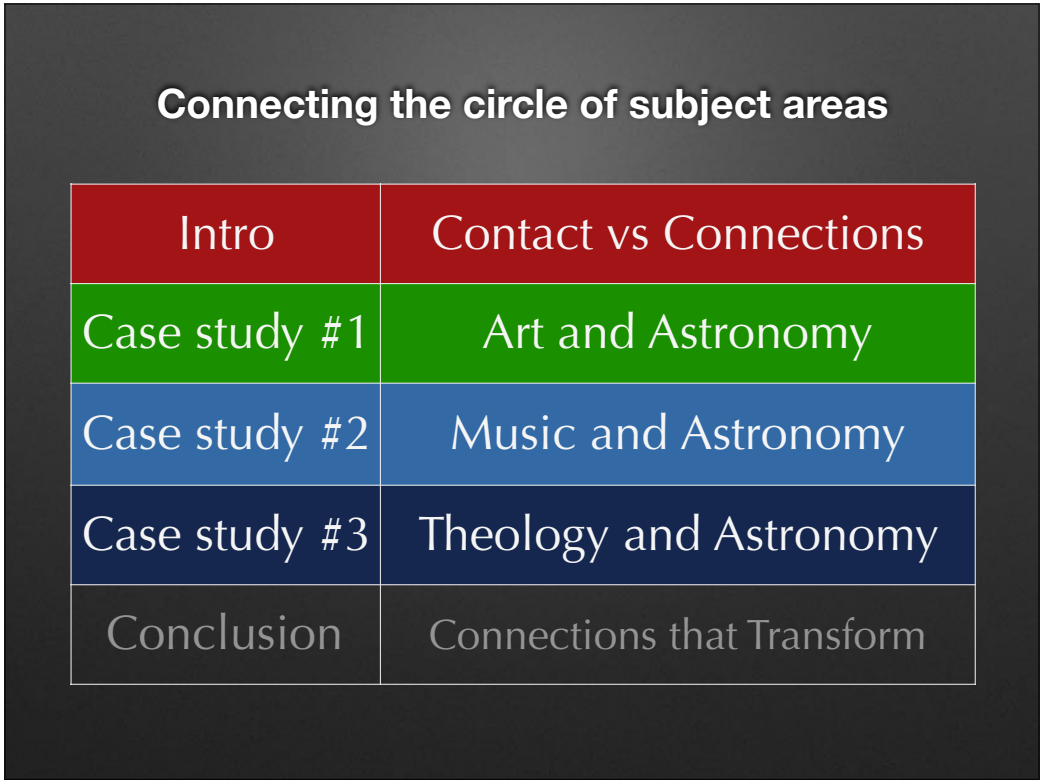
So as with the first case study, in Galileo's World astronomy and music were connected by mathematics. Boxes, rather than marbles.



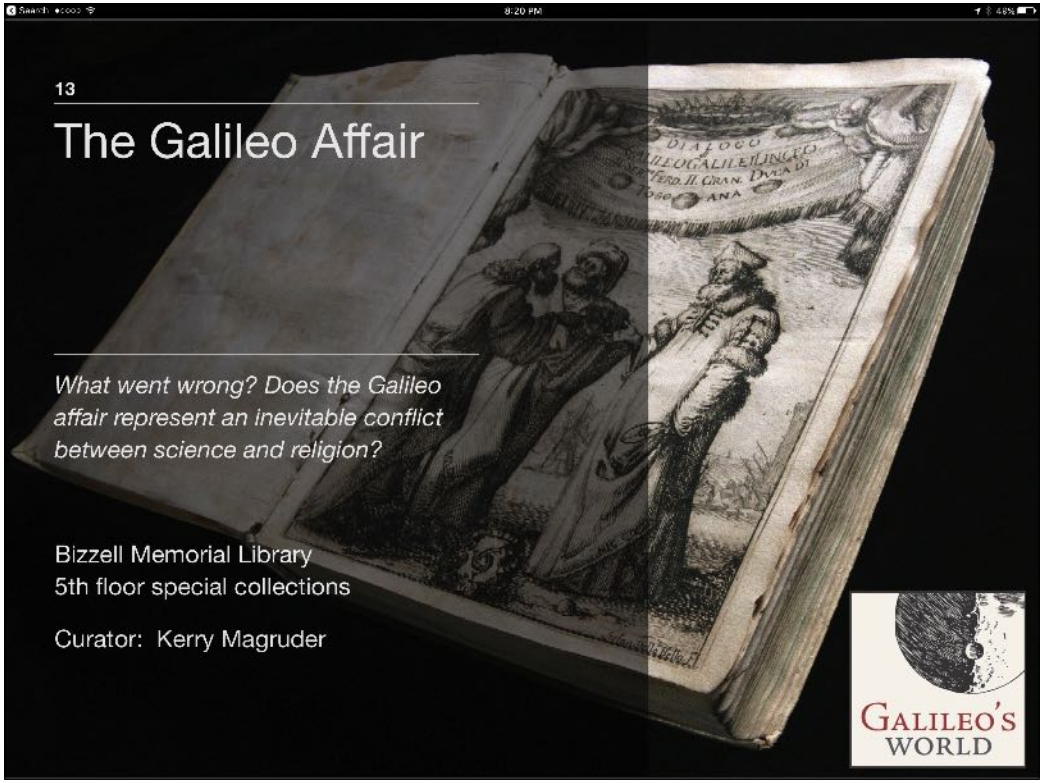
Let's take an intermission. We'll come back at [insert time] for the final case study, astronomy and theology, and some concluding reflections.



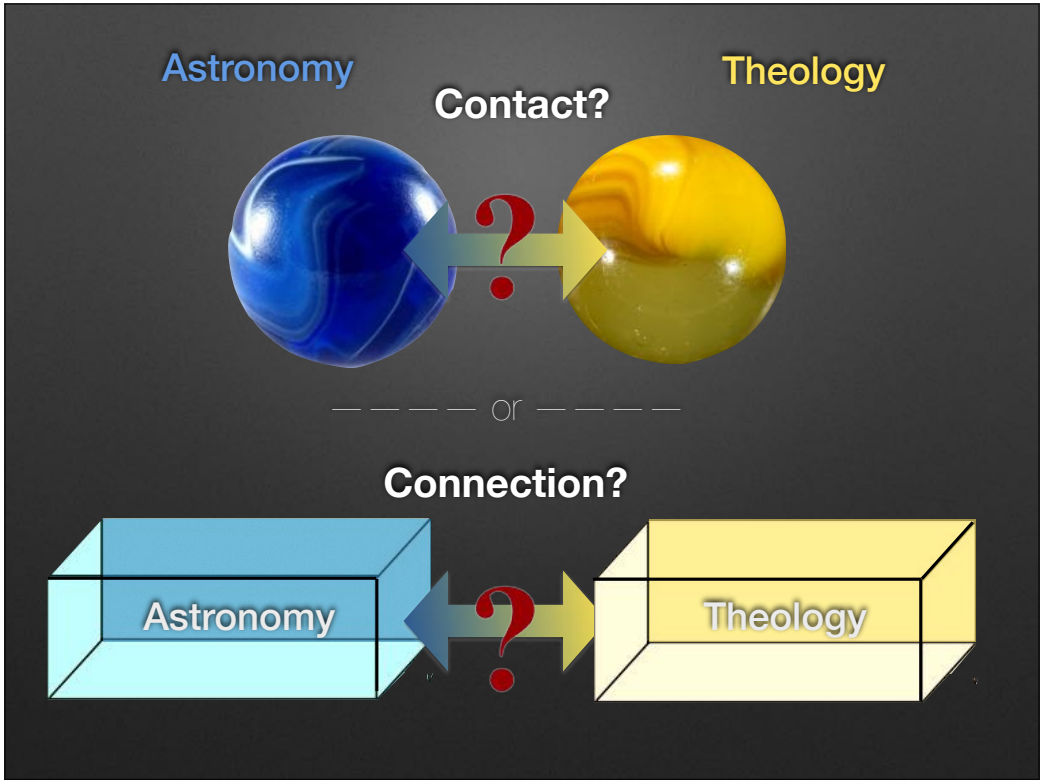
From Music and Astronomy, let's move on to…



Case Study #3: Theology and astronomy. How many of you are interested in theology? Show of hands. How many believe theology to be connected to science in a meaningful way?



One of the 20 galleries of Galileo's World, called The Galileo Affair, is devoted to science and religion. The reflection prompt is: What went wrong? Does the Galileo Affair represent an *inevitable* conflict between science and religion?



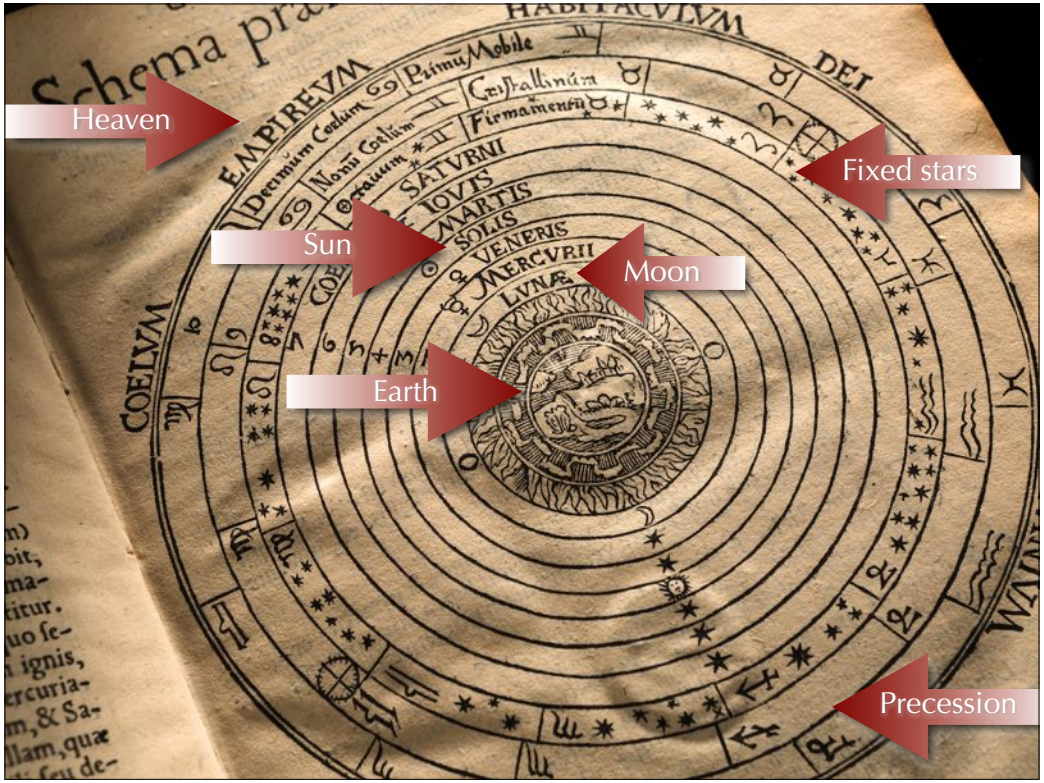
In Galileo's World, will we find astronomy and theology colliding like marbles, or connecting through common surfaces natural to each discipline? The answer is mixed. Let's look at examples of both.

The first section of The Galileo Affair • explores the relations between the Bible and science, which collided in the case of Galileo, but needlessly so. • Tonight, we'll also take a look at methodologies, since a fundamental misunderstanding of disciplinary methodologies lay at the heart of the conflict. • And thirdly, we'll look at the principle of contingency, that nature might be other than it is, where in the midst of the Galileo Affair there was an unrealized promise for a deeper and natural connection between astronomy and theology.

So, first, the Bible and science.

Let’s imagine ourselves in the position of theologians in Galileo’s world: we have received their education and know only what they knew about the world. Peter Apian's Cosmographia shows the map of the universe that educated people took for granted.

A central spherical Earth, ❒ is surrounded by the Moon embedded within a solid sphere carrying it around the Earth once a month. Why does the same side of the Moon always face the Earth? This solid sphere explains why. ❒ Another solid sphere contains the fixed stars, and rotates around the Earth once each day. Why do the stars appear fixed in constellations? This solid sphere explains why. If the idea of spheres so easily explains the appearances of the Moon and stars, why not use them to explain the other planets? …

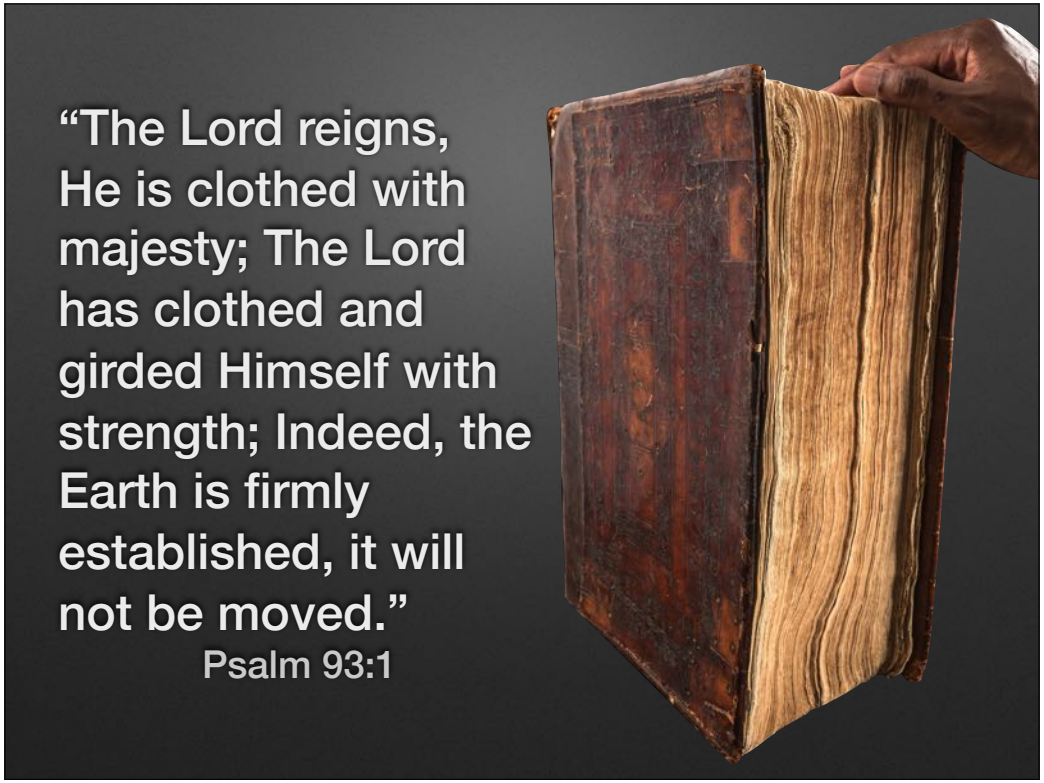


including the Sun? The relative motions of these giant solid turning spheres expressed mathematical harmonies, the music of the spheres. ❒ Extra spheres were added as needed for long-term periodical phenomena such as precession. • Finally, beyond the outermost sphere lies the empyrean heaven, or habitation of God and all of the saints. The Earth-centered Aristotelian cosmos was built on common sense: natural motions of the elements, the observed movements of the stars and Sun, the face of the Moon.

Copernicus, *De revolutionibus* (1543)

In contrast, the Sun-centered system proposed by Nicholas Copernicus in 1543 seems to fly in the face of common sense. We are hurtling at thousands of miles per hour through the heavens, yet we can't feel any wind or observe any effects of that motion? Surely this theory of Copernicus must be merely a hypothetical convenience for making calculations; surely it's not to be taken seriously as a statement about physical reality!

Besides, the Earth-centered cosmology bears a striking congruence with theology: we can see that heaven is literally high overhead, above us and incorruptible. We pass our earthly lives within the small sphere of mortality, a region of death and corruption. Hell lies down here with us below, within the Earth. So it's easy for us to prefer the Earth-centered view, considering our standpoint from a traditional theological education.

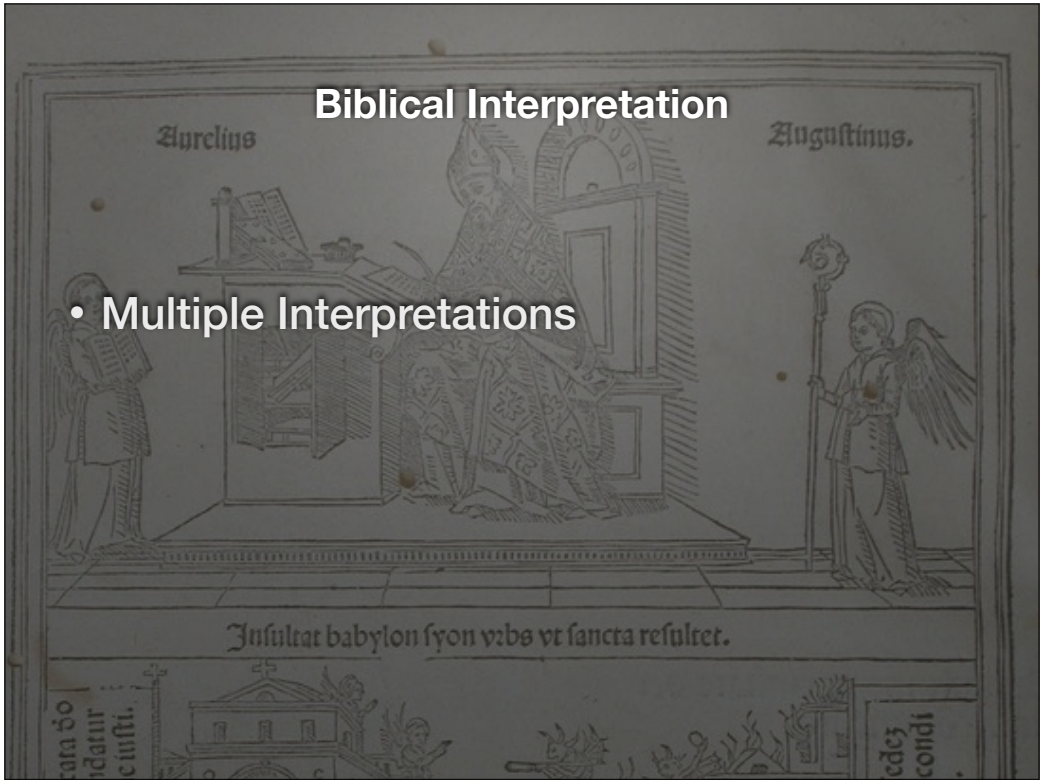


Now we come to scripture verses like this one. (read) Given our education, would we be likely to read verses like this as providing a biblical warrant to prefer the Earth-centered view, against Copernicus who said the Earth is in fact in motion?

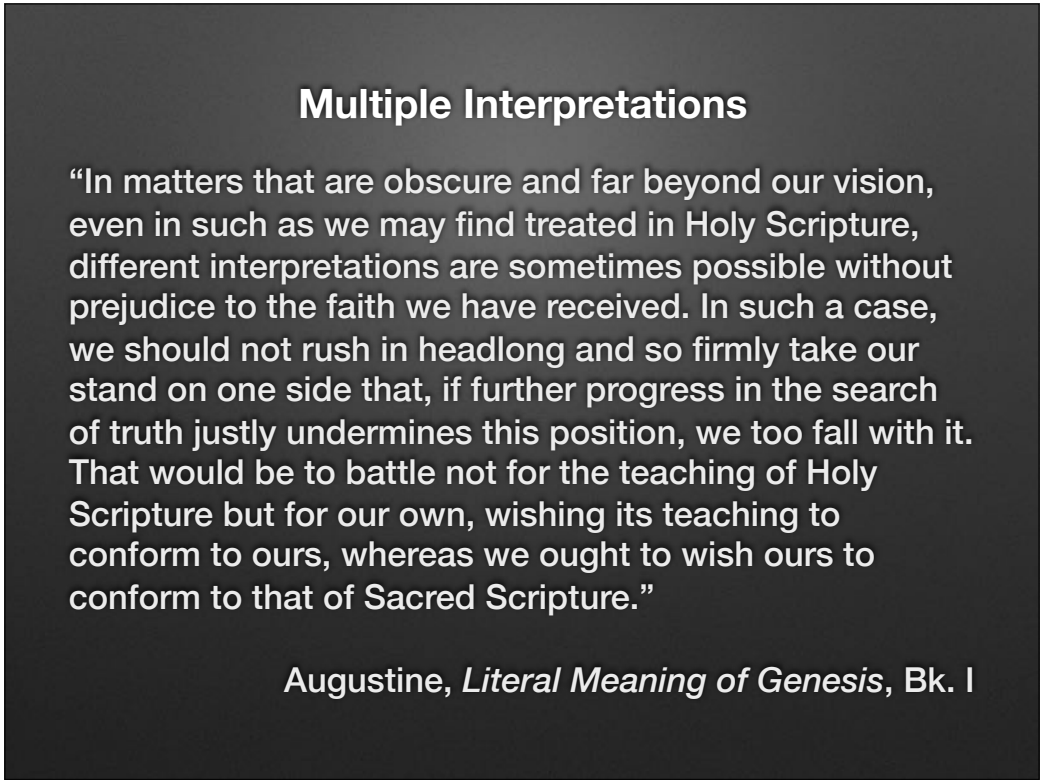
Scripture verses like this one provided a flash point, but the real obstacle to the new science was the profound synthesis of science and traditional interpretation. Scripture had long been interpreted in light of the Earth-centered scientific cosmology. Most people were unable to consider the interpretation of the Bible apart from tradition.

Augustine, *De civitate Dei* (Venice, 1489)

For help, they might have turned to Augustine, who articulated several principles to guide the interpretation of the Bible with respect to natural science.



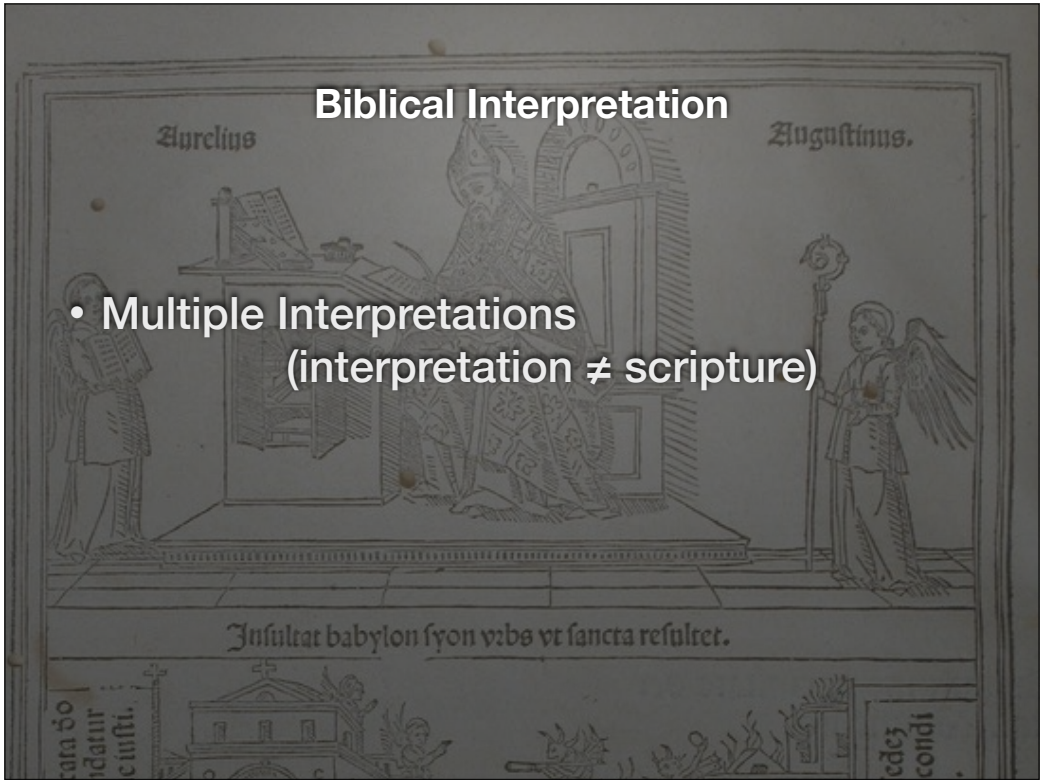
Augustine's first principle is Multiple Interpretations. This means that references to nature in the Bible should not be read as confirming any single scientific explanation.



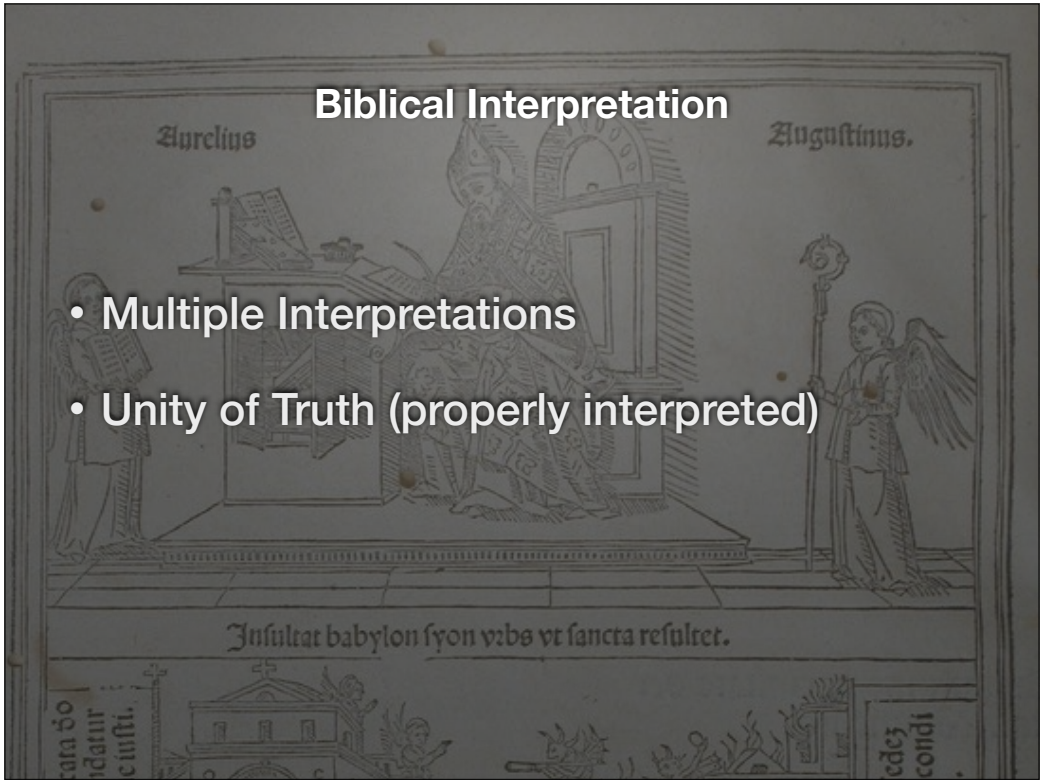
For example, Augustine wrote: (read).

———————

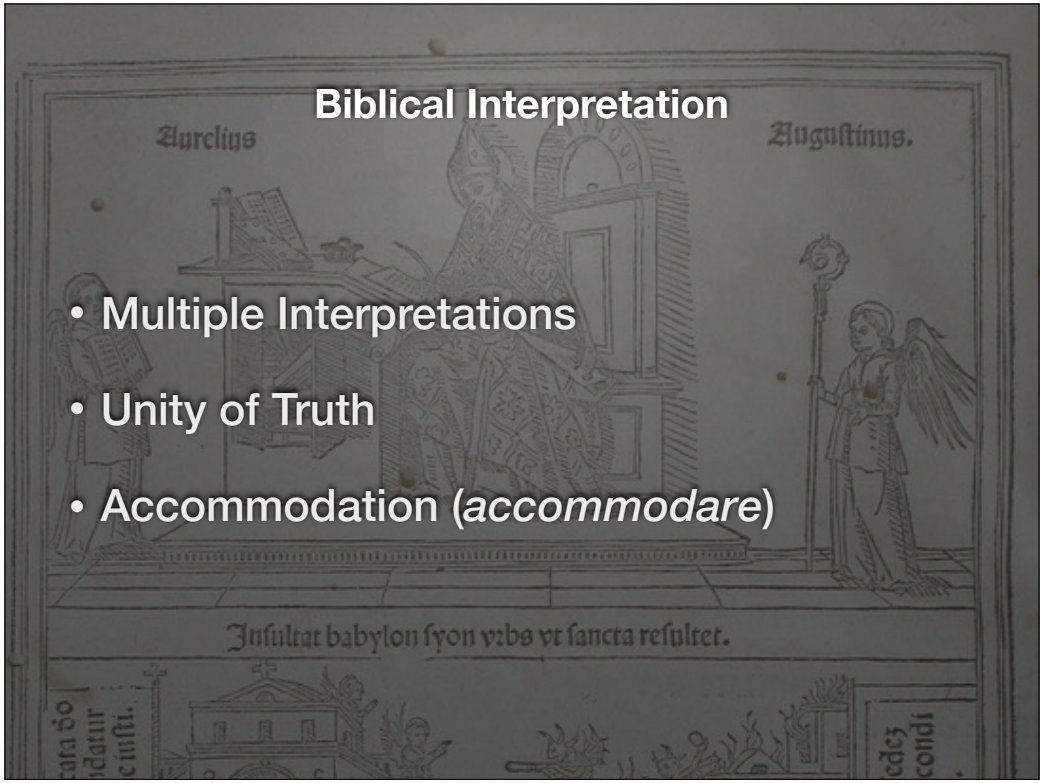
Augustine, Literal Meaning of Genesis, Bk. I, ch. 18; 1:41; cf. Bk. I, ch. 19; 1:41 42.



The principle of multiple interpretations means that in applying the Bible to scientific matters, we must be careful to always distinguish our interpretations of scripture from the authority of scripture itself.



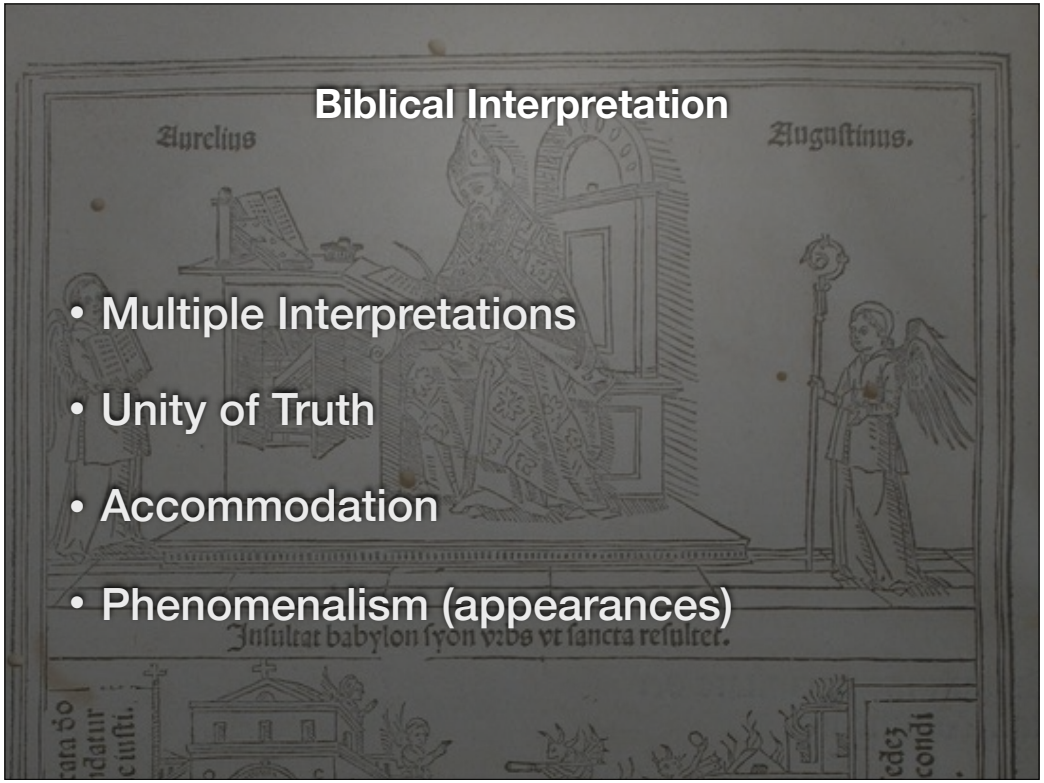
Second is unity of truth. Unity of truth means that properly interpreted, science and scripture will not conflict.



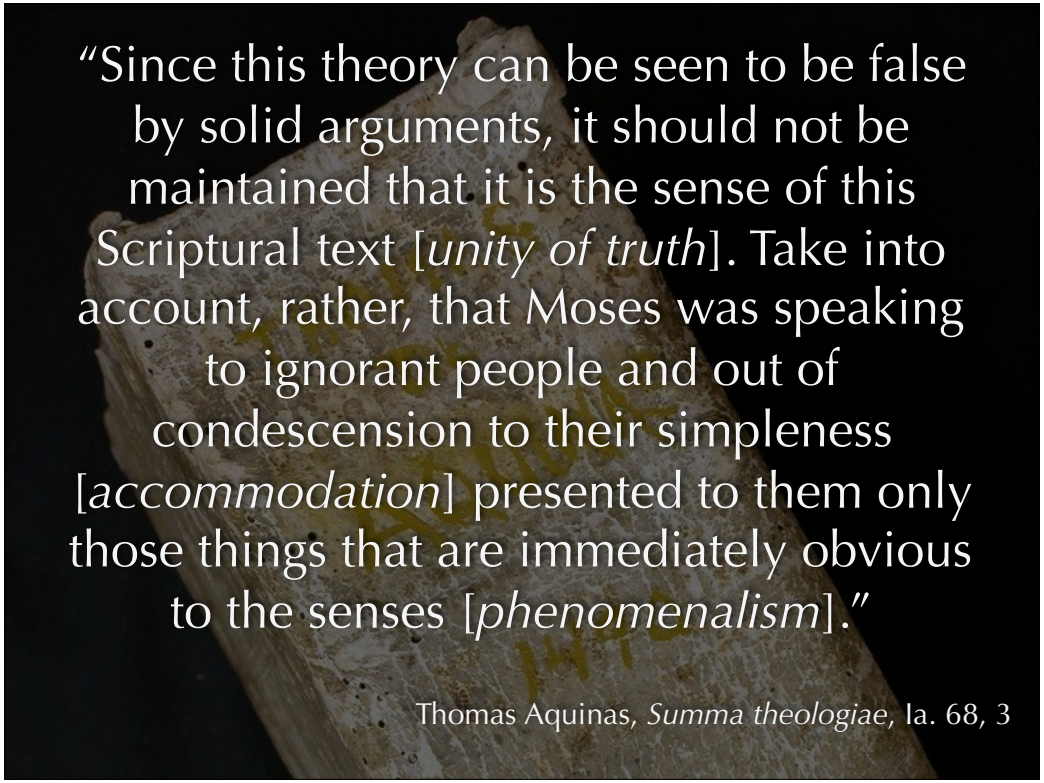
Third is Accommodation. In Cicero and ancient rhetorical manuals, “accommodare” meant to adapt one’s language to be better understood by an intended audience for a specific purpose. Accommodation in this sense does not mean to compromise what the Bible teaches; rather, accommodation refers to the kind of language God chose for the Bible in order to communicate and make truth intelligible to the widest possible audience, in all times and places. Augustine taught that the language of Scripture is accommodated to the understanding of ordinary readers and therefore not intended to impart theoretical knowledge in natural science. Modern science is not the key to the scriptures.

———-

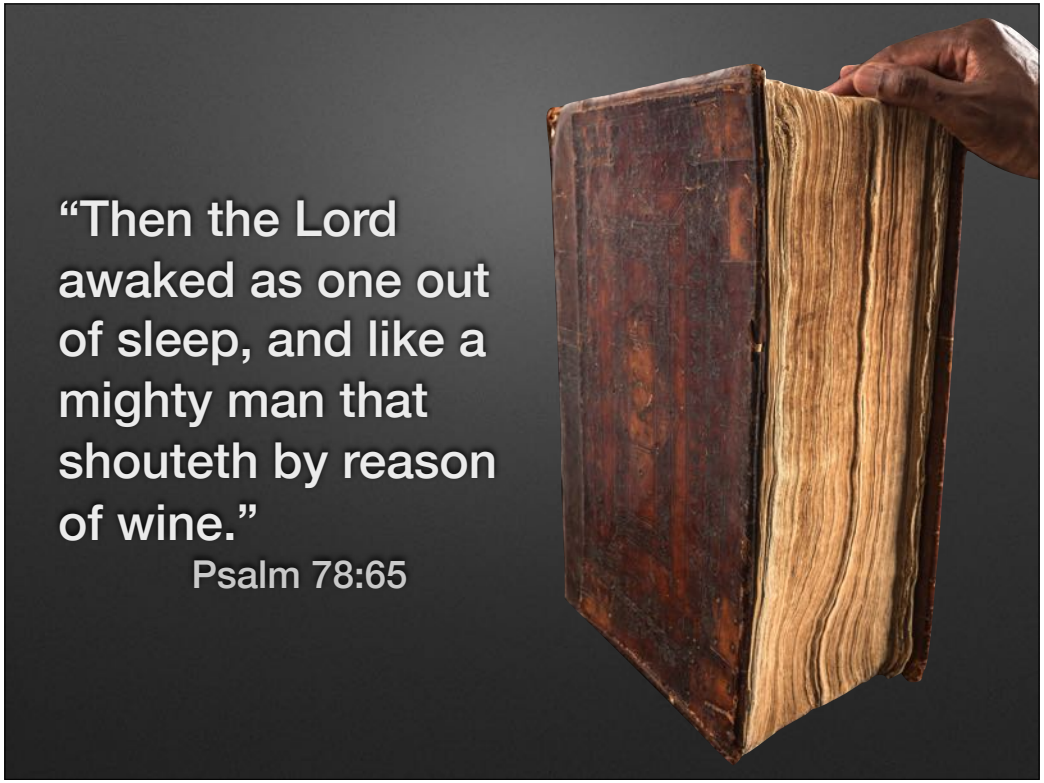
We can speak truly to kindergartners but we don’t use the same language as in a college chemistry class. When God speaks to us, even in a scientific age, we are like the kindergartners, and he speaks to us with accommodation.



Fourth is phenomenalism. The word phenomena means “appearances,” how nature appears to our senses, in contrast to theories, which are explanations involving hidden causes. The original writers of Scripture simply described sensible phenomena as they appeared. Therefore physical references in Scripture should be interpreted whenever possible as entailing only those things that are immediately obvious to the senses.



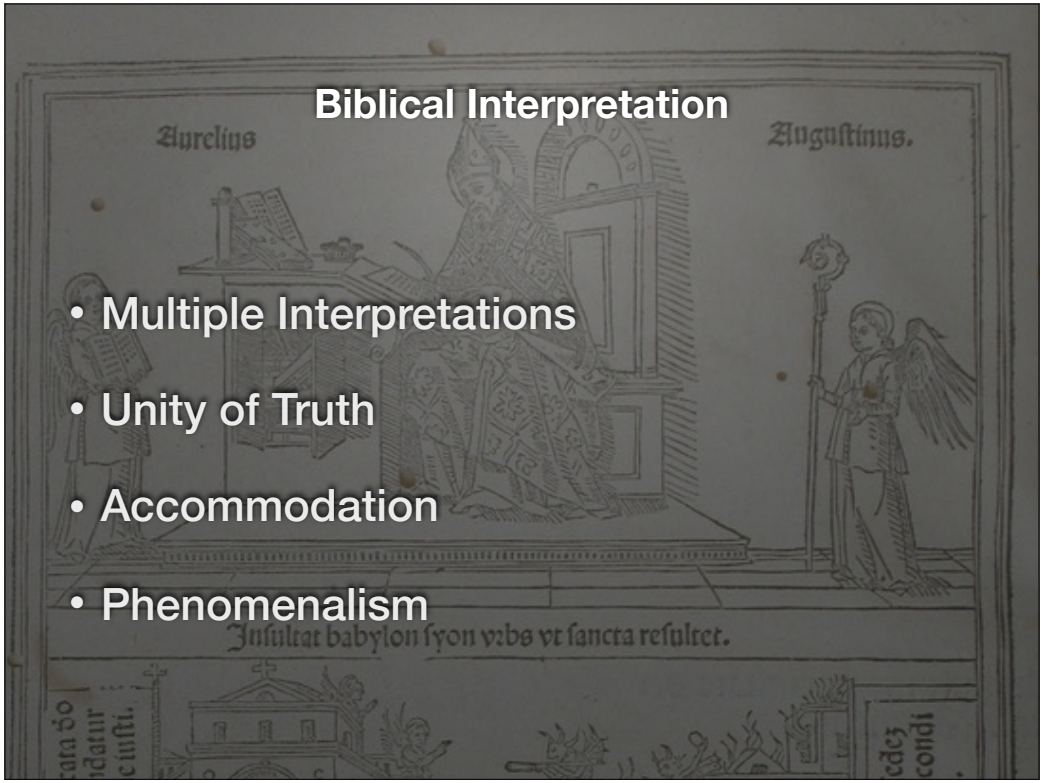
Thomas Aquinas agreed with Augustine's principles, writing that…



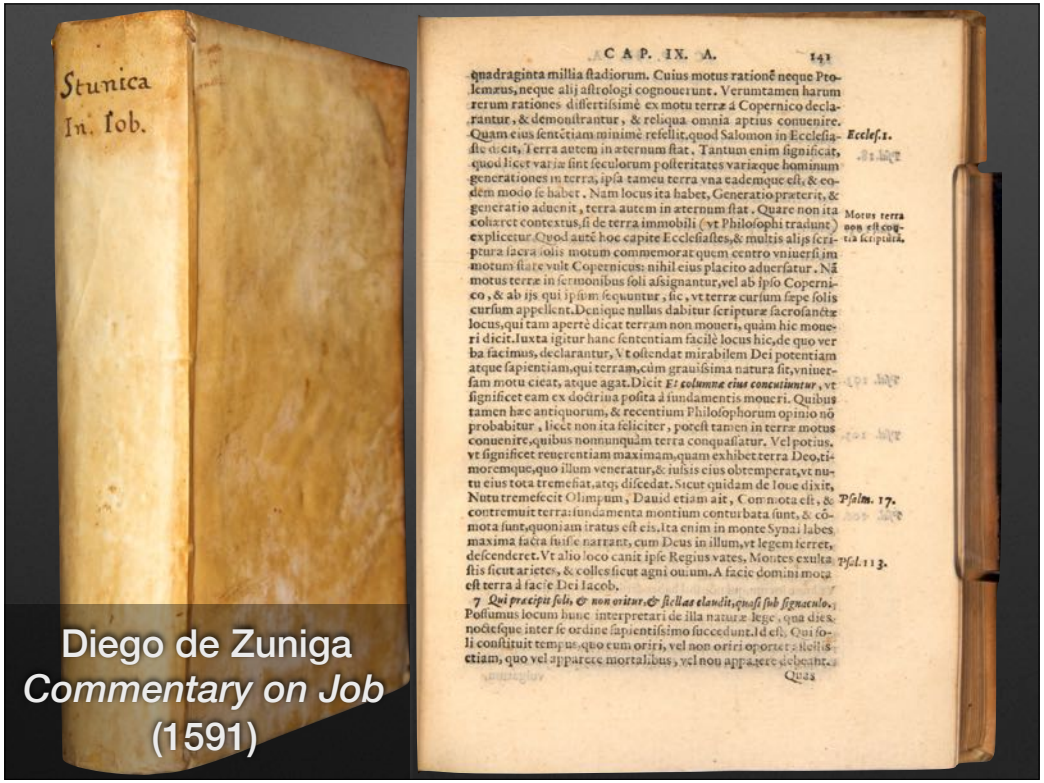
Consider the wording of Psalm 78: (read). Calvin asked: Does this mean God is literally a drunken man? Of course not; biblical language is accommodated to common idiom.

———

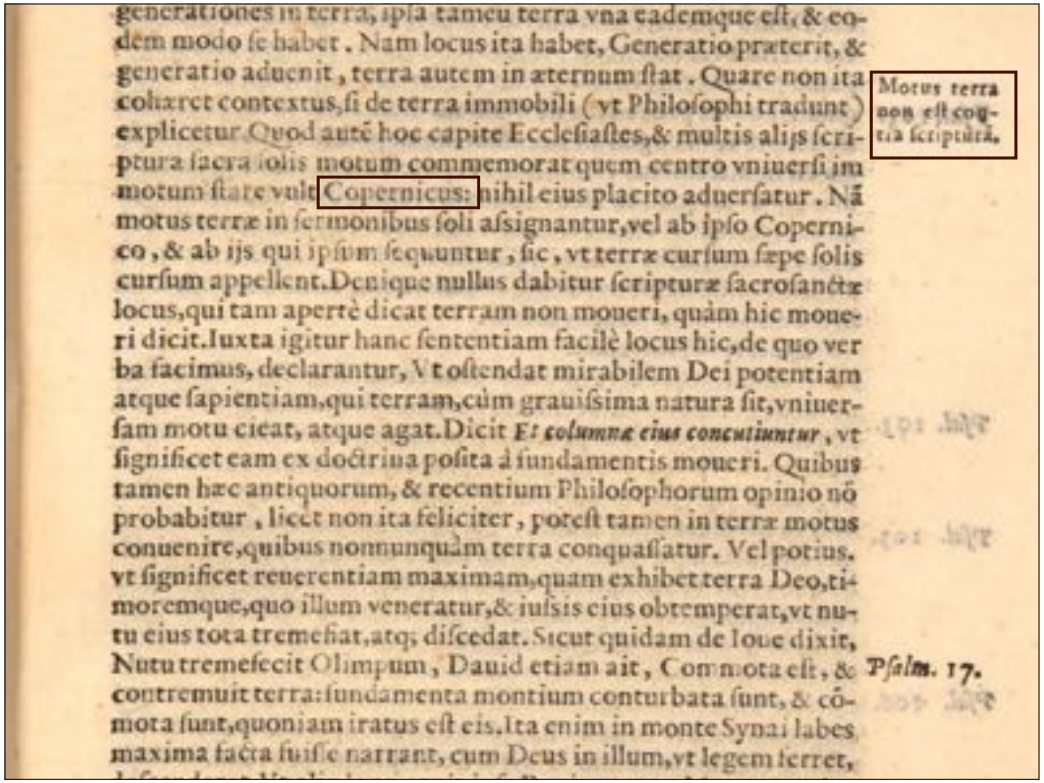
On this verse, Calvin said: “The figure of a drunken man may seem somewhat harsh, but … it is employed in accommodation to the stupidity of the people. Had they been of a pure and clear understanding, God would not have … assumed a character foreign to his own.”



So Augustine, Aquinas, Calvin and other figures throughout the history of the church agreed upon these principles of biblical interpretation so helpful for matters related to natural science.



With these principles in mind, perhaps it is no longer surprising that the first defense of Copernicus in Spain was written by a theologian, Diego de Zuniga, in a commentary on the book of Job.



generationes in terra, ipsa tamen terra vna eademque est, & eodem modo se habet. Nam locus ita habet, Generatio præterit, & generatio aduenit, terra autem in æternum stat. Quare non ita cohæret contextus, si de terra immobili (vt Philosophi tradunt) explicetur. Quod autē hoc capite Ecclesiastes, & multis alijs scriptura sacra solis motum commemorat quem centro vniuersi immotum fiare vult Copernicus: nihil eius placito aduersatur. Nā motus terræ in sermonibus soli assignantur, vel ab ipso Copernico, & ab ijs qui ipsum sequuntur, sic, vt terræ cursum sæpe solis cursum appellent. Denique nullus dabitur scripturæ sacrosanctæ locus, qui tam apertè dicat terram non moueri, quàm hic moueri dicit. Iuxta igitur hanc sententiam facilè locus hic, de quo verba facimus, declarantur, Vt ostendat mirabilem Dei potentiam atque sapientiam, qui terram, cùm grauissima natura sit, vniuersam motu cieat, atque agat. Dicit *Et columnæ eius concutiuntur*, vt significet eam ex doctrina posita à fundamentis moueri. Quibus tamen hæc antiquorum, & recentium Philosophorum opinio nō probabitur, licet non ita feliciter, potest tamen in terræ motus conuenire, quibus nonnunquàm terra conquassatur. Vel potius, vt significet reuerentiam maximam, quam exhibet terra Deo, timoremque, quo illum veneratur, & iussis eius obtemperat, vt nutu eius tota tremefiat, atq; discedat. Sicut quidam de Ioue dixit, Nutu tremefecit Olimpum, Dauid etiam ait, Commota est, & contremuit terra: fundamenta montium conturbata sunt, & cōmota sunt, quoniam iratus est eis. Ita enim in monte Synai labes maxima facta fuisse narrant, cum Deus in illum, vt legem ferret,

Motus terra non est contra scripturā.

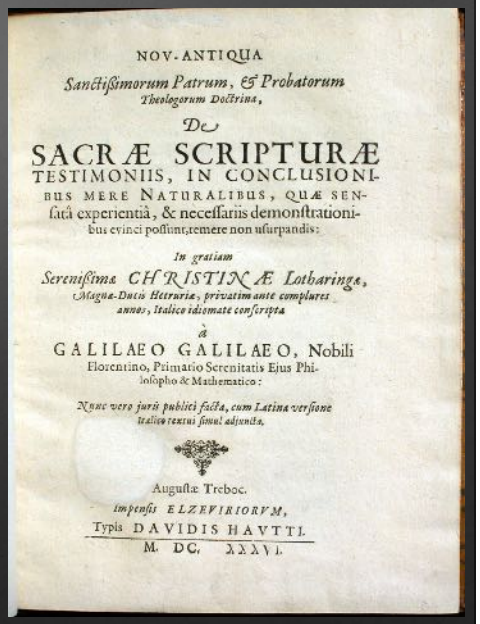
Psalm. 17.

Zuniga's commentary on Job shows that he possessed a working knowledge of Copernicus' system, including some of its technicalities.

Letter to the Grand Duchess Christina

Galileo Galilei, 1615

First printed edition, 1636



NOV. ANTIQUA

Sanctißimorum Patrum, & Probatorum Theologorum Doctrina,

De

SACRÆ SCRIPTURÆ TESTIMONIIS, IN CONCLUSIONIBUS MERE NATURALIBUS, QUÆ SENSATÂ experientiâ, & neceſſariis demonſtrationibus evinci poſſunt, temere non uſurpandis:

In gratiam

Serenißimæ CHRISTINÆ *Lotharingæ, Magnæ Ducis Hetruriæ, privatim ante complures annos, Italico idiomate conſcripta*

à

GALILÆO GALILÆO, Nobili Florentino, Primatio Serenitatis Ejus Philoſopho & Mathematico:

Nunc vero juris publici facta, cum Latina verſione Italico textui ſimul adjuncta.

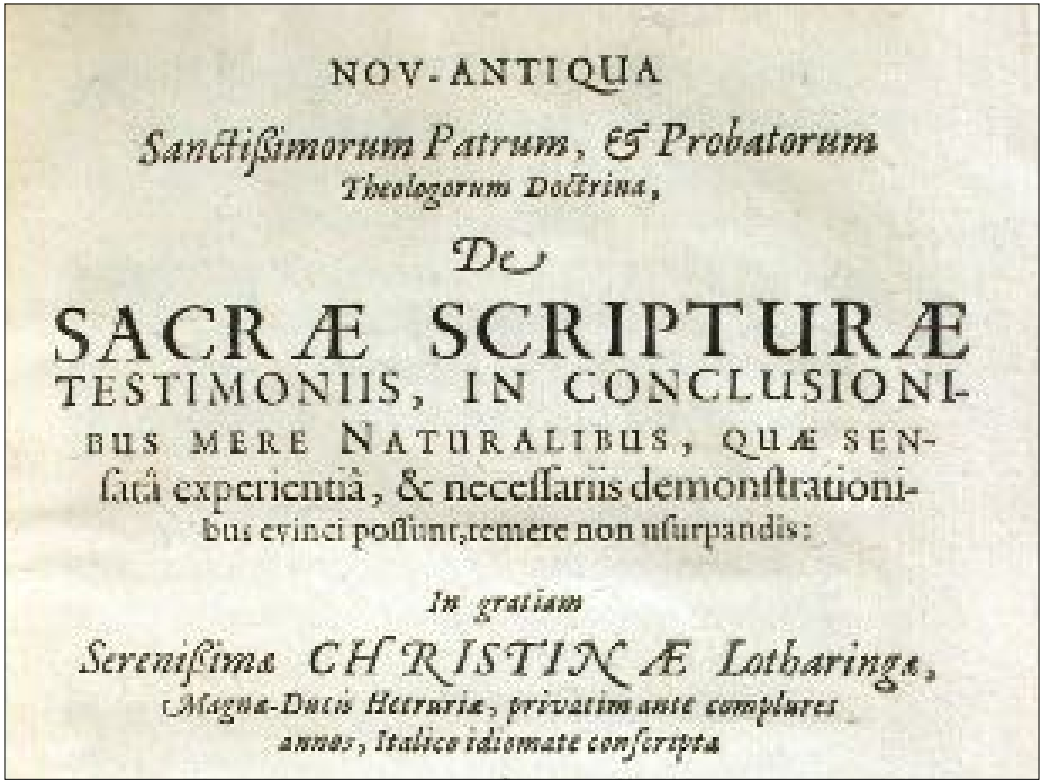
Auguſtæ Treboc.

Impenſis ELZEVIRIORUM,

Typis DAVIDIS HAUTTI.

M. DC. XXXVI.

Galileo in 1615 wrote a little book on biblical interpretation, reconciling Scripture and Copernicanism. From this work, it's obvious that Galileo read Zuniga, as well as Augustine. It circulated in manuscript as the Letter to the Grand Duchess Christina. This is the first printed edition, which appeared in 1636.


NOV. ANTIQUA

Sanctissimorum Patrum, & Probatorum
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SACRÆ SCRIPTURÆ
TESTIMONIIS, IN CONCLUSIONI-
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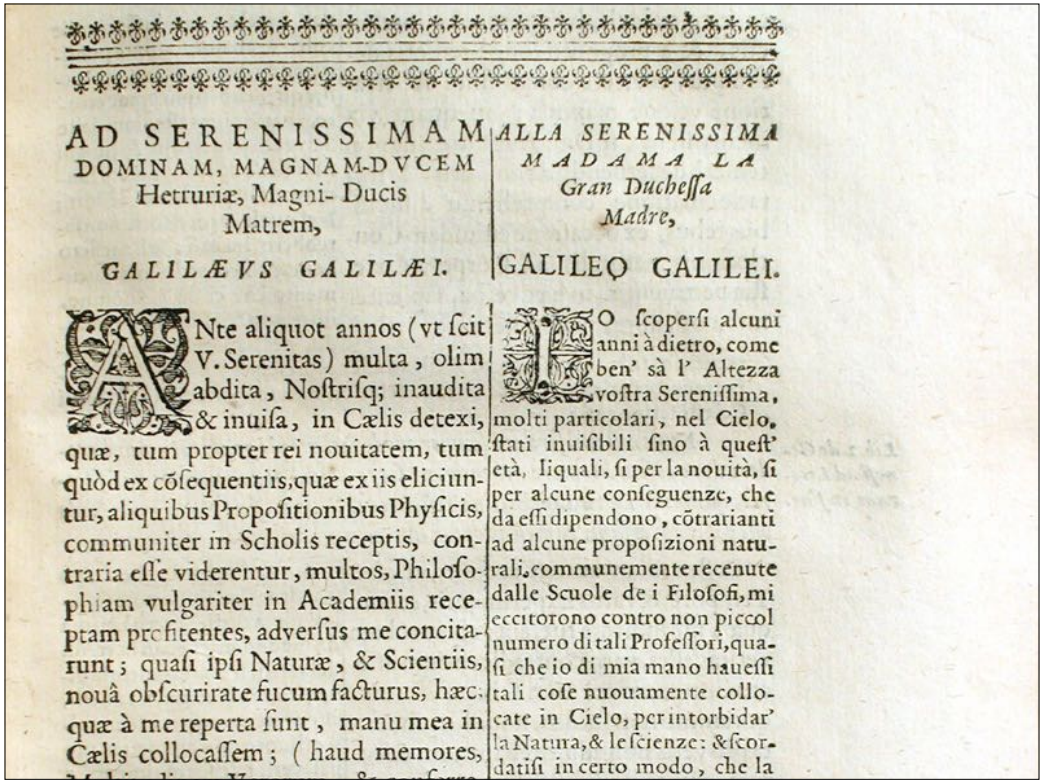
In gratiam

Serenissimæ CHRISTINÆ Lotharingæ,
Magnæ-Ducis Hetruriæ, privatim ante complures
annos, Italico idiomate conscripta

In the Letter to Christina, Galileo argued that the purpose of Scripture is to tell us how to go to heaven, not how the heavens go; Scripture never errs, but its interpreters do err; and read rightly, Scripture and Science will never conflict (there is a unity of truth). That which is obscure (such as figurative language) should be explained by that which is clear (such as mathematical demonstrations).



AD SERENISSIMAM
DOMINAM, MAGNAM-DVCEM
Hetruriæ, Magni- Ducis
Matrem,

GALILÆVS GALILÆI.

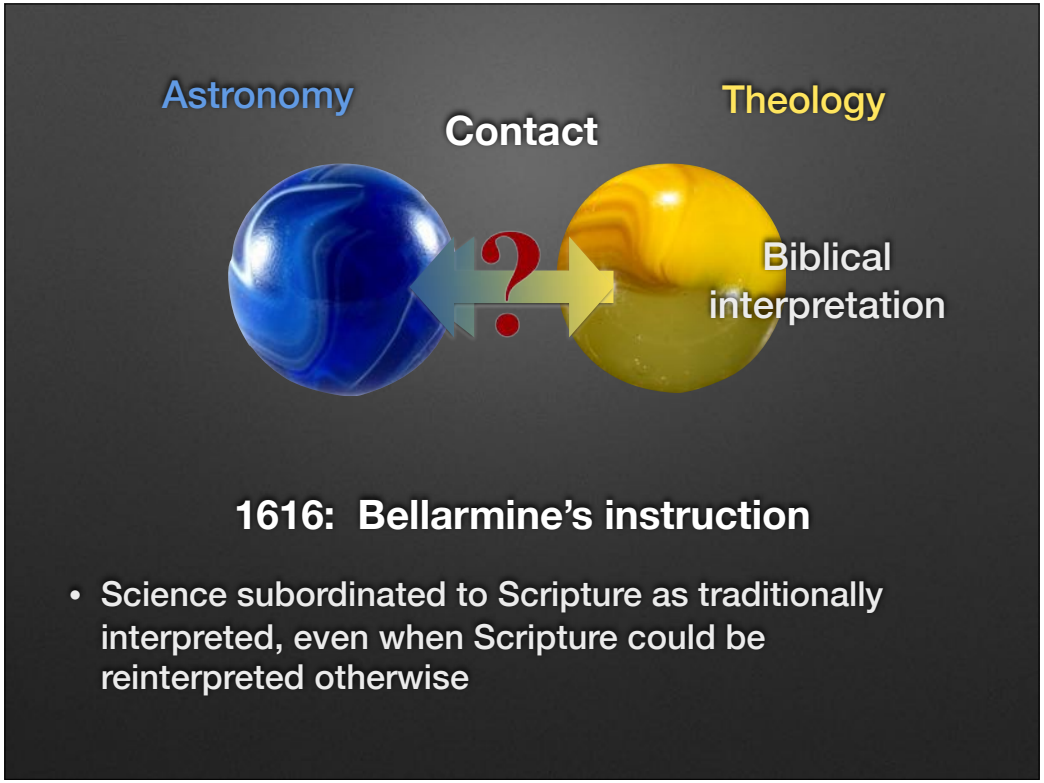
ANte aliquot annos (vt scit V. Serenitas) multa, olim abdita, Nostrisq; inaudita & inuisa, in Cælis detexi, quæ, tum propter rei nouitatem, tum quòd ex cõsequentiis, quæ ex iis eliciuntur, aliquibus Propositionibus Physicis, communiter in Scholis receptis, contraria esse viderentur, multos, Philosophiam vulgariter in Academiis receptam profitentes, adversus me concitarunt; quasi ipsi Naturæ, & Scientiis, nouâ obscurirate fucum facturus, hæc quæ à me reperta sunt, manu mea in Cælis collocassem; (haud memores,

ALLA SERENISSIMA
MADAMA LA
Gran Ducheſſa
Madre,

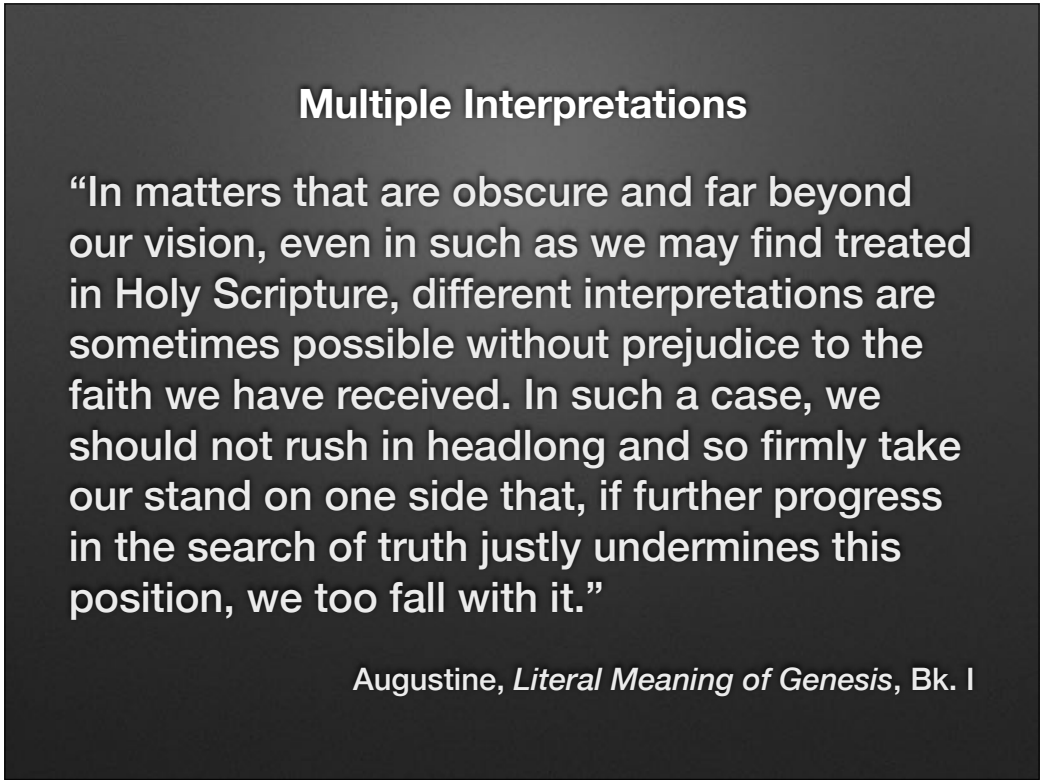
GALILEO GALILEI.

IO scoperſi alcuni anni à dietro, come ben' sà l' Altezza vostra Sereniſſima, molti particolari, nel Cielo, stati inuisibili sino à quest' età, liquali, si per la nouità, si per alcune conseguenze, che da essi dipendono, cõtrarianti ad alcune proposizioni naturali, communemente recenute dalle Scuole de i Filosofi, mi eccitorono contro non piccol numero di tali Professori, quasi che io di mia mano haueſſi tali cose nuouamente collocate in Cielo, per intorbidar' la Natura, & le scienze: & scordatisi in certo modo, che la

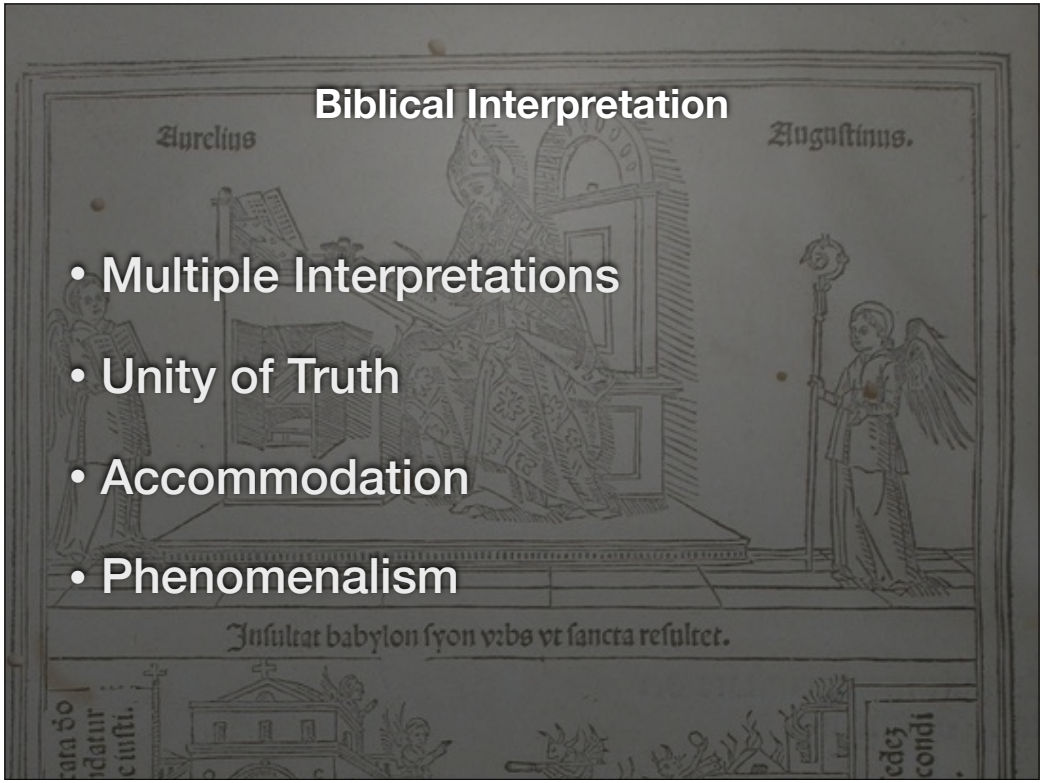
To show the traditional basis of his approach, Galileo cited St. Augustine throughout. Galileo certainly did biblical interpretation better than the theologians did physics.



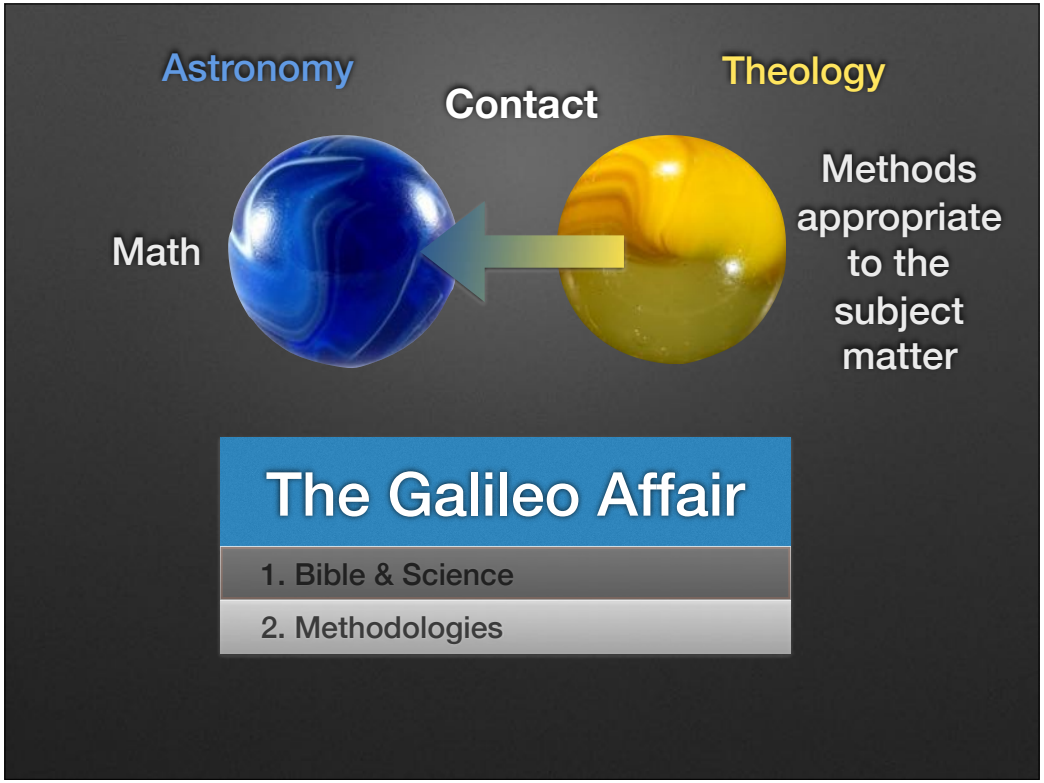
Unfortunately, in 1616, Cardinal Robert Bellarmine met with Galileo and instructed him in a manner contrary to Augustine's principles. Bellarmine sought to advance the Counter-Reformation during the decades after the Council of Trent. In that tense international moment, Bellarmine argued • that science must be subordinated to scripture as traditionally interpreted, even when scripture could be reinterpreted otherwise. •We'll represent this subordination as a one-way arrow. Instead of mutual dialogue, Bellarmine's subordination of science to traditional biblical interpretation set aside the principle of multiple interpretations:



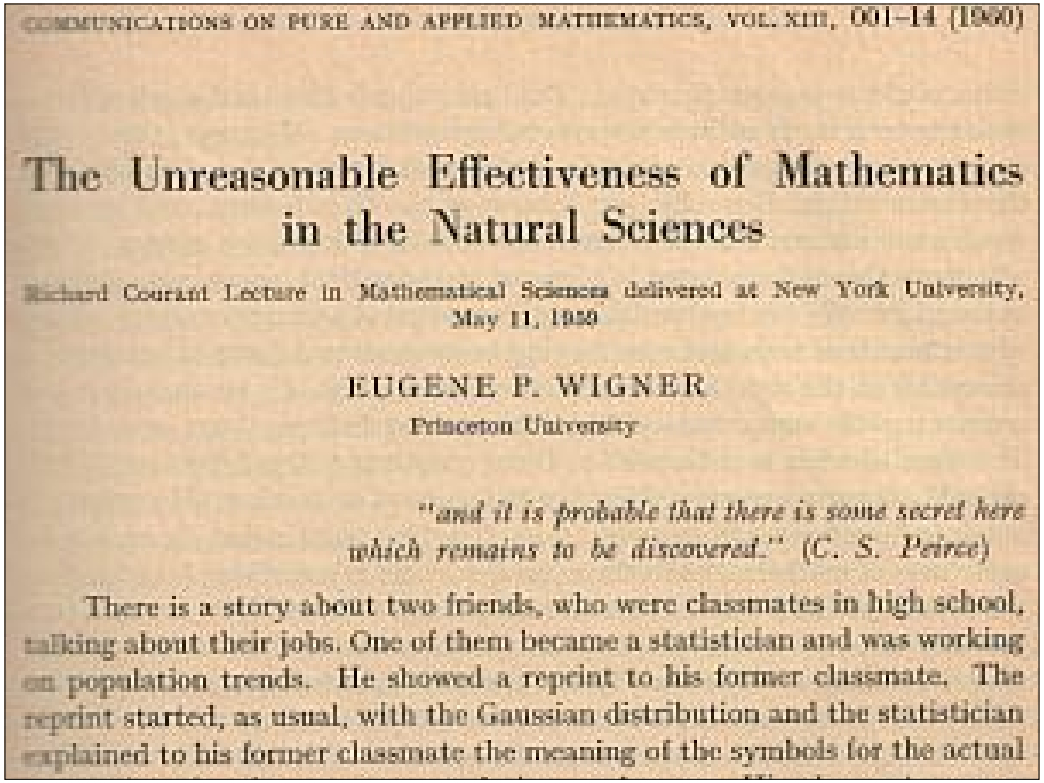
You’ll recall how Augustine put it: (read). Led by Bellarmine, the Church rushed in headlong, taking its stand on the side of what it thought was the best science of the day, against Copernicus.



Yet if these four principles of interpretation had been followed, there would have been no Galileo Affair. In theory, nothing would have prevented Bellarmine and other Roman Catholic theologians in Galileo's day from accepting Copernicus, had they rigorously followed their own principles of interpreting scripture. Back in 1543, Copernicus himself, a Catholic, had dedicated the *De revolutionibus* to Pope Paul III. Centuries later, in 1992, Pope John Paul II deliberately used Galilean language to affirm similar hermeneutical principles.



So we have seen that the Bible and science collided in the case of Galileo, but needlessly so. • Now let's take a look at methodologies. • If the aim of any science is to develop methods appropriate to the subject matter, then a fundamental misunderstanding of disciplinary methodologies lay at the heart of the conflict in the Galileo Affair.



COMMUNICATIONS ON PURE AND APPLIED MATHEMATICS, VOL. XIII, 001–14 (1960)

The Unreasonable Effectiveness of Mathematics in the Natural Sciences

Richard Courant Lecture in Mathematical Sciences delivered at New York University, May 11, 1959

EUGENE P. WIGNER
Princeton University

"and it is probable that there is some secret here which remains to be discovered." (C. S. Peirce)

There is a story about two friends, who were classmates in high school, talking about their jobs. One of them became a statistician and was working on population trends. He showed a reprint to his former classmate. The reprint started, as usual, with the Gaussian distribution and the statistician explained to his former classmate the meaning of the symbols for the actual

In 1960, the physicist Eugene Wigner wrote a famous article, “The Unreasonable Effectiveness of Mathematics in the Natural Sciences.”

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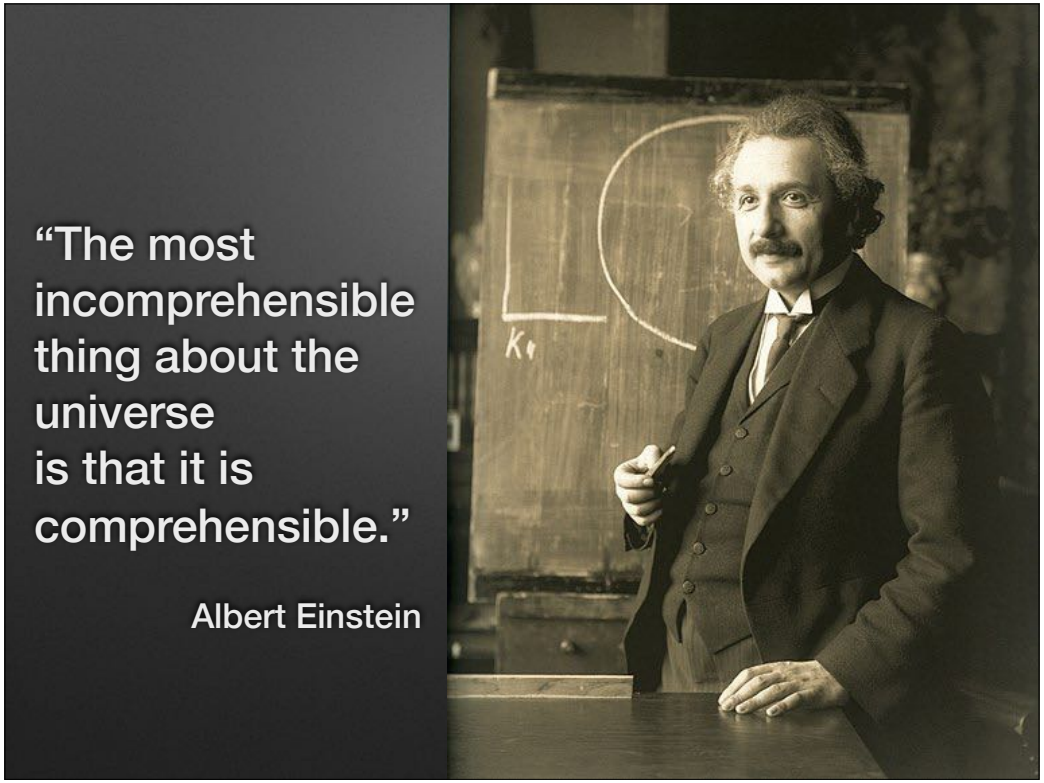
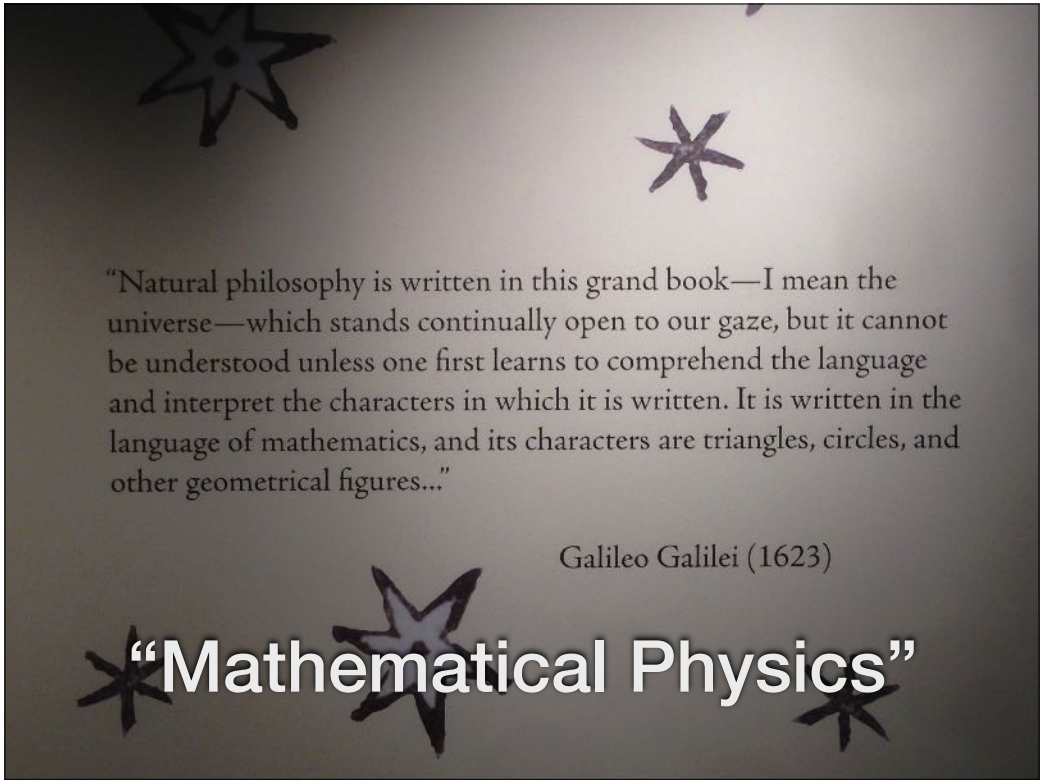
1960. Communications on Pure and Applied Mathematics. 13: 1–14



Albert Einstein said:

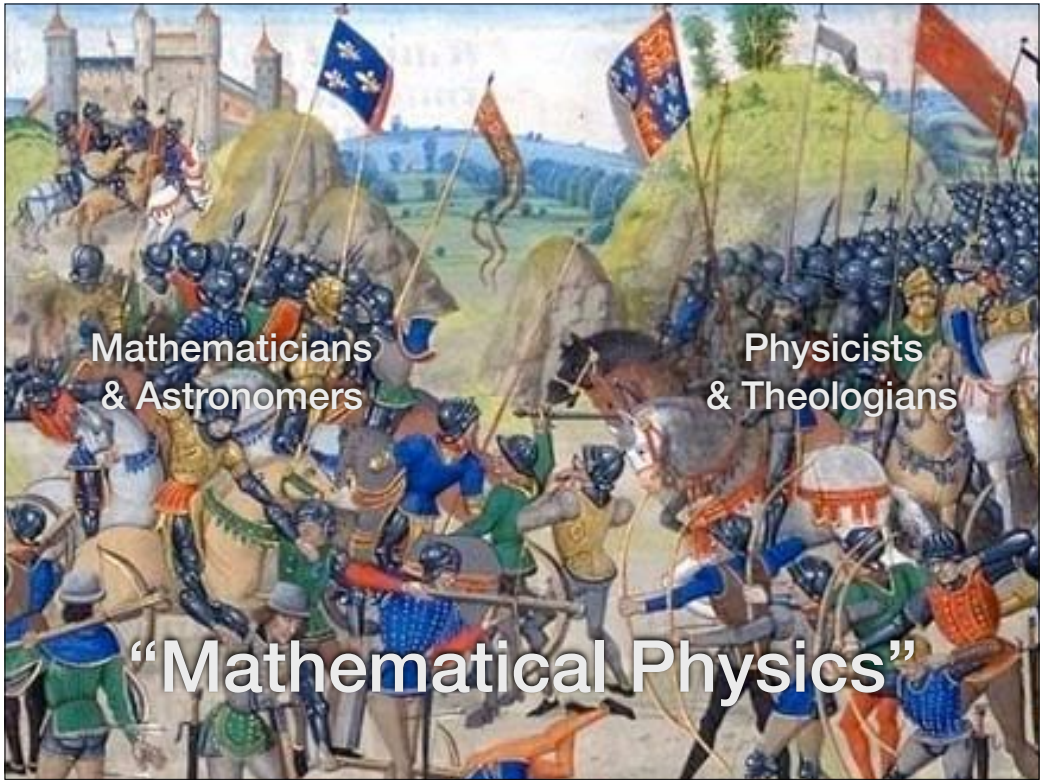


Galileo pioneered the mathematical physics of Einstein and Wigner. He wrote that science, or natural philosophy, is written… (read). • This is a manifesto for the birth of the "mathematical physics" that led to Newton and Einstein and Wigner.

In Galileo's day, the Jesuits, like Galileo, placed a high value on mathematics. Two galleries of the exhibit, Galileo and China, and Controversy over the Comets, explore how, by the time of Galileo, the Jesuits had become leaders in the mathematical sciences, including astronomy. Unlike physicists of the day, Jesuits were routinely trained in mathematics.

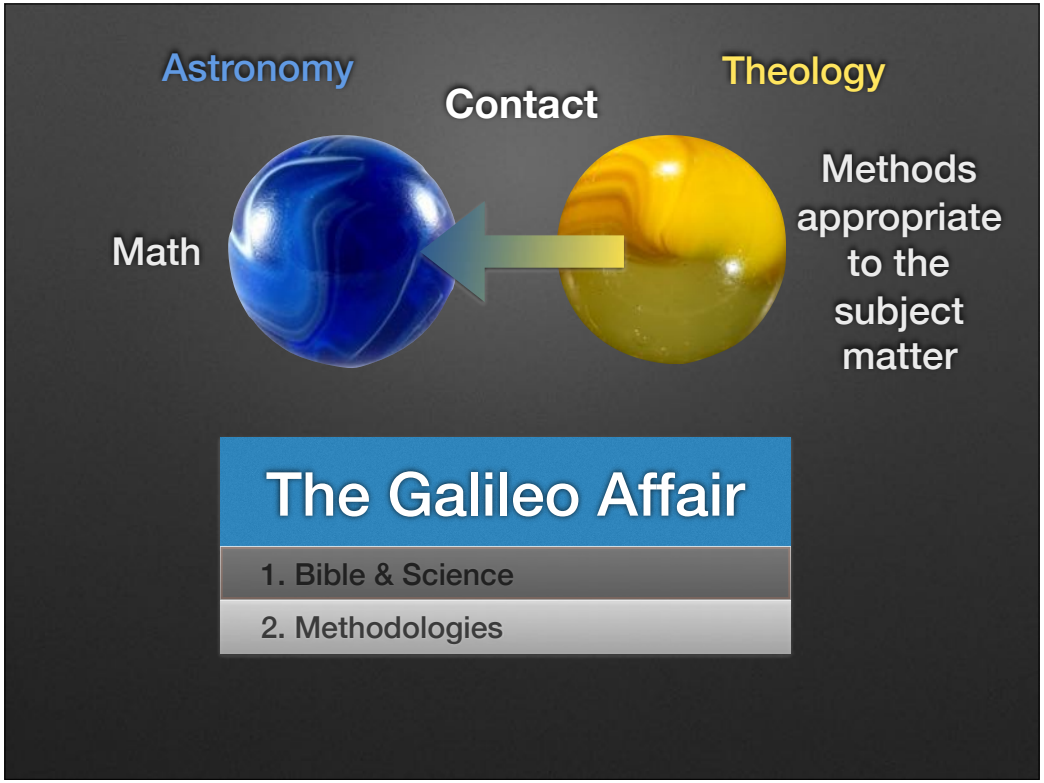
Mathematics lay at the heart of the creative spark in Florentine culture. Mathematics ignited innovation in the disciplines of art, architecture, painting, and engineering. • But mathematicians worked in courts and wider cultural spaces largely outside the universities.

Physicists and theologians failed to see it. With the exception of the Jesuits and a few others, • physicists and theologians were not trained in mathematics, and underestimated its potential. To most physicists and theologians, mathematics was simply a calculating tool, not a means of gaining insight into reality.



So there was a real battle in Galileo’s day, but it was not between science and religion. Rather, it was a battle between methodologies, mathematical vs. non-mathematical. Mathematicians like Galileo believed they could do physics better than the university-based physicists. • In this intellectual and political battle, mathematicians before and after Galileo attacked Aristotelian physics and replaced it with the mathematical physics we know today.

The Jesuits show that the battle for mathematical methods was not a battle between science and religion. In the Spring of 1611 Galileo visited Rome, invited by the Jesuits to demonstrate his telescope. Because they were trained in mathematics, the Jesuits were sympathetic to Galileo, in opposition to the physicists in the universities. Jesuit astronomers eagerly looked through Galileo's telescopes, confirmed his observational discoveries, and certified their validity to Cardinal Robert Bellarmine. Their leading astronomer, Clavius, indicated that the new discoveries would require the reinterpretation of accepted astronomical views. In other words, Ptolemy's system was dead, so far as mathematical astronomers were concerned. The Jesuits feasted and honored Galileo, offering him speeches and gifts as the leading light of Tuscany.



So the problem lay in determining which methods were appropriate for different subject matters. Should the non-mathematical methods of physics and theology be imposed upon the mathematicians and astronomers? Galileo's trial manifests the inadequacy of a subordination of disciplines that have different kinds of methodologies.

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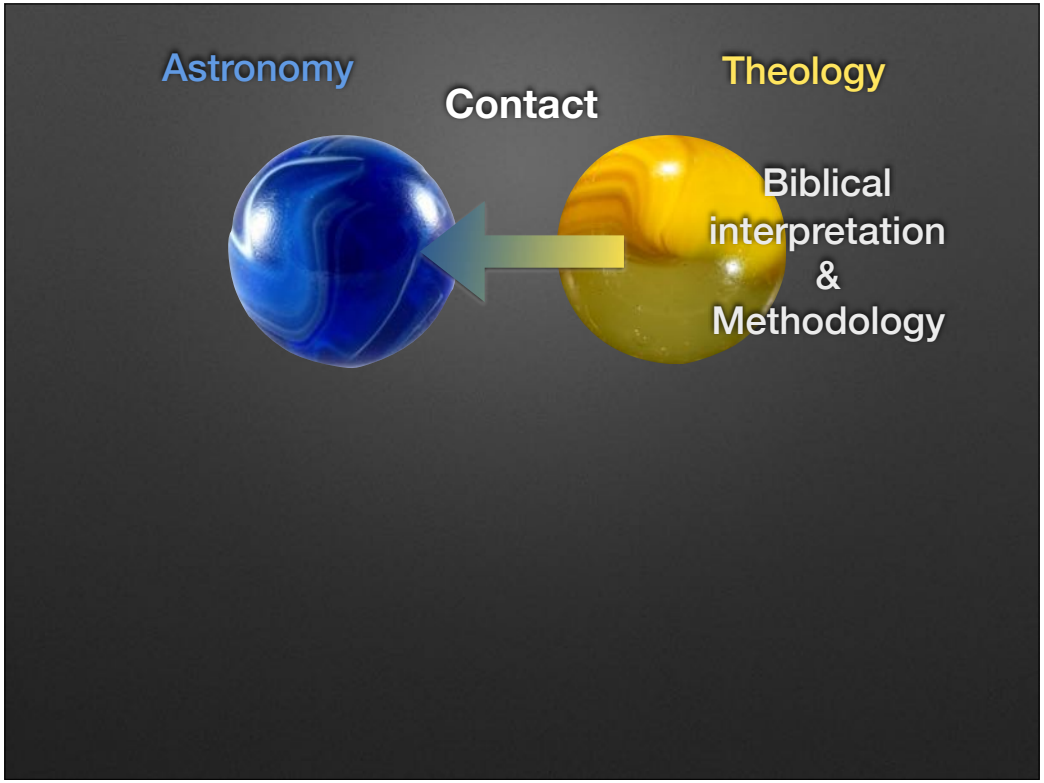
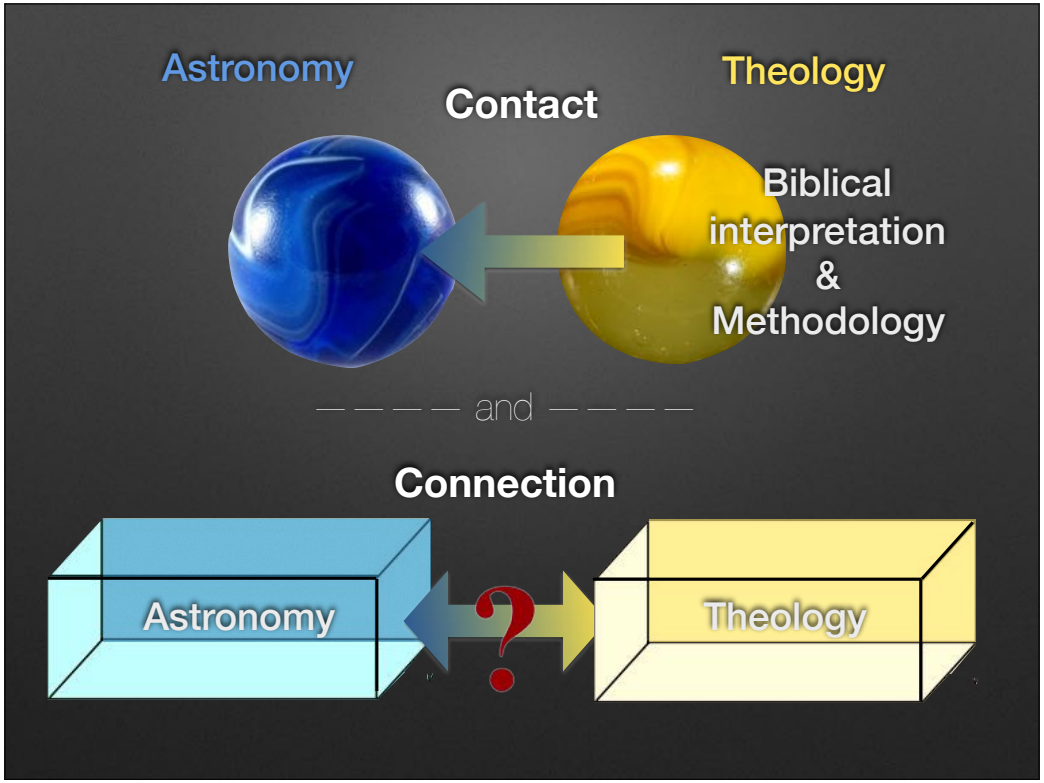
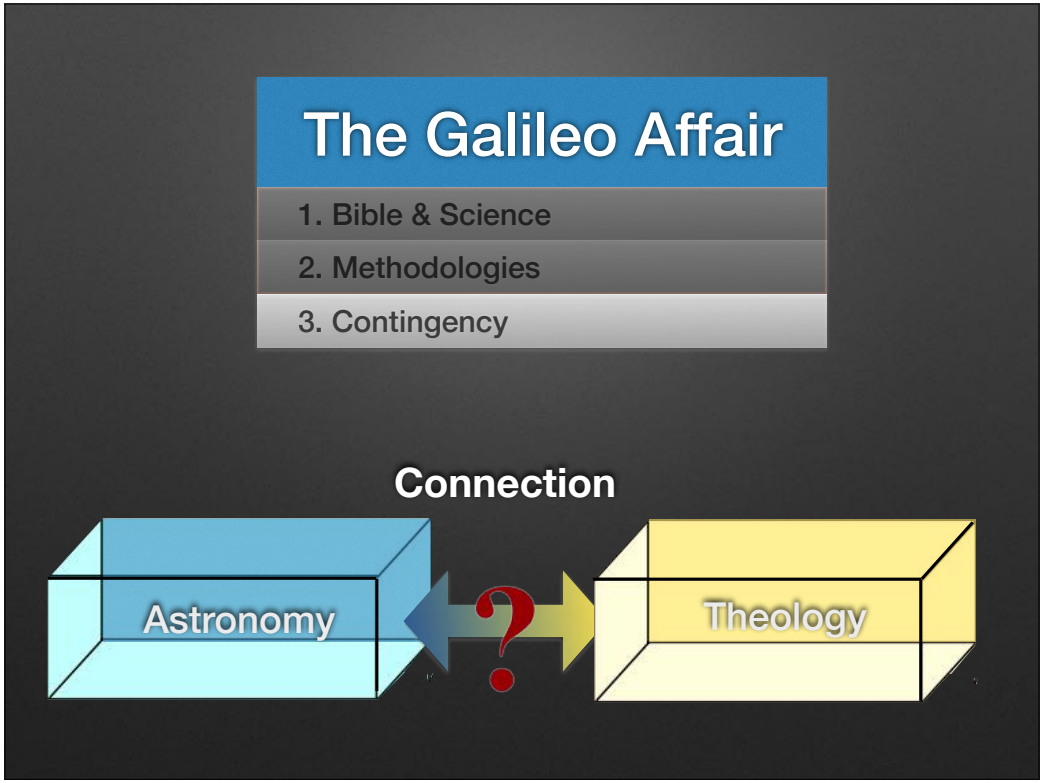
At the time, physicists were trained in logic rather than mathematics, yet physicists were granted more authority and credibility than astronomers in their statements about the universe. The greatest resistance to Copernicus came from those who underestimated the power of new mathematical methodologies. Both physicists and theologians were similarly unprepared to recognize the potential of mathematical arguments for the motion of the Earth. Galileo's astronomy posed a challenge from mathematics to the established and reputable domains of physics and theology, both of which had to learn to adapt to the knowledge claims of the new mathematical science. Galileo's trial represents the inadequacy of a subordination of disciplines. Galileo championed the unexpected reach of emerging mathematical investigations compared with traditional methodologies.



So with biblical interpretation on questions related to natural science, and with methodologies like mathematics, theology fell into an unfortunate model of contact by collision and attempted disciplinary subordination.



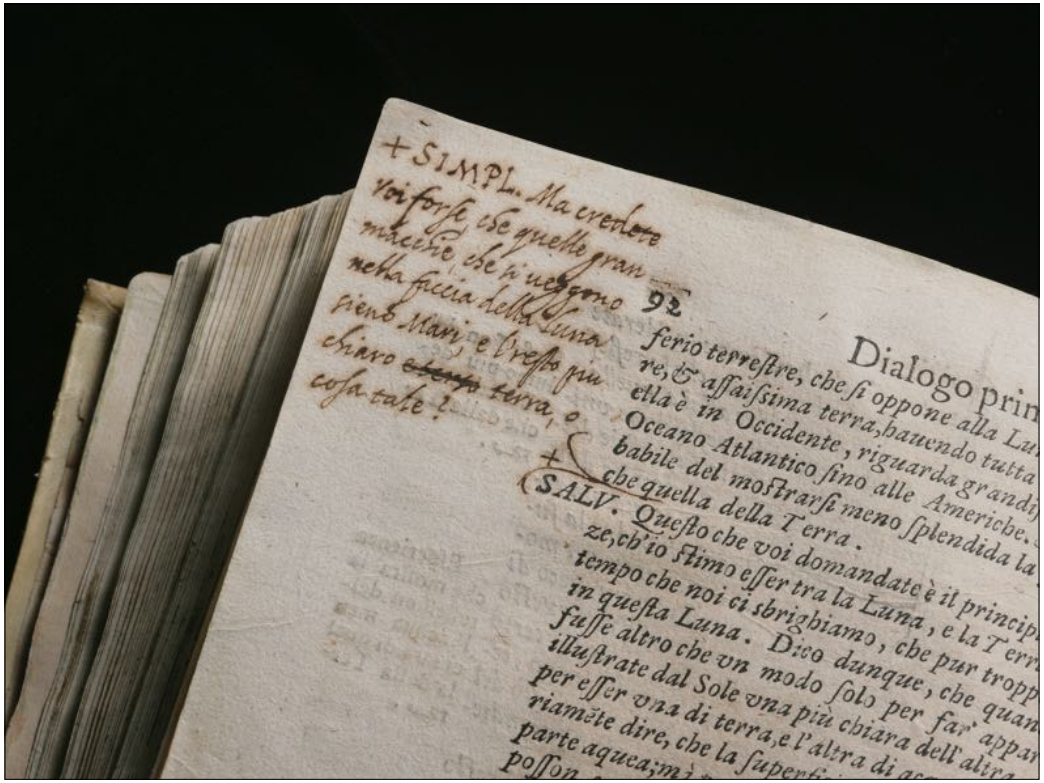
Now let's turn to what might have been a natural and constructive connection between astronomy and theology that also surfaced in the Galileo Affair.



This is the principle of contingency, which means that the natural order is not necessary, but might be other than it is.

Galileo, *Dialogo* (Florence, 1632)

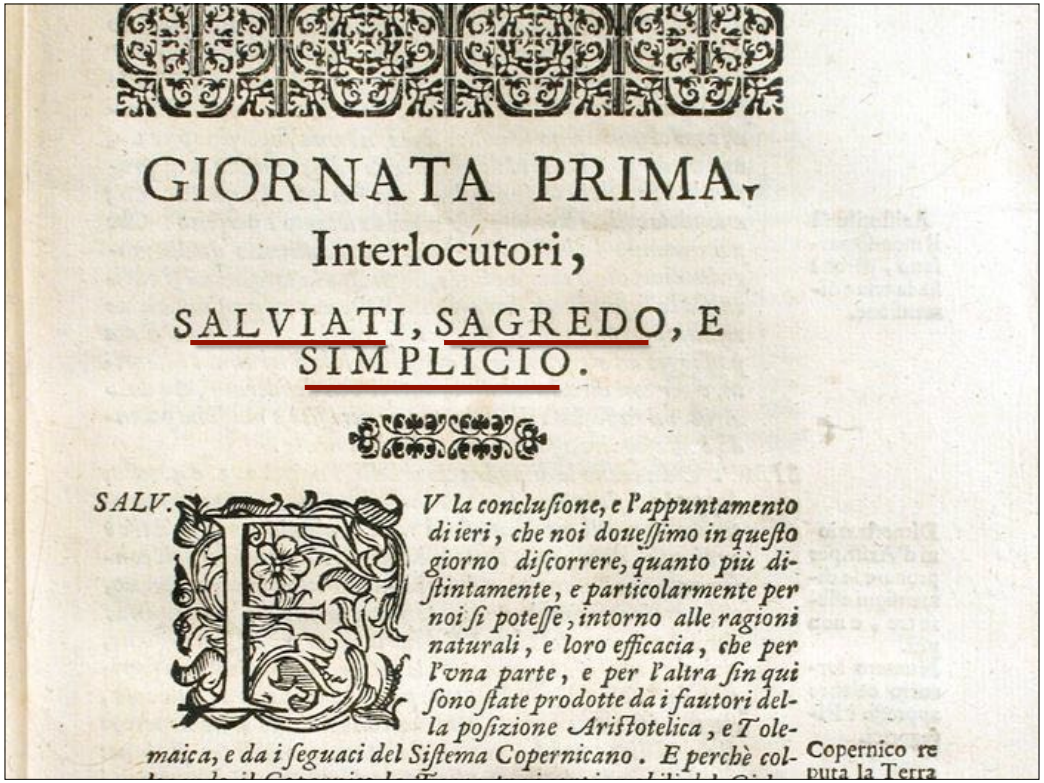
Here is Galileo's Dialogue on the Two Chief Systems of the World, the book for which he was put on trial.



The OU copy again contains Galileo's handwriting.

DIALOGO
DI
GALILEO GALILEI LINCEO
MATEMATICO SOPRAORDINARIO
DELLO STVDIO DI PISA.
E Filosofo, e Matematico primario del
SERENISSIMO
GR. DVCA DI TOSCANA.
Doue ne i congressi di quattro giornate si discorre
sopra i due
MASSIMI SISTEMI DEL MONDO
TOLEMAICO, E COPERNICANO;
Proponendo indeterminatamente le ragioni Filosofiche, e Naturali
tanto per l'una, quanto per l'altra parte.

Galileo wrote this in Italian, and as a dialogue. It was an immediate best-seller, entertaining and delighting readers both then and now. The book is cast in the form of a Platonic dialogue between three characters:



GIORNATA PRIMA.

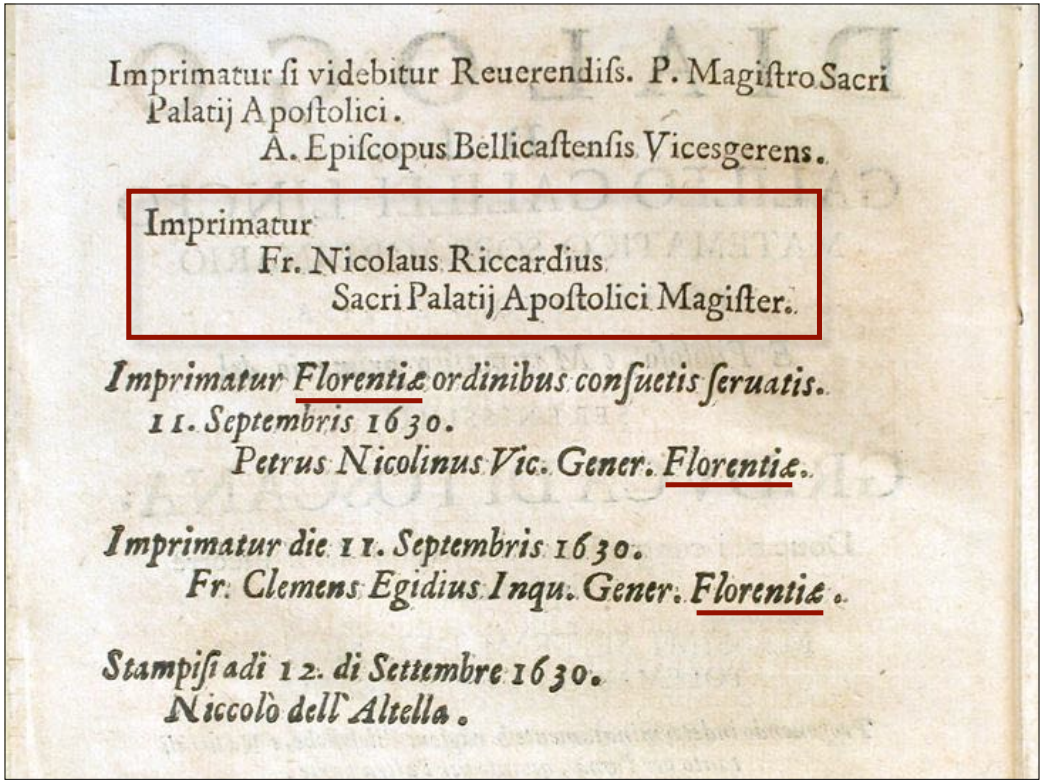
Interlocutori,

SALVIATI, SAGREDO, E SIMPLICIO.

SALV. E V la conclusione, e l'appuntamento di ieri, che noi douessimo in questo giorno discorrere, quanto più distintamente, e particolarmente per noi si potesse, intorno alle ragioni naturali, e loro efficacia, che per l'vna parte, e per l'altra sin qui sono state prodotte da i fautori della posizione Aristotelica, e Tolemaica, e da i seguaci del Sistema Copernicano. E perchè col-

Copernico re
puta la Terra

• Salviati, who speaks for Galileo. • Sagredo, who represents you or me on our best days, an open-minded reader. • And then there is poor, simple-minded Simplicio, who ineptly defends the Earth-centered system. Simplicio frequently doesn't understand, and provides comic relief along the way.



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A. Epiſcopus Bellicaſtenſis Vicesgerens.

Imprimatur
Fr. Nicolaus Riccardius
Sacri Palatij Apoſtolici Magiſter.

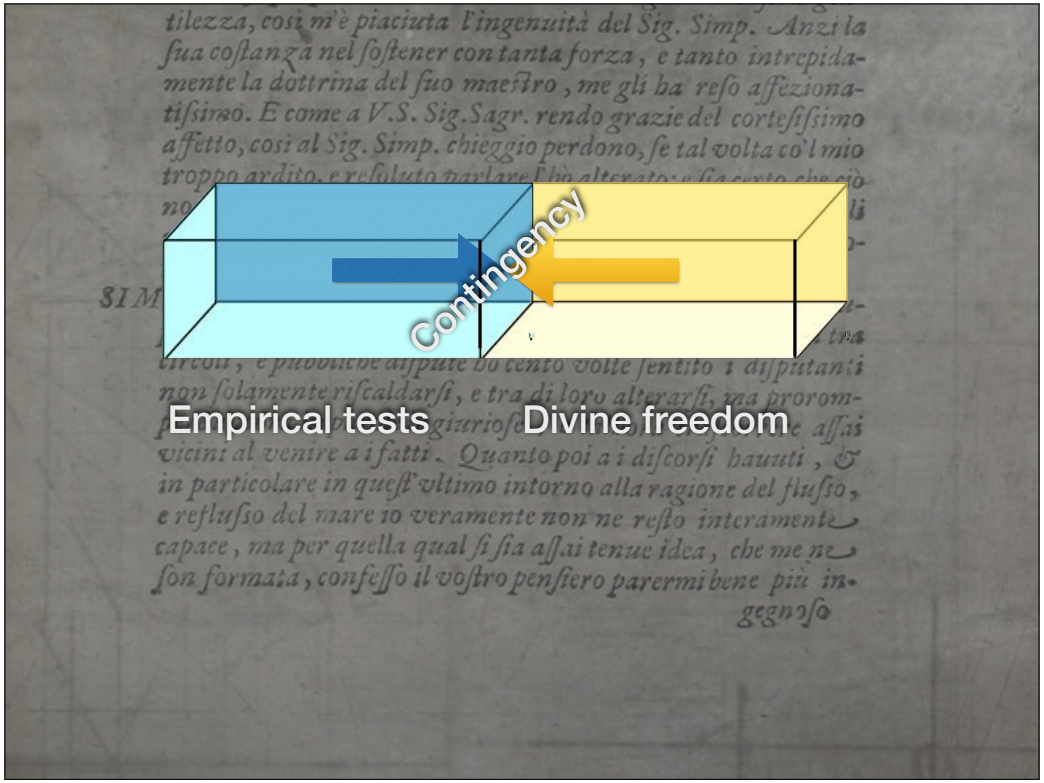
Imprimatur Florentiæ ordinibus conſuetis ſeruatis.
11. Septembris 1630.
Petrus Nicolinus Vic. Gener. Florentiæ.

Imprimatur die 11. Septembris 1630.
Fr. Clemens Egidius Inqu. Gener. Florentiæ.

Stampiſi adi 12. di Settembre 1630.
Niccolò dell' Altella.

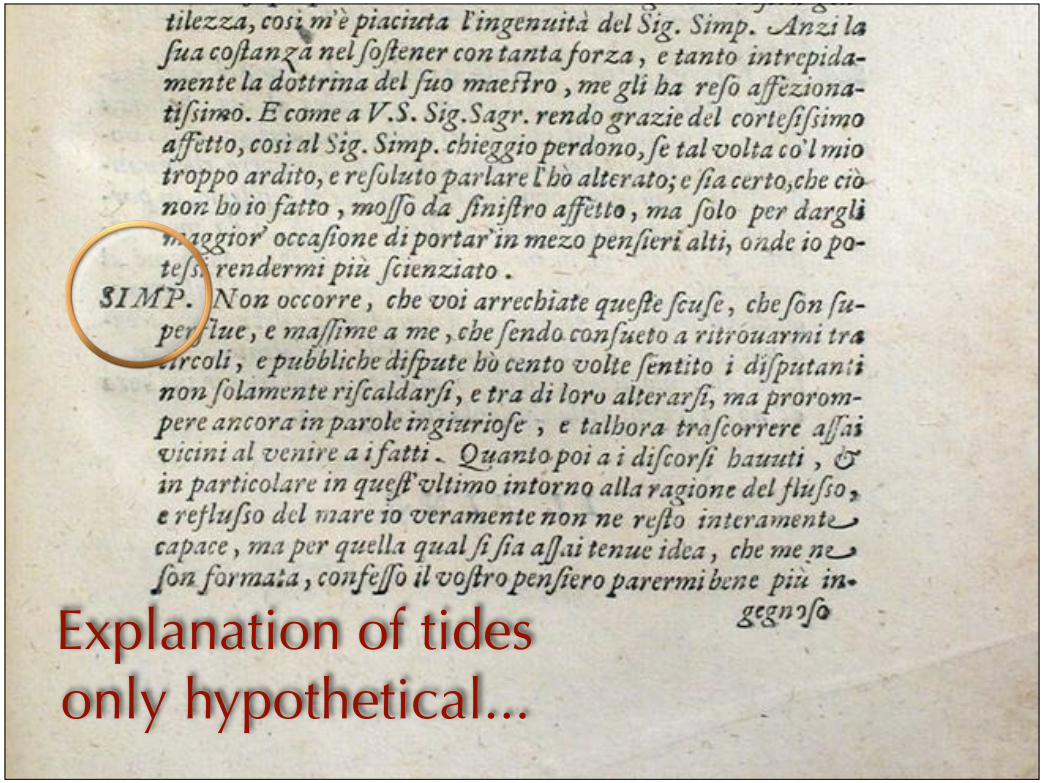
Galileo went through official channels and obtained permission to publish this book. Riccardi, the Vatican's master of the sacred page, was personally sympathetic to Copernicanism. Printing was transferred to ❒ Florence, and the book appeared early in 1632.

Earlier, in a personal meeting with Galileo, Pope Urban VIII had instructed Galileo to defend Copernicus only hypothetically.

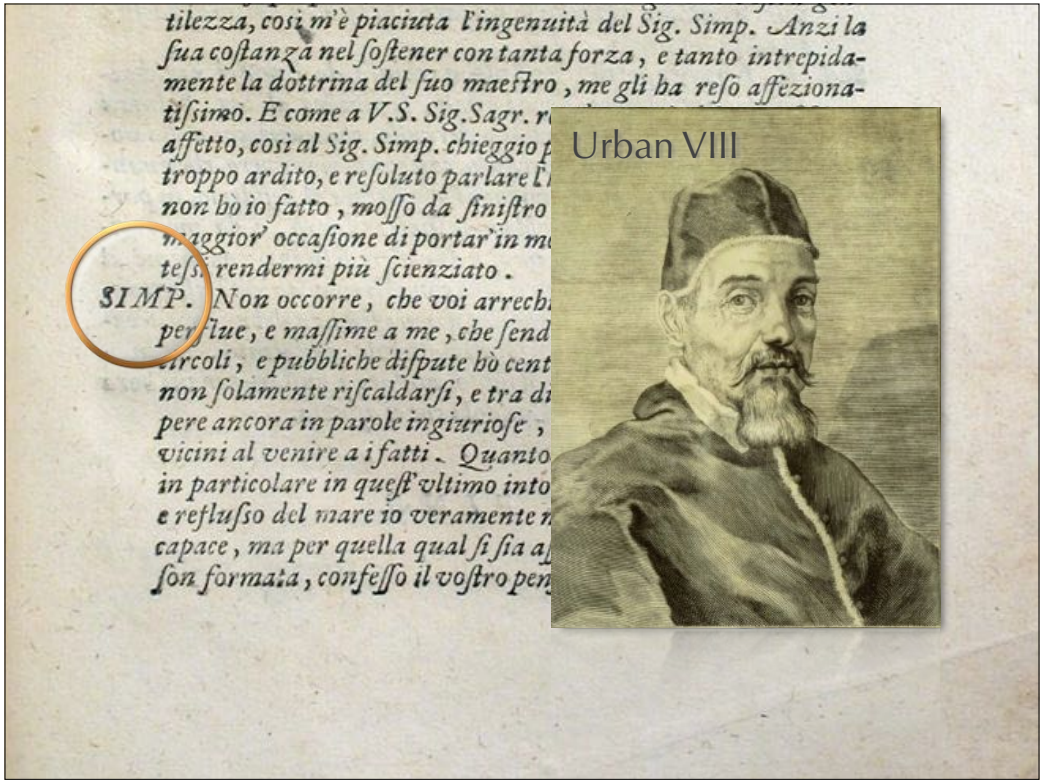


On the side of theology, Urban's concern was with divine freedom, to preserve God's prerogative to establish the created order however he pleased. If there was divine freedom in the creation, if God had a choice in making the universe, then nature is contingent, not necessary, which means that it could have been other than it is, different from however we reason it out to be. But this principle of contingency is shared alike by the natural sciences, for • the natural sciences hold theories provisionally and recognize the need for empirical testing. Because the natural order is contingent, armchair reasoning to the best possible world is not enough.

Unfortunately, Galileo regarded his own argument for Copernicus from the tides as a demonstration *with certainty* that could not be otherwise. ❒ Urban was intrigued by Kepler's competing theory that the tides are caused by an invisible attraction between the Earth, Moon and Sun, contrary to Galileo. So the doctrine of divine freedom constrained Urban to admonish Galileo to present his explanation of the tides as provisional. Perhaps God had so ordered nature that the tides occur according to Galileo's theory, or according to Kepler's, or according to a third way as yet undiscovered by anyone.



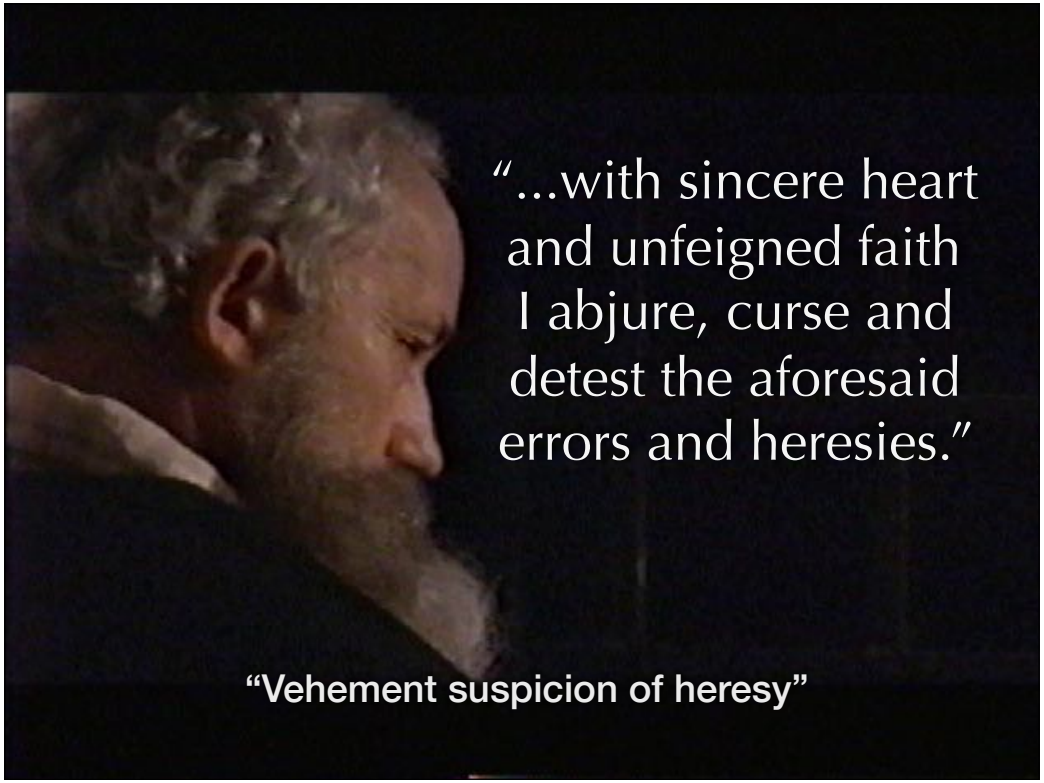
In the very last exchange of the Dialogue, Simplicio concludes that Salviati's theory of the tides is only hypothetical, because God in his freedom could have produced the tides in some other way, if he had wanted to.



The Pope was furious. The Pope's favored argument from divine freedom was put into the mouth of *Simplicio,* the butt of satire, the simple-minded fool. • He gave orders for the book to be recalled, and summoned Galileo to Rome for trial. Their long friendship was irretrievably broken.

The trial lasted for several weeks. Historians debate a multitude of theories to explain what took place behind the scenes, including ❒ Urban's sense of personal betrayal and the reversal of Galileo's papal support; ❒ controversies related to courtly performance and patronage; Galileo's overconfident sense of personal mission ❒ as if he were destined to convert the Church to Copernicanism; and political events related to the Thirty Years war. He faced concerted maneuvers by ❒ Aristotelian physicists against his mathematical methods, ❒ Dominican theologians against what they viewed as novel, anti-Catholic interpretations, ❒ and others like Scheiner and Grassi who had suffered public humiliation at Galileo's hands. There is no simple explanation.

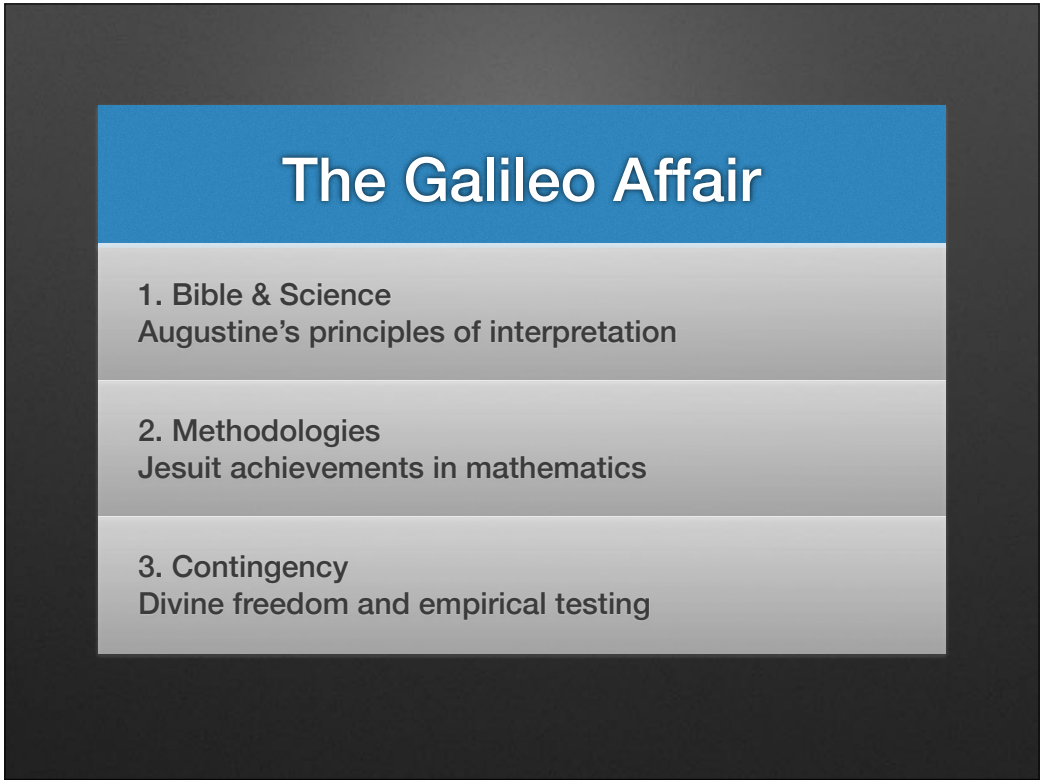
Yet one fact was obvious: Overall, Galileo's *Dialogue* was not the *hypothetical* treatment required by Urban. To resolve the impasse, unofficial negotiations resulted in a compromise plea-bargain where Galileo formally confessed that in writing the *Dialogue* he was carried away by enthusiasm and vainglorious ambition. The compromise seemed to assure Galileo of leniency, and to leave open the possibility that the *Dialogue* could be corrected instead of prohibited. Contrary to what is sometimes claimed, there was never any credible threat of torture.



But after a month of waiting the compromise abruptly fell through, for reasons historians cannot yet determine. • Unexpectedly, Galileo was sentenced as one "vehemently suspected of heresy" – not heresy itself, but one step short. The charge required a humiliating act of public abjuration. The sentence was distributed widely, and read aloud to Galileo's acquaintances in Florence. The *Dialogue* was prohibited. On June 22nd, 1633, Galileo was led in a penitent's robe before a plenary session of Cardinals meeting in the Dominican convent of Minerva. He knelt before them, and recited from the prescribed statement: ❒ "with sincere heart and unfeigned faith I abjure, curse and detest the aforesaid errors and heresies...."

The sentence of life imprisonment was quickly commuted to house arrest, and Galileo was released to the custody of the Archbishop of Siena. Eventually the 70-year-old Galileo returned home. His confinement was humiliating and extremely inconvenient. Yet he was able to continue his work. This is Florence seen from Arcetri, at the house where Galileo spent his last years. He was not far from the convent of San Mateo, where his daughter Maria Celeste died the following year.

Galileo stands as the paradigm example of a scientist with novel ideas and emerging methodologies who was suppressed by a centralized institution more concerned with maintaining its cultural authority and political power than pursuing truth. • With this said, however, professional historians of science reject the widespread popular assumption that science and religion are locked in an inevitable conflict. Instead of seeing conflict everywhere, historians of science ❒ see "complexity": the relations between science and religion then, as now, are highly specific, local, and caught up in wider cultural and political currents, always defying easy summary. Some of Galileo's enemies were in the church, but so were many of his most ardent *supporters*. And some of his strongest supporters were Jesuits. Many of Galileo's most powerful antagonists were based in the *universities*. The political aspects of the conflict were at least as significant as the religious. The real story of Galileo is far more complicated than an inevitable conflict of science and religion, and I hope I have suggested that it is far more interesting.



So in each of these three aspects of the Galileo Affair the results are mixed. From Augustine's principles of interpretation, from Jesuit achievements in mathematics, and from the principle of contingency, it is clear that the unfortunate outcome was far from necessary. The circumstances were complex, and easily might have turned out otherwise. The Galileo Affair was not an *inevitable* conflict between science and religion.

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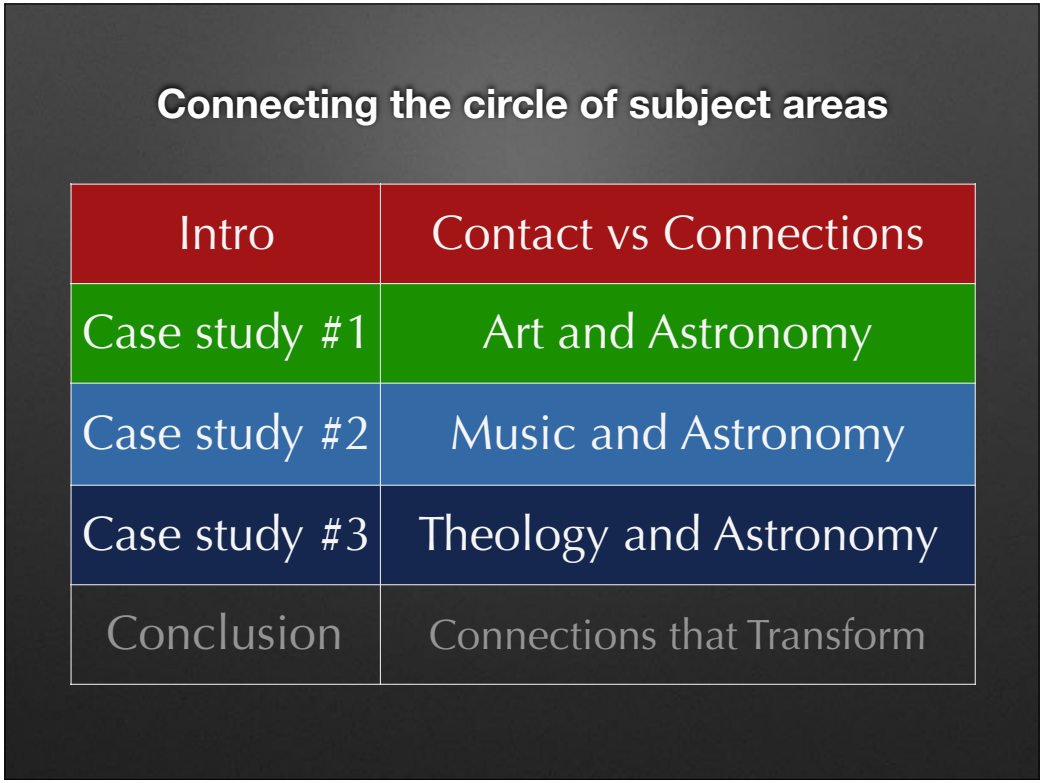
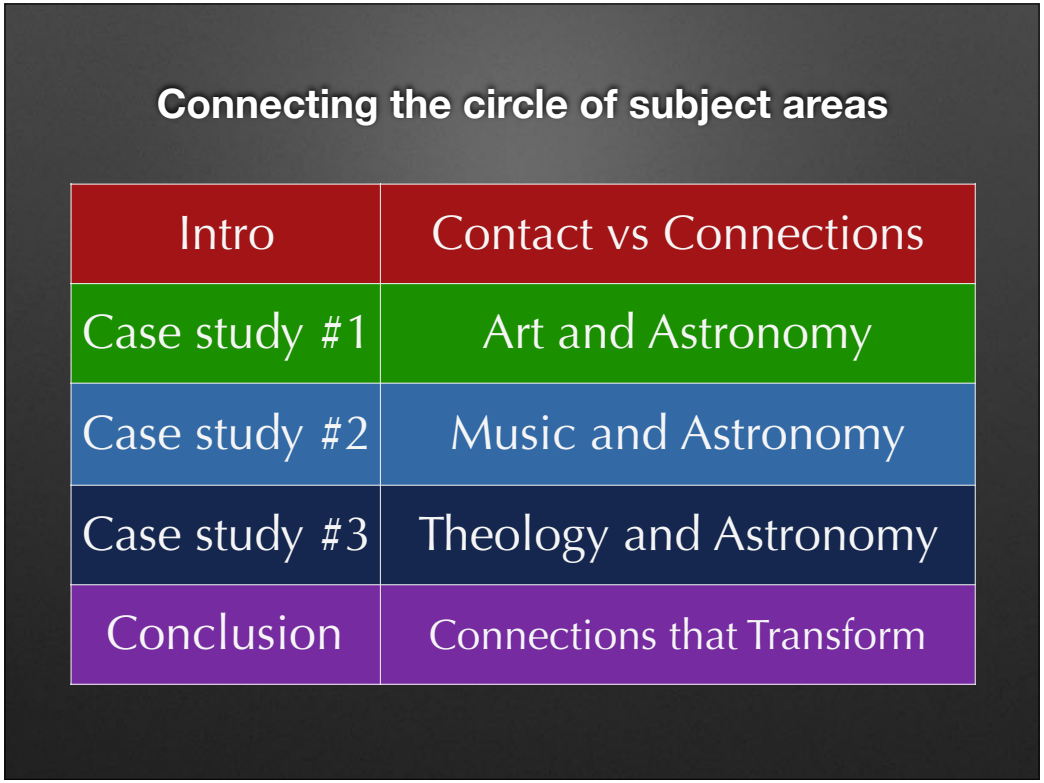
(shared alike by theology's concern for divine freedom and by the natural sciences in their need for empirical testing)

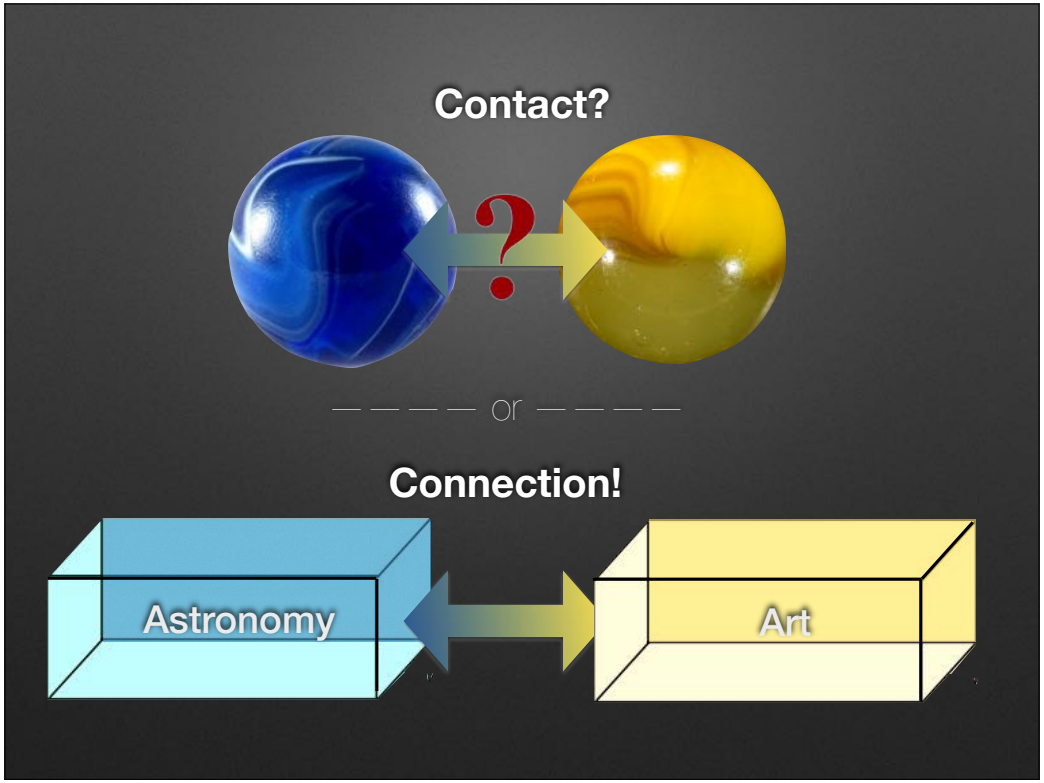


Let's move from theology and astronomy to

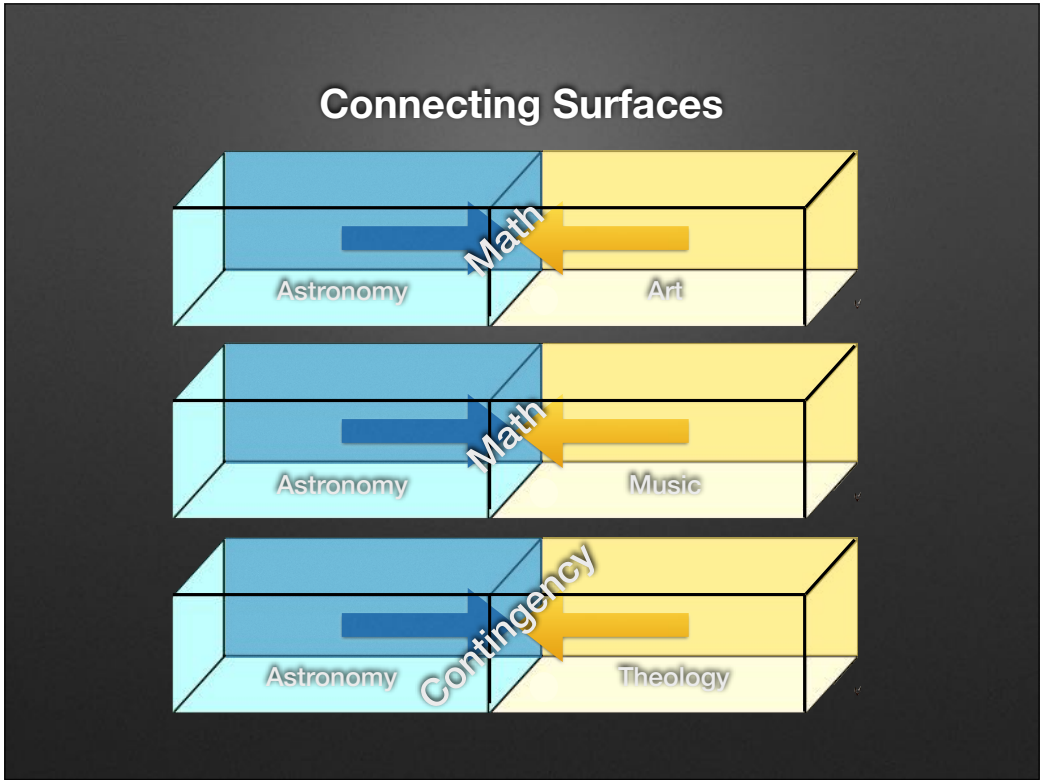


our conclusion, connections that transform, with some theological reflections. What does this all mean for JBU?

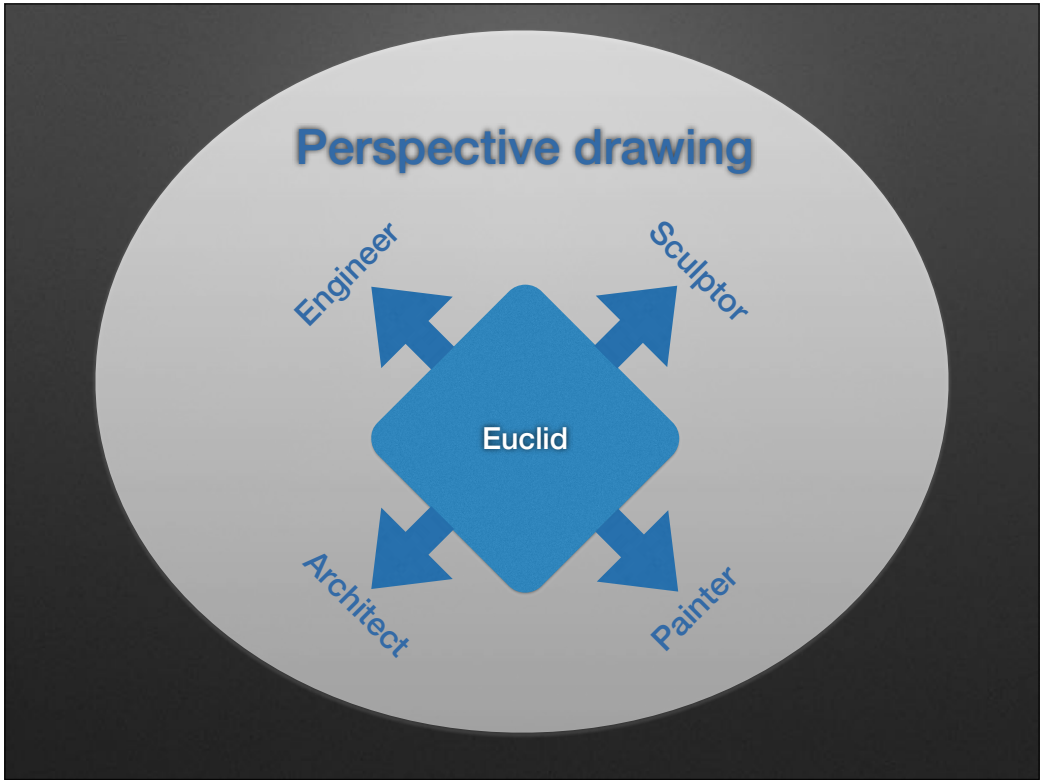
Galileo's World suggests that *NATURAL connections between disciplines… promote relationships of MUTUAL SERVICE… that spark creative transformations.*



To achieve that role of mutual service, the connections need to be natural connecting surfaces, not accidental contact; boxes, not marbles.



In Galileo's world we saw connections that occurred in a natural and constructive way between art and astronomy, and between music and astronomy, via the common surface of mathematics. We saw at least the possibility of a constructive connection between theology and astronomy, via the principle of contingency.



We saw that if you were a teacher in a Tuscan artisanal workshop, through the commonality of perspective drawing, you had something to offer students in diverse disciplines. What about at JBU? What shared interest does your discipline have in common with another? What is your Euclid, that connects you to others the way that perspective drawing did for them? How can your discipline help others to be more creative in what they do?

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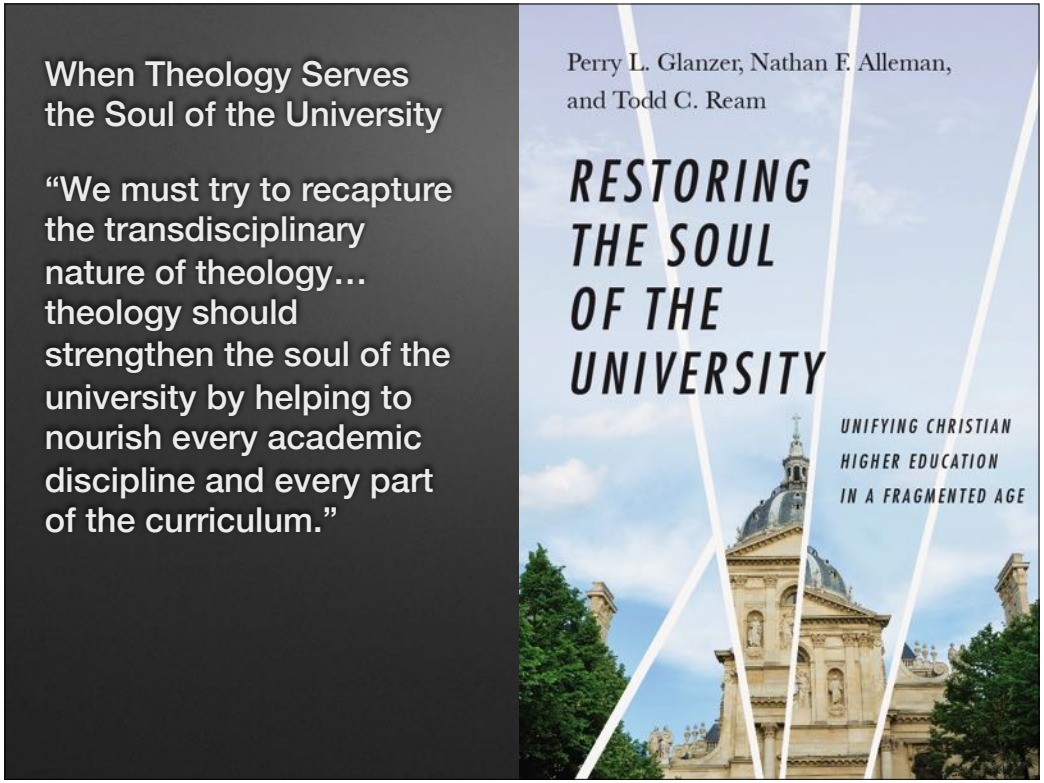
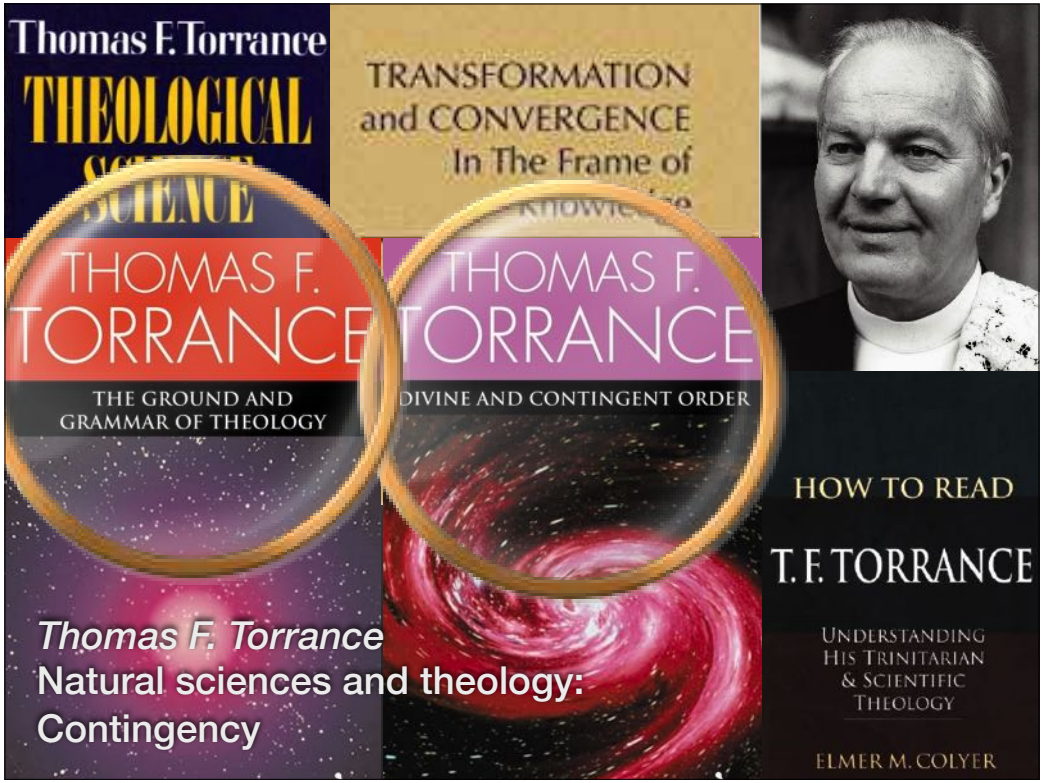
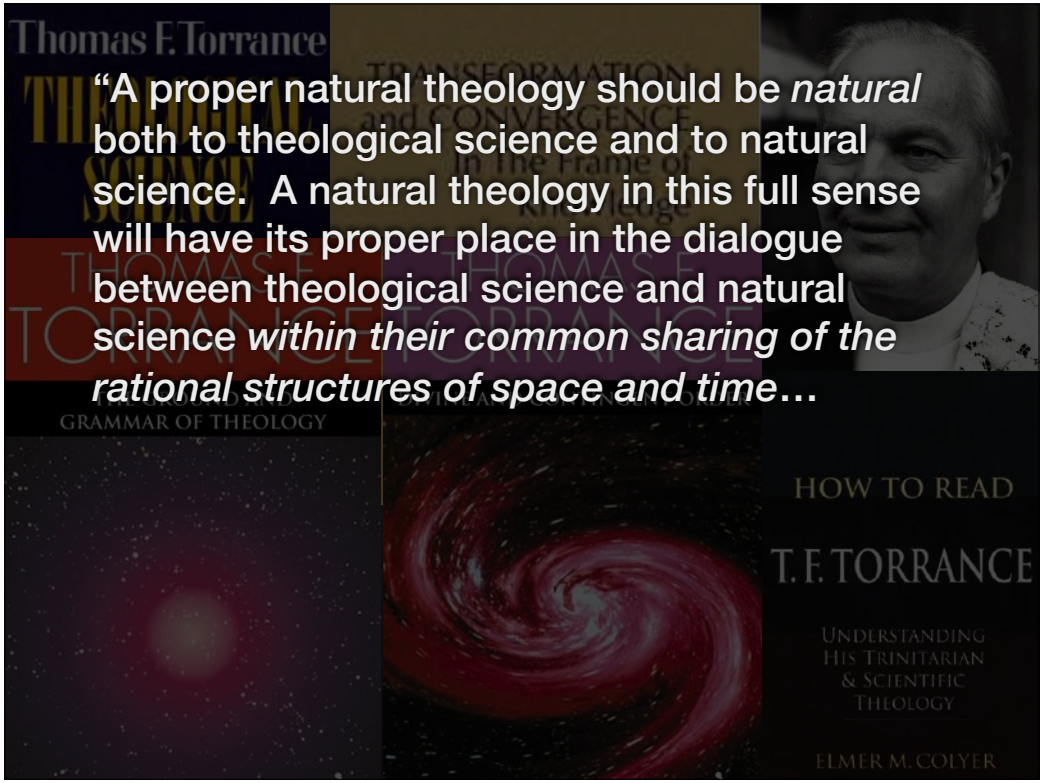
Look for emerging areas of multidisciplinary research, where common ground may be found in the development of new methodologies appropriate to new subject matter.



Let's start with shared theological perspectives. A recent study by Glanzer, Alleman and Ream, entitled Restoring the Soul of the University: Unifying Christian Higher Education in a Fragmented Age, • contains a chapter: "When Theology serves the soul of the university." They write: (read).

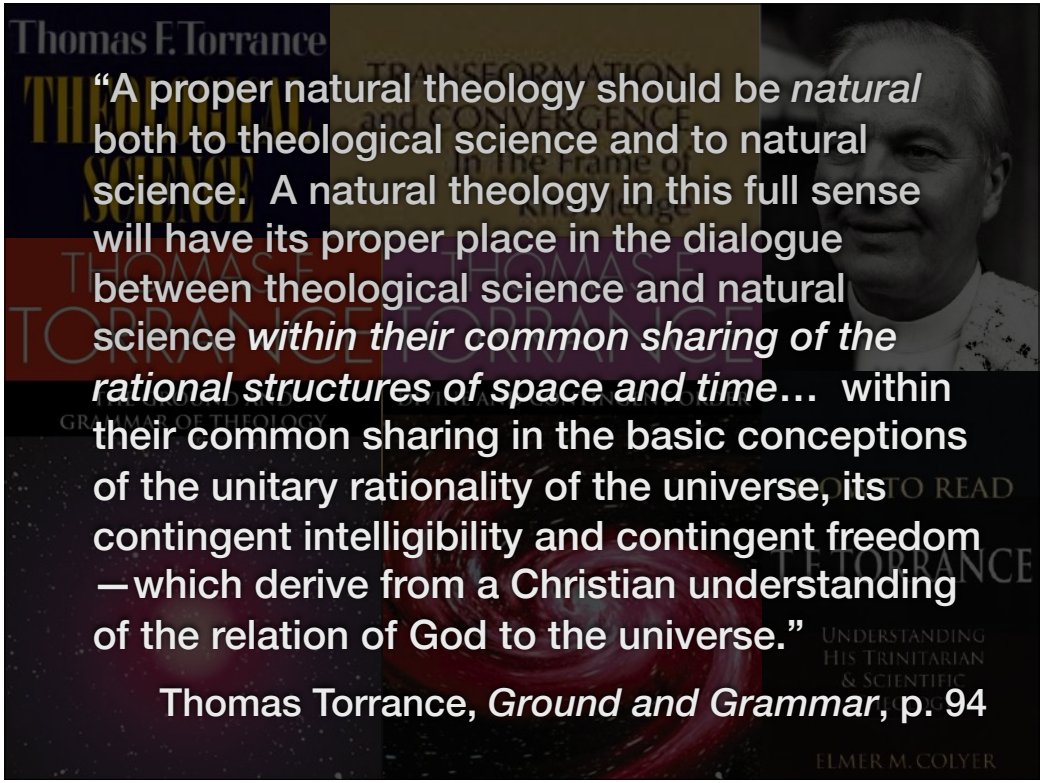


The writings of Thomas F. Torrance, mentioned earlier, exemplify the call for theologians to strengthen the soul of the university by seeking to nourish every academic discipline. • Torrance's *Divine and Contingent Order*, for example, is a magisterial exploration of the principle of contingency. • In *Ground and Grammar of Theology*, Torrance writes,

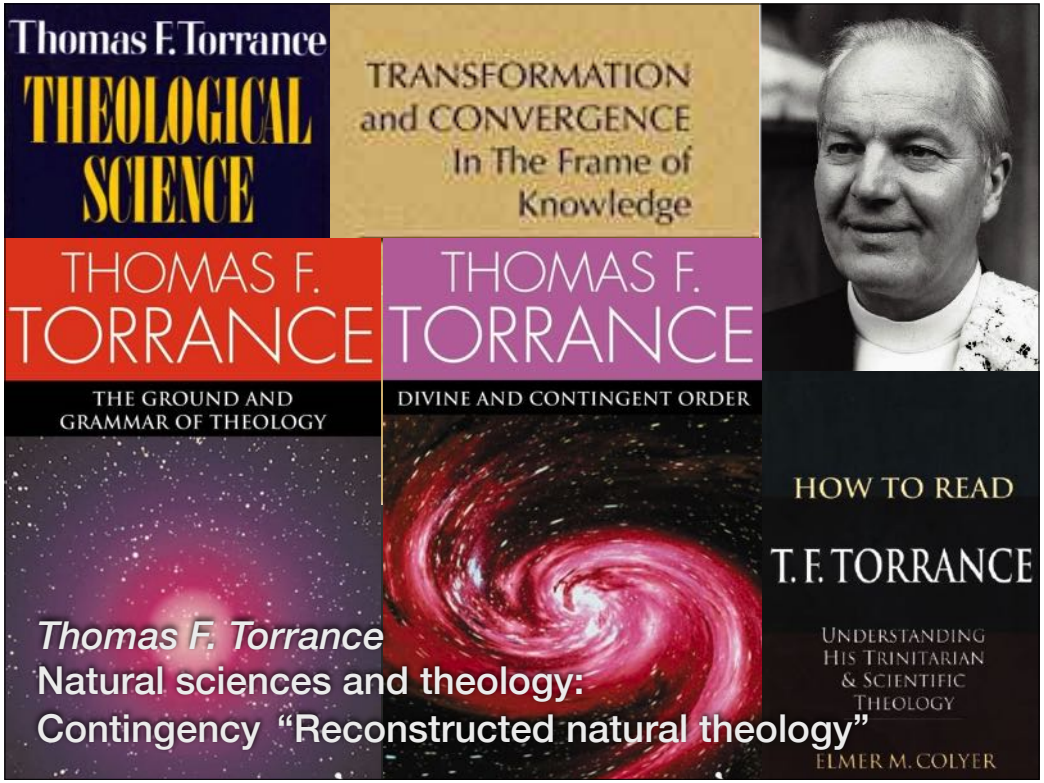


"A proper natural theology should be natural both to theological science and to natural science. A natural theology in this full sense will have its proper place in the dialogue between theological science and natural science within their common sharing of the rational structures of space and time."

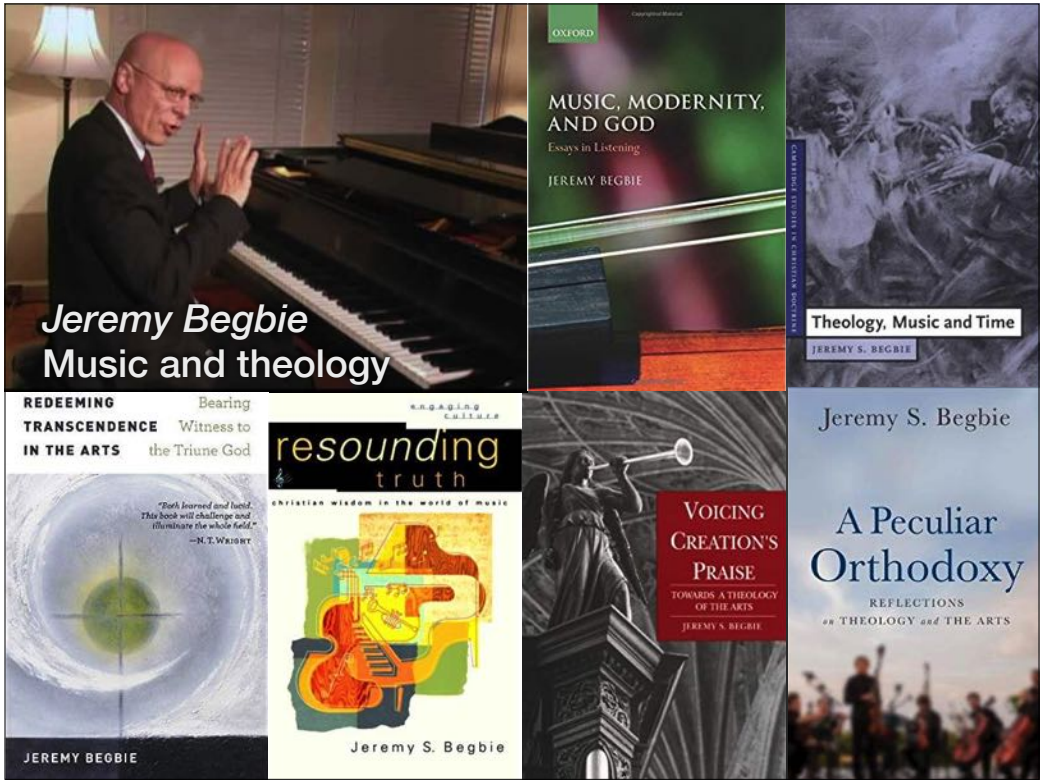
Those "rational structures of space and time" are the common surfaces, the shared sides of the boxes, such as, in the case studies we've explored tonight, mathematical intelligibility and the principle of contingency. Torrance refers to these kinds of connections in the next sentence:



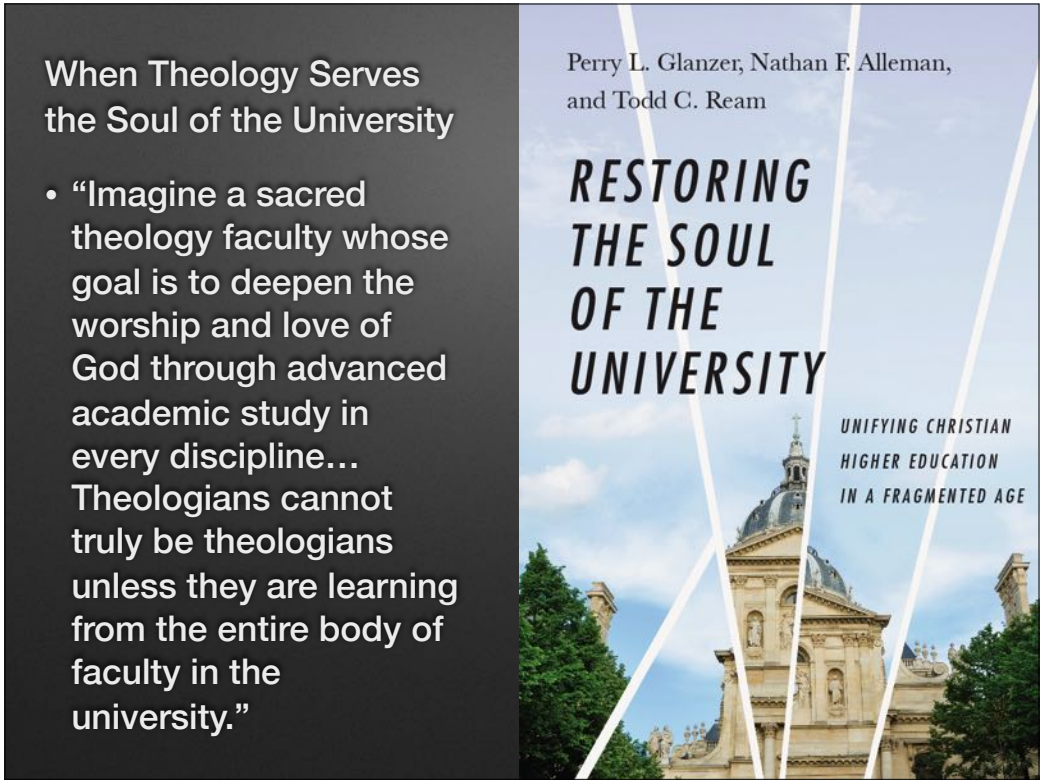
"within their common sharing in the basic conceptions of the unitary rationality of the universe, its contingent intelligibility and contingent freedom—which derive from a Christian understanding of the relation of God to the universe." Those rational structures of space and time include the language of mathematics and the principle of contingency we've touched upon tonight.



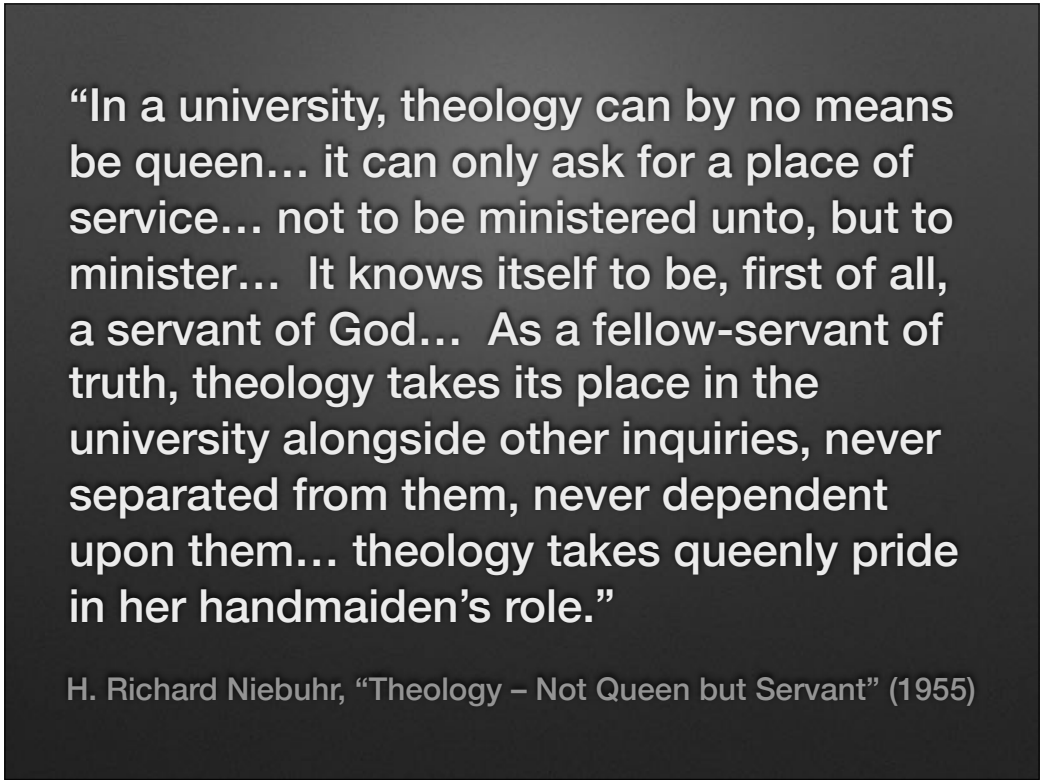
To repeat, Torrance's **reconstructed natural theology** is not apologetics in the sense of proving theology by means of science, but rather a searching out of how the sciences and other disciplines relate to one another in light of Christian theology. Why not pick up one of his books and dive deeper into Torrance's thought yourself? In my opinion, Torrance's writing on science and theology is one of the most valuable resources we have to help us think through these fundamental questions.



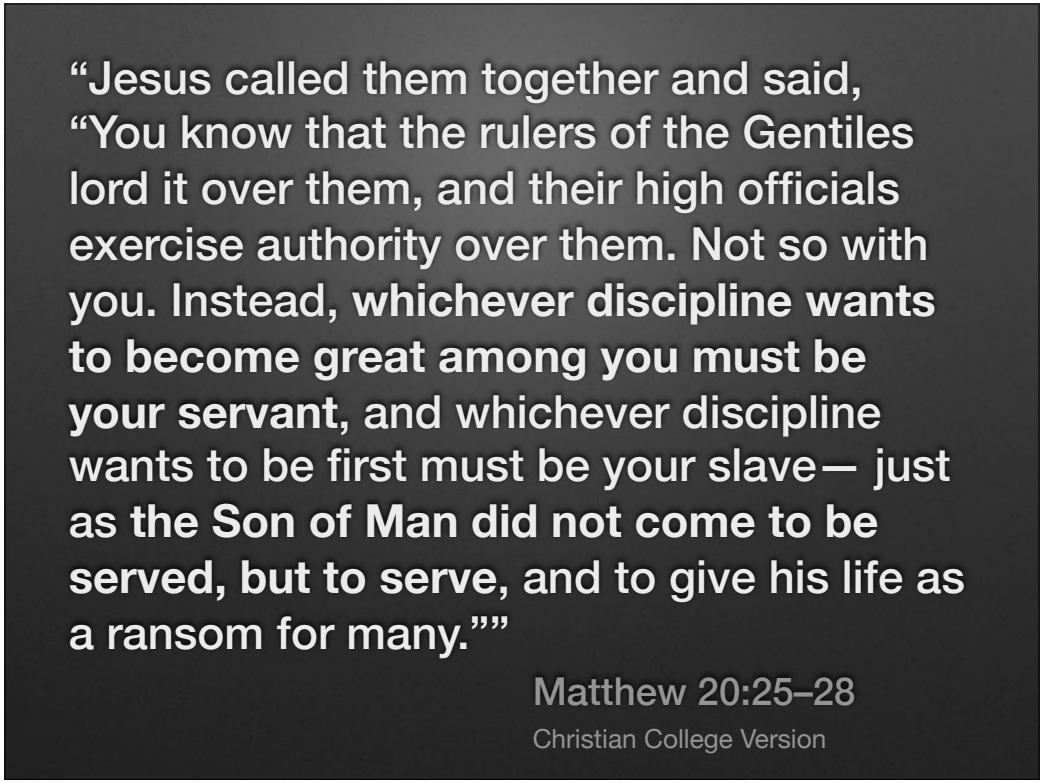
What would such an endeavor look like? Another theologian engaged in this kind of transdisciplinary conversation, influenced by Torrance and working in the tradition of Trinitarian theology, is Jeremy Begbie. Begbie's explorations of the interplay between music and theology exemplify the kind of connection we've examined tonight. If you will, Torrance and Begbie bring the spirit of Galileo's World into the modern university.



Theologians in the mold of Torrance and Begbie exemplify the ideal described by Glanzer, Alleman and Ream: (read). Such theologians respect the methodologies of other disciplines. Such theologians would not have committed the error of Bellarmine. Such theologians would have helped Galileo uncover the implications of divine freedom for the contingency of the universe.



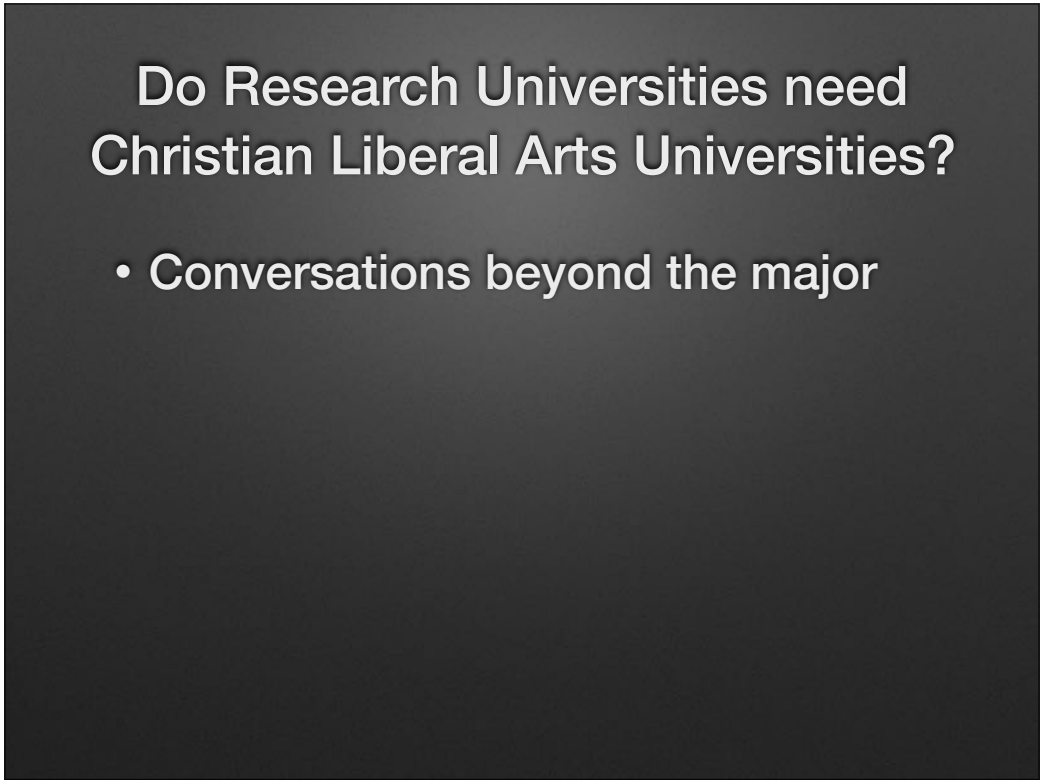
As Richard Niebuhr put it more than a half century ago: (read). It is not enough to call theology the queen of the sciences. If theology is to be queen, then in the kingdom of God she must be the handmaiden or servant of all. And as a servant, theology shows other disciplines by her example that they, too, must become servants. So theology herself calls us to go beyond the integration of theology and our own discipline, to a vision of multidisciplinary conversation in which the natural sciences also take up the handmaiden role as servant to others.



(READ). • This paraphrase is the Christian College Version. :) The theologian does not come to be served, but to serve. The mathematician does not come to be served, but to serve. The biologist, chemist, geologist, physicist and engineer do not come to be served, but to serve. Whatever your discipline and calling, it is given to you in order that you may give your life to serve those in other disciplines, those with other callings.

The challenge every research university faces is that all interesting problems are multi-disciplinary. If so, we need each other. We cannot all be Galileo's, Michelangelo's, Leonardo's, nor should we try to be polymaths of that sort. Rather, our aim is to • facilitate multi-disciplinary conversations. The Galileo's World exhibition was a multi-disciplinary conversation. To work in collaboration requires authentic conversations. As it happened in Galileo's World, how is it happening here, at this university?

Your experience may answer the question: Do research universities like OU need Christian Liberal Arts Universities like JBU? There are several reasons why Christian Liberal Arts Universities can show the way forward.



First, as a university that places a premium on teaching, you already cultivate conversations with students who are not majoring in your discipline. This deep, attentive listening, and these reflective conversations, are harder to achieve in a research multi-university. The kind of insight we need will come from these conversations beyond the major.

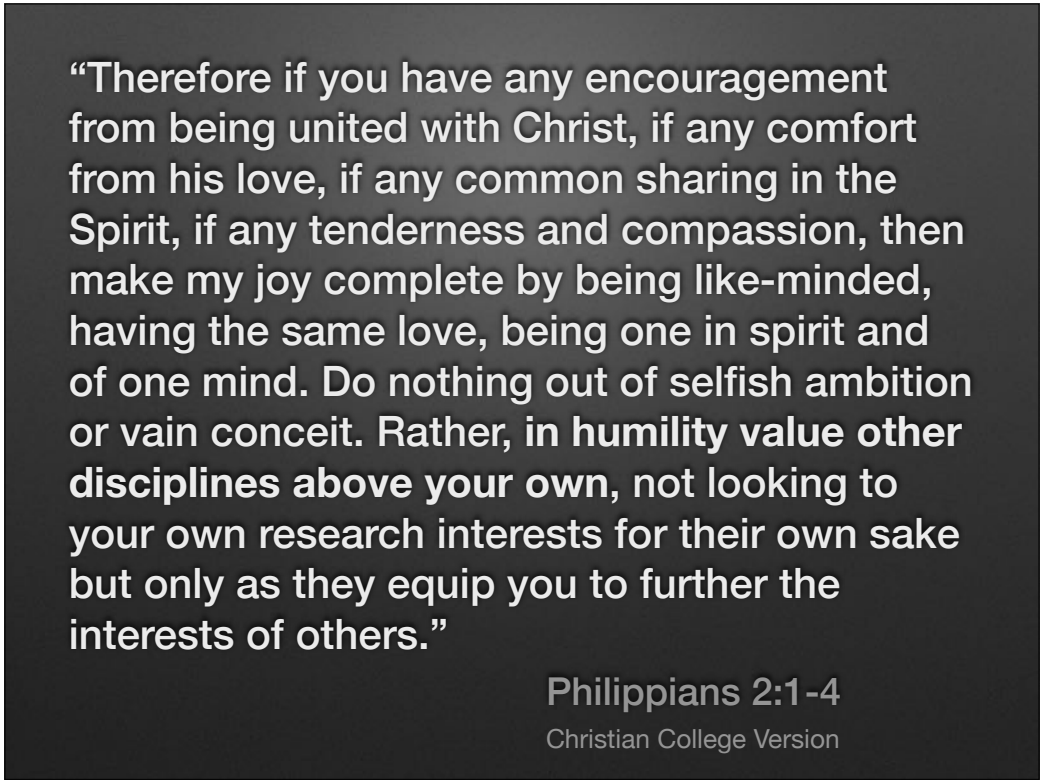
A second advantage is your ability to think through disciplinary identity in terms of disciplines-in-relation to others. • For Christians, there is no such thing as a thing-in-itself. Everything in all creation is being-in-relation, or “onto-relational.” If anything I’ve said tonight makes sense, then faculty and students in a Christian University will go beyond thinking through the integration of faith and learning in terms of one’s own specific discipline, and take up the calling to think through one’s own specific discipline as it is in relation to others, including – but not limited to – theology. Commit yourself to the idea that you do not really understand your own discipline until you can make clear its natural relationships with other disciplines. You cannot be who you are except in relation.

Let’s go back to the boxes. Neither box would be a box without this surface that, as it turns out, can be shared in common. The very definition of one box includes the relation shared with the other. The potential relations of your discipline to other disciplines, even though they require effort to uncover, are fundamental to the very definition of your discipline. It’s harder to develop the habit of thinking this way in a research university, but it’s essential nonetheless for all of us.

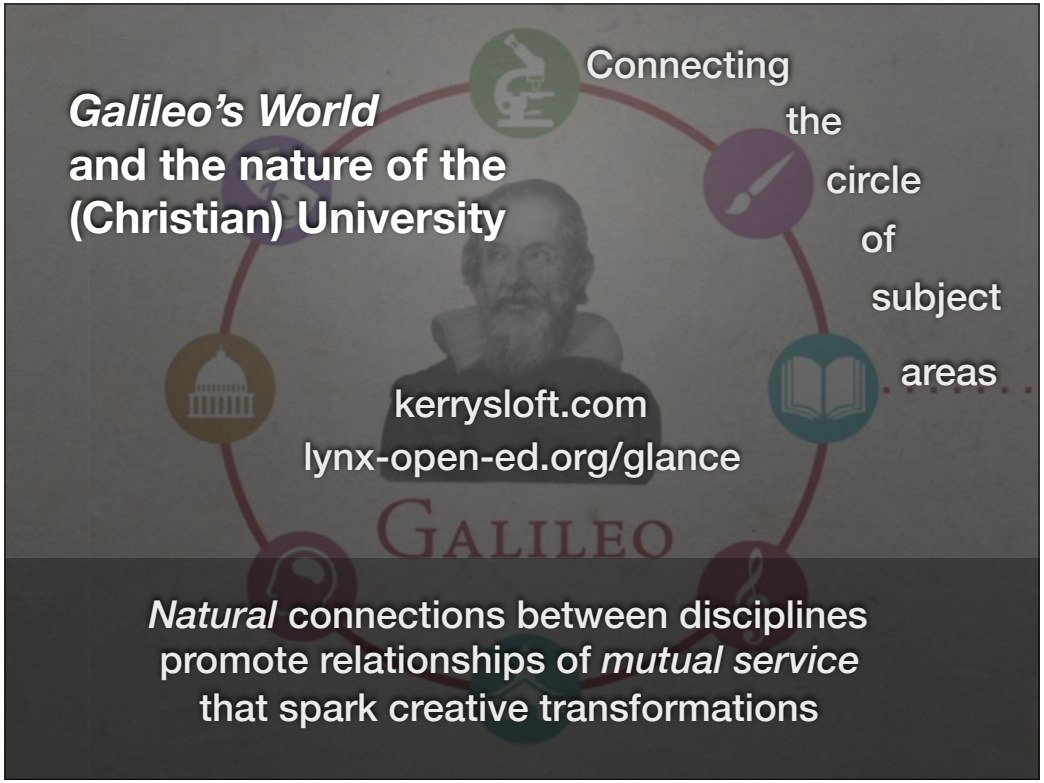
For Christians, thinking in terms of the onto-relational character of being is a habit formed by reflection on the Trinity. The relations between the Persons of the Trinity are essential to understanding any one of the three. The Son is the eternal Son of the Father, bound together in a relationship of love. If we know the Son, then we know the Father, and we know their love. If we then believe there is a created reflection of the Triune God's onto-relational nature in every creature, that would include disciplines. • So if you want a fancy name for what we've been exploring tonight, try onto-relational theory of disciplines. • Or a Trinitarian theory of disciplines. • This is another name for what Torrance called a "reconstructed natural theology," discerning the natural relations of disciplines in light of Trinitarian theology. Or, for my friend Dr. Hahn: Instead of marbles and box surfaces, we might have used instead the analogy of • a field theory of disciplines. James Clerk Maxwell tried to think through then current problems of physics, in light of his Trinitarian theology. As a result, he taught us to think of electromagnetism in terms of field theory rather than discrete atoms or electrons. So, rather than conceiving the University as discrete particles, think of the University as an electromagnetic field, where each discipline exists in fundamental relations with others. So that's disciplines-in-relation.

Furthermore, in the Christian university, each discipline-in-relation will be marked by the humility of a calling to mutual service. The hierarchy of disciplines is turned on its head. The one that is greatest will be the discipline that succeeds most effectively in service to all. Give your life to the calling of your discipline for the sake of service to others. Serve others as a member of the one body of the university.

Dare we say it? In a Christian ordering of the disciplines, love is the ultimate form of interdisciplinarity. All of these points are just another way of asking: • (SLOW) What would a Christian university look like if practitioners in every discipline were devoted to placing their discipline in humble service for the benefit of every other? (PAUSE) This would be the university analogue of the Trinitarian relations, the loving communion of the Godhead. What does this look like for you?



READ. If Christian universities fulfill their calling in this way, then it is not too much to hope that the renewal of higher education that results may spread to the large research universities as well. It may contribute to fulfilling the vision Eaton described for universities to restore communities of trust, and to live out a radical hope for the flourishing of the world. That is my prayer.



Thank you.

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