One World, One Sky
The Big Picture

John R. Percy

Department of Astronomy and Astrophysics
University of Toronto
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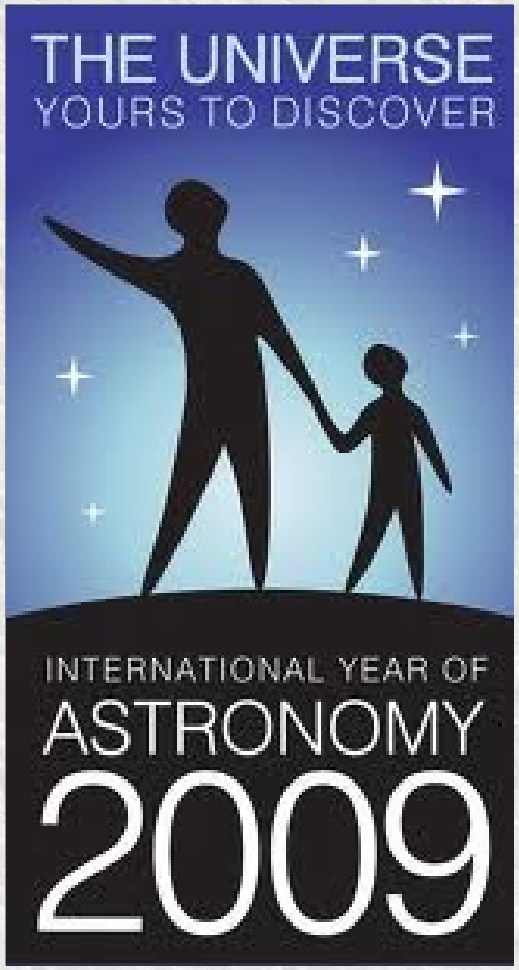
Outline

- International Year of Astronomy, and beyond
- Astronomy and culture: practical and philosophical connections
- The development of astronomical science
- Broadening astronomy
- Diversifying astronomy
- Developing astronomy

International Year of Astronomy 2009



International Astronomical Union

- A 148-country celebration of Galileo's development and first use of the astronomical telescope
- In Canada: over 3,600 events reaching millions of people in schools, libraries, parks etc.
- Success due to partnerships, and thousands of volunteers

Beyond IYA

International Astronomical Union

- Astronomers around the world will continue their outreach to the public
- In Canada: focus on reaching youth in underserved populations – inner-city, rural/remote, Aboriginal, Black etc.
- Strategy: partnership with schools, libraries, parks, communities – partners with knowledge and experience

Reaching the Underserved

Through inspiration, diversity, culture

- Inspire every young person through the excitement of the universe, and the wonder of the night sky
- Demonstrate that astronomy is done by diverse people of both genders and all cultures
- Connect people – young and old – with the astronomy which is deeply rooted in their culture

We Are All Starstuff

NASA/ESA/HST

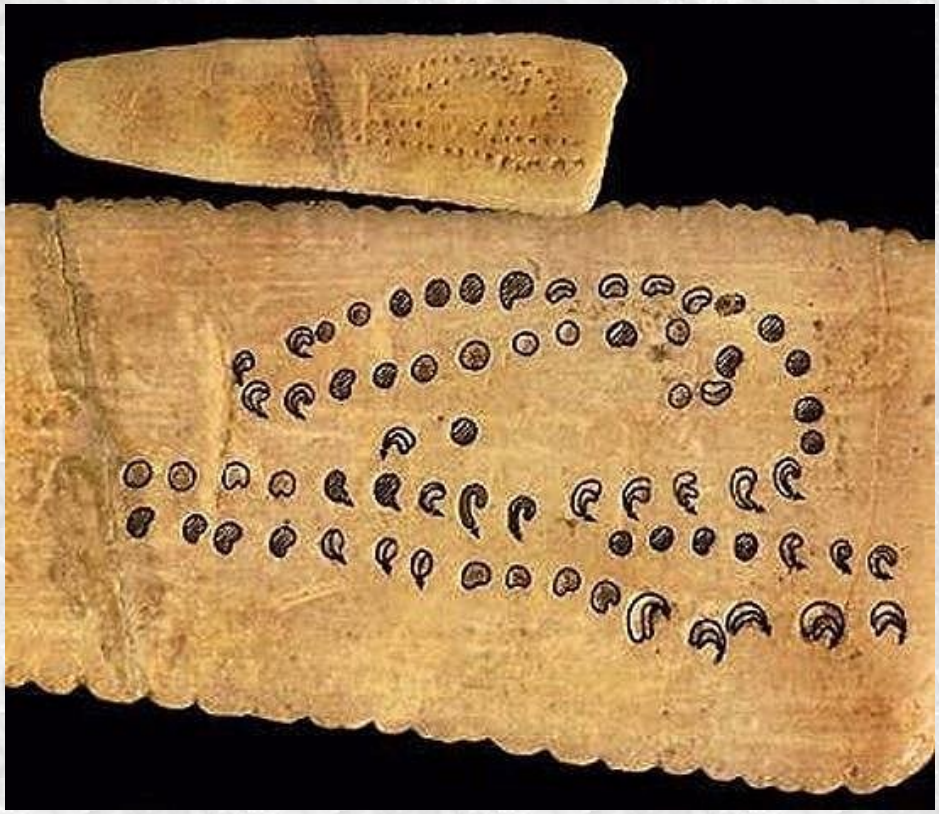
- The atoms of life were created in the birth of the universe, and inside stars, and recycled into the clouds from which planetary systems are born – including our earth and sun
- All life on Earth is related; extraterrestrials (if any) are our “cosmic cousins”

Earth – Our Common Home

NASA

- Life has developed on our planet for 4 billion years
- We share our planet with billions of other people, and countless other living organisms
- We all have a cosmic origin, and a common history – one world, one sky!

The Beginning of Astronomy



- This may be a moon calendar, carved on a bone, tens of thousands of years ago
- Over 70,000 years ago, humans in Africa may have used observation of moon phases to determine when to catch shellfish

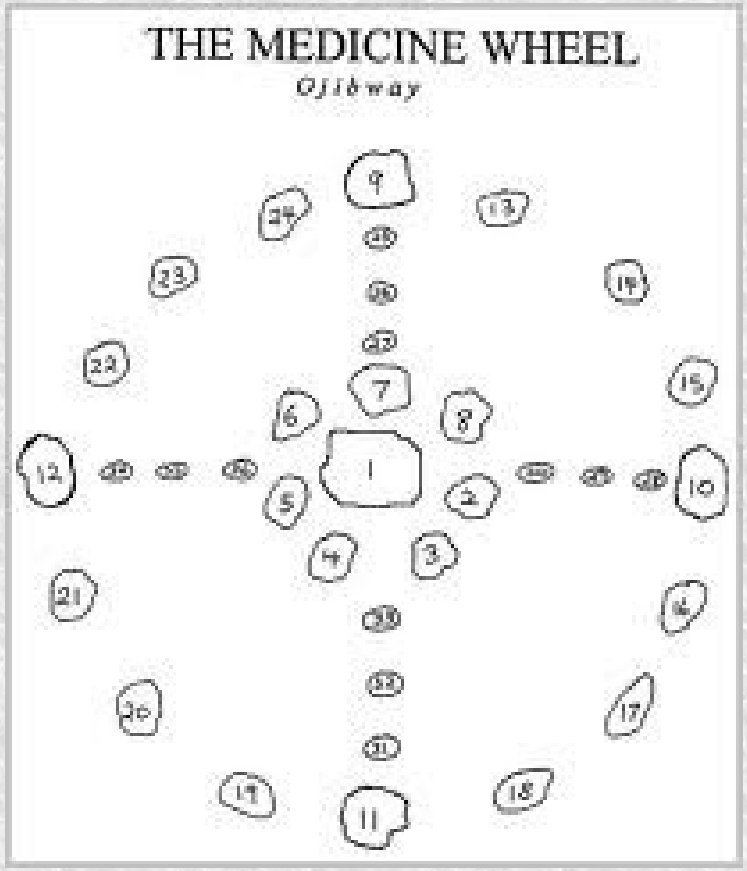
Astronomy and Civilization

Chichen Itza: Cesar Ramirez

Great Pyramid: Paul James Cowie

- Every advanced civilization has used the sky as a clock, calendar, and compass, for practical and ceremonial purposes
- This includes the great old-world (China, Egypt, India) and new-world (Inca, Maya) civilizations
- Astronomy is part of the technology and culture of these civilizations, and should be studied as such

Astronomy and Aboriginal Civilizations



- Aboriginal civilizations, including those in North America, have also used astronomy for practical and ceremonial purposes
- Astronomy is part of their deep understanding of their environment, as well as part of their spiritual world -- as it is for other civilizations

Integrative Science

Gerald Gloade

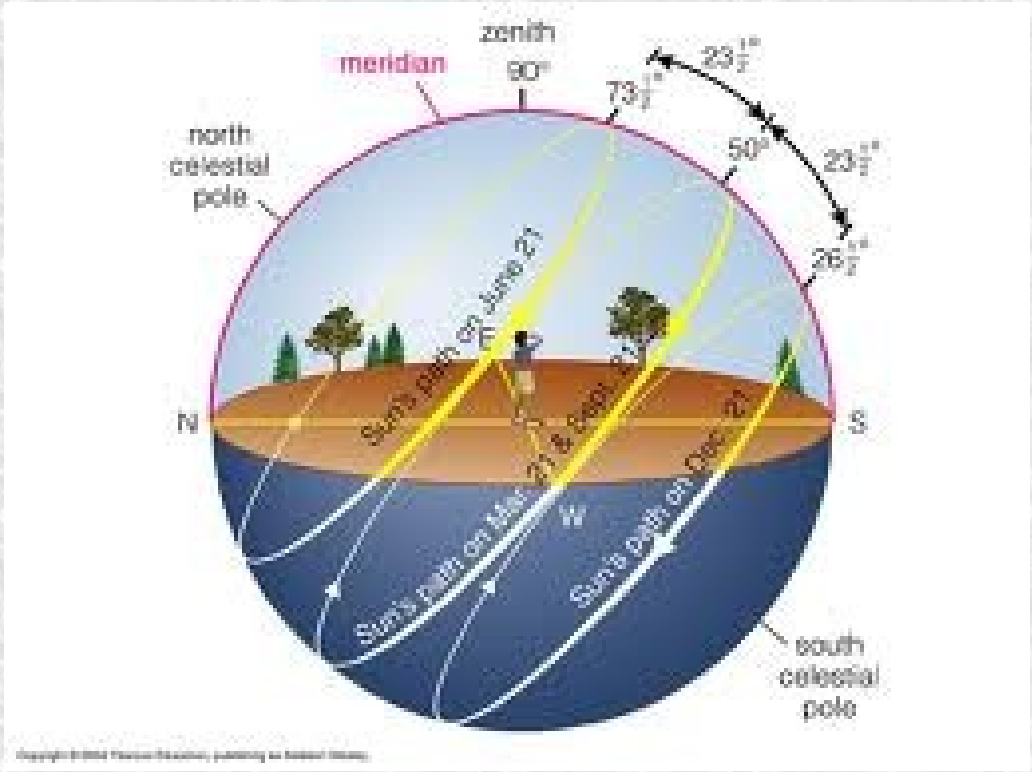
- Integrative science brings together knowledges and ways of knowing from indigenous and Western science
- It was developed at Cape Breton University by scientists and elders from Mi'kmaq College Institute
- It enhances education, outreach, research, and application

The Starry Sky

The constelaltion Orion

- The stars form arbitrary patterns which are defined and named differently by different civilizations – according to their needs, beliefs, and culture
- We use Graeco-Roman constellations, plus southern constellations named during the industrial revolution – 88 in all

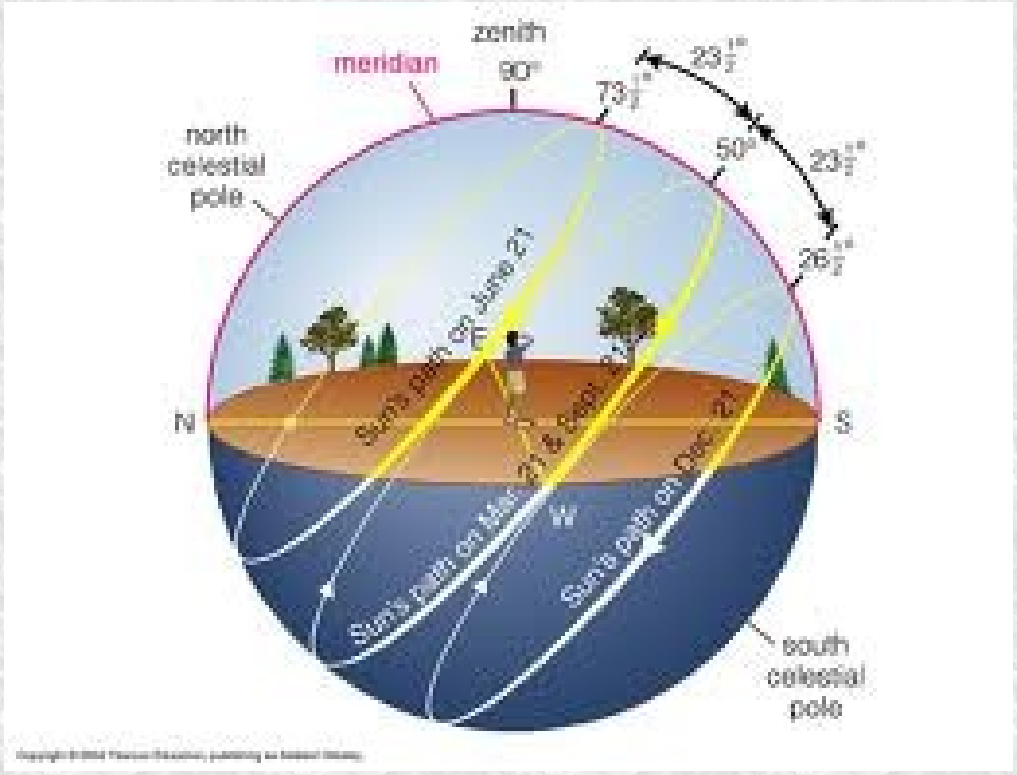
The Sky Clock



- The earth's daily rotation, and the light of the sun define a day-night cycle
- The sun is highest in the sky at noon; this (or midnight) defines a starting point
- The celestial equator can be divided into “hours”
- The rising and setting of these, and the sun, further divide day and night

Professor C. Seligman

The sun's daily path in different seasons

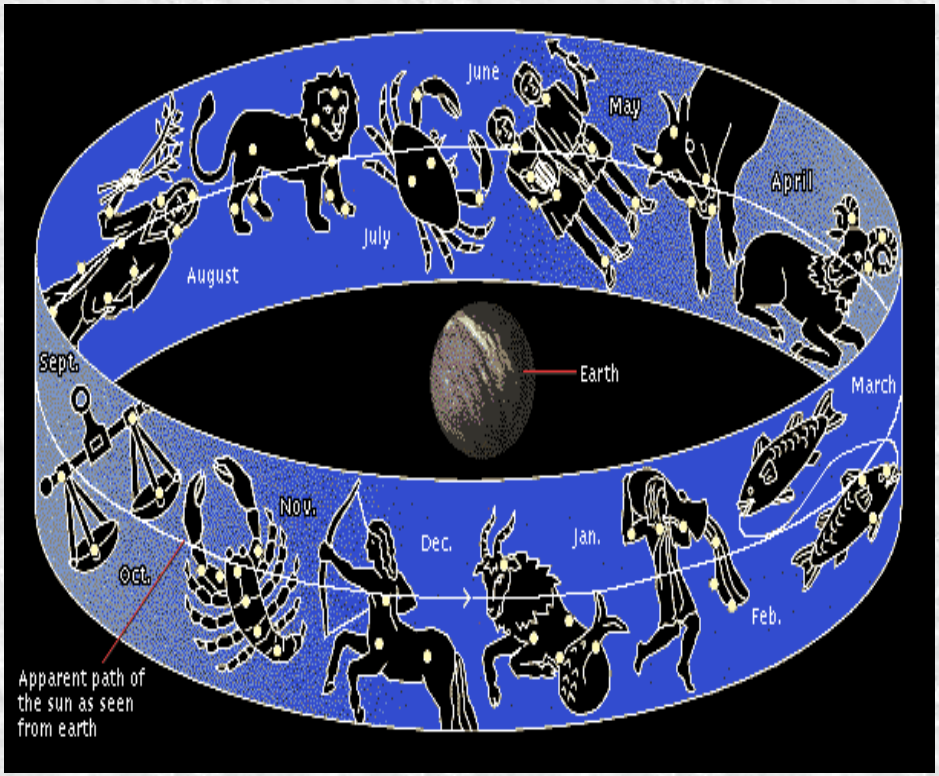


- As a result of the tilt of the earth's axis, the sun moves north and south during the year
- This affects the number of hours of daylight, and the height of the noonday sun; this causes the seasonal changes in temperature
- It also affects the position of sunrise and sunset

The Sky Compass

- The earth's rotation axis defines directions on earth: the north and south poles and equator
- Their projections on the sky – the celestial poles and equator – define the same directions
- And the sun is due south or north when highest in the sky at noon

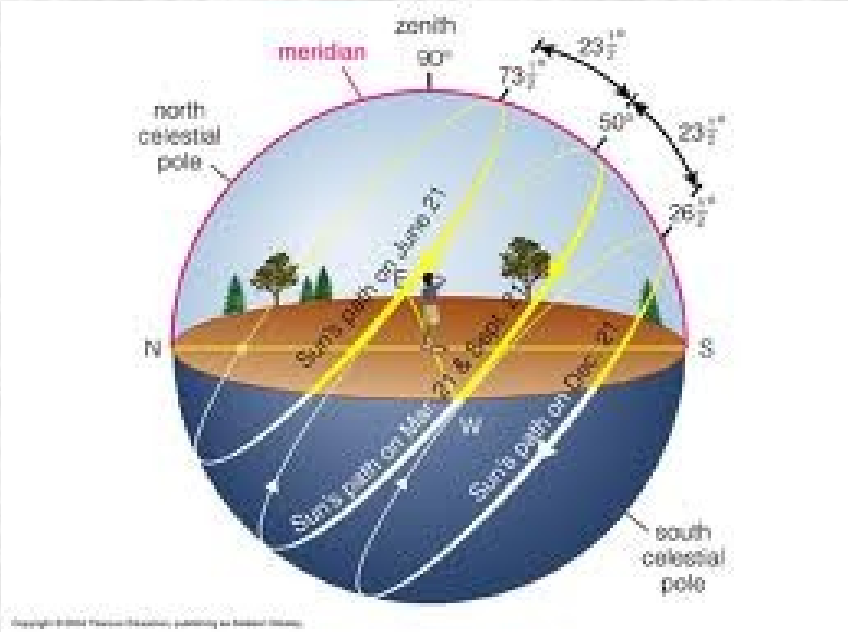
The Sky Calendar



dailygalaxy.com

- The earth's rotation axis is tilted; this and the earth's revolution produce seasonal changes in temperature which had crucial effects for every civilization
- As a result of the earth's revolution around the sun, the constellations visible in the night sky change during the year, and can be used to keep track of, and predict the seasons

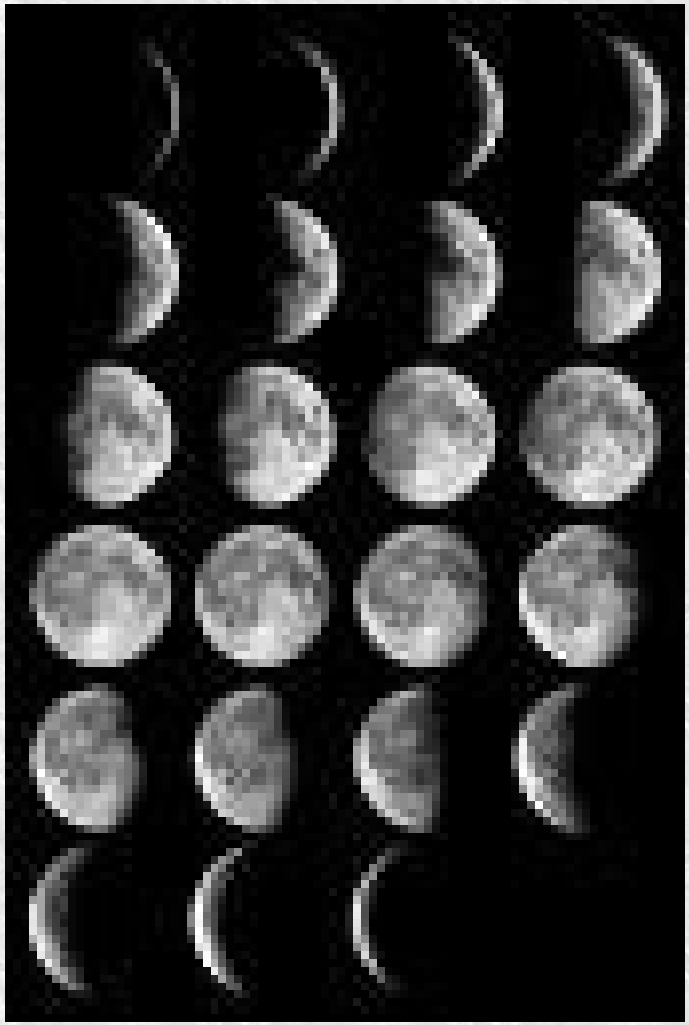
Seasons and Sunrises/sets



Stonehenge: British Tourist Board

- Sunrise and sunset points move northward and southward during the year
- Early astronomers could determine the time of year (seasons) by observing the rising or setting point of the sun on the horizon
- This was done in many parts of the earth

The Moon



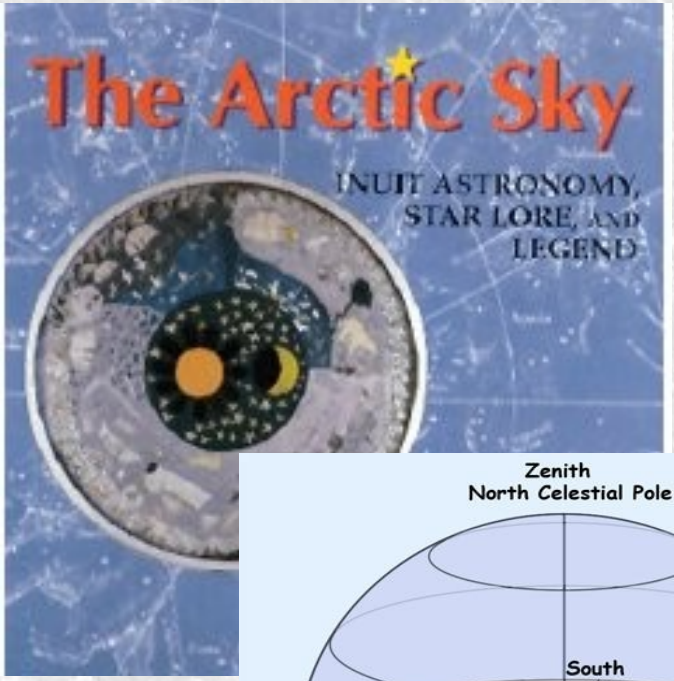
Antonio Cidadao

- The moon revolves around the earth; this and its illumination by the sun produce a 29.5-day cycle of phases
- The moon provides light for night-time activities, and also affects the cycle of the tides
- Humans, 70,000 years ago, may have used observations of the moon when collecting shellfish

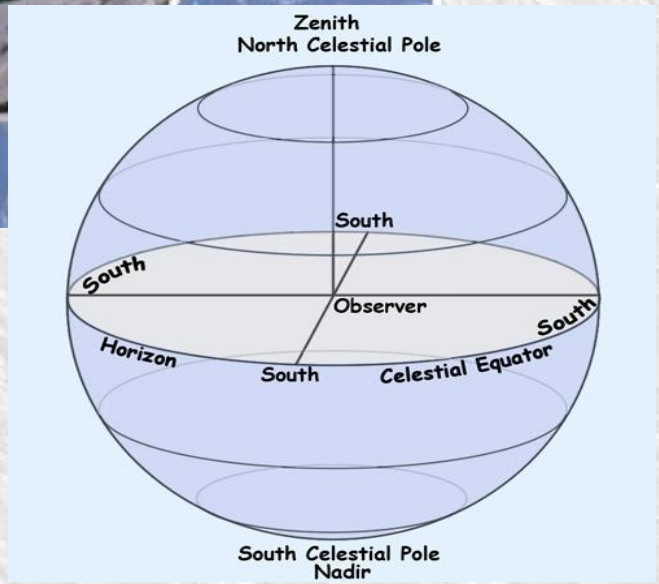
Calendars Today

- Problem: the lengths of the day and month (29.53 days) do not divide evenly into the length of the year (365.2422 days)
- The Islamic calendar is based on the moon; the month and year begin with the crescent moon, and the year is 12 “moons” long.
- The Christian calendar (which is used in Canada for civil purposes) is based on the sun: the year begins (approximately) on the first day of northern winter.
- Many Asian calendars are luni-solar; they are based on the sun and moon. The year begins with the new moon, but the year may be 12 or 13 “moons” long, to keep it in step with the solar year.

Inuit Astronomy



Royal Ontario Museum



Professor C. Seligman

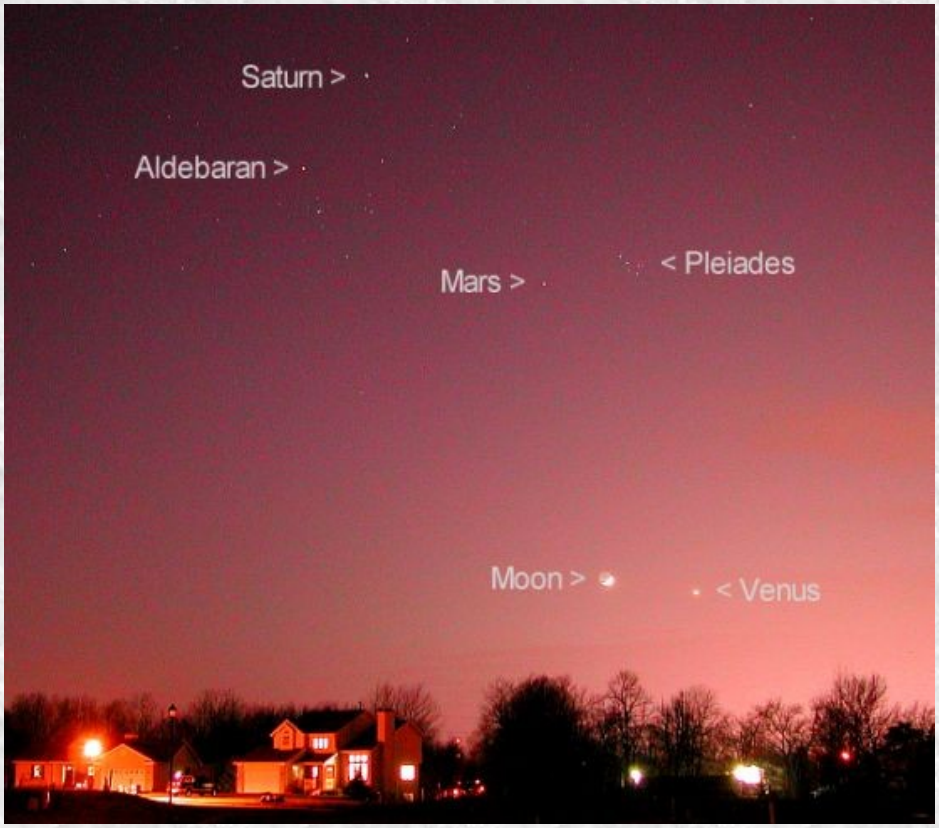
- At high Arctic latitudes, the sky moves more parallel to the horizon; rising and setting are less apparent
- The sun is below the horizon for many weeks in winter, and above the horizon for many weeks in summer (“the midnight sun”)
- The Inuit used the day and night sky, and other observations of the environment, for practical and ceremonial purposes

Polynesian Astronomy

US Postal Service

- For their long sea voyages between islands, the Polynesians needed to be able to navigate
- They used the night and day sky, including the rising and setting points of equatorial stars and other observations to do this
- Their knowledge and traditions were handed down from generation to generation

The Planets -- Wanderers



John French

- The sun, moon, and five naked-eye planets move against the background of the stars
- They were associated with gods and supernatural effects
- The seven days of the week are named after these seven bodies

Explaining Things -- Astrology?

- Lacking any natural explanation for earthly events, civilizations developed supernatural explanations (or religions), including astrology; this is still true today!
- These were connected with the sun, moon, and five naked-eye planets
- Perhaps their motions could explain – and even predict – events on earth, a hypothesis not supported by evidence

Explaining Things -- Comets?

- Comets are icy objects from the outer solar system which appear in the sky for a period of weeks, unpredicted -- unlike the planets
- They were regarded as omens, especially by civilizations (such as the Chinese) whose culture was sensitive to unpredicted events

Explaining Things – The Aurora?

Terence Dickinson

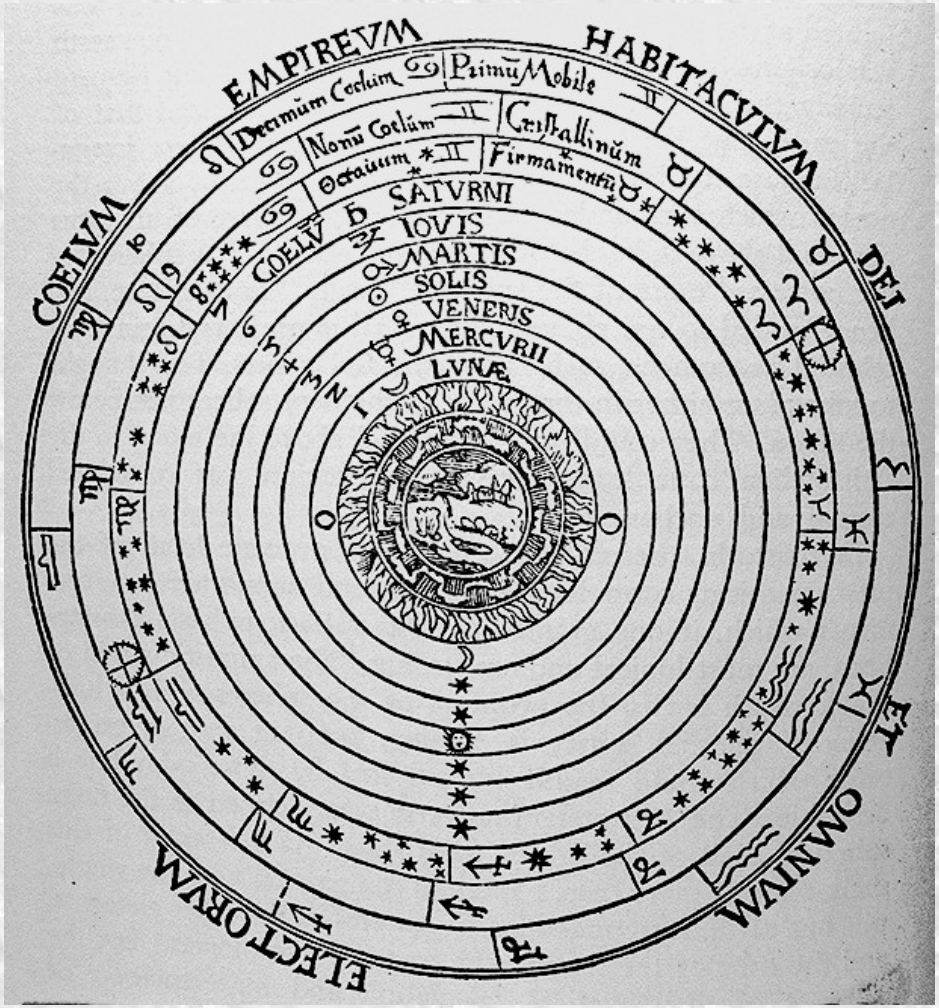
- The aurora is produced by solar particles which energize atoms in the upper atmosphere, and make them glow; it is most common at high latitudes
- For cultures such as the Inuit and Sami, living under dark skies, it was especially striking; they developed various explanations and meanings for it

Astronomical Science -- Babylonian

Babylonian stone with astronomical Inscriptions: British Museum

- Western astronomy, including systematic observation and record-keeping, is descended, though Greek astronomy, from Babylonian astronomy
- Predictions of the positions and motions of the sun, moon, and planets were developed (mostly for astrology) and verified by observation, starting over 3000 years ago

Astronomical Science -- Greek



- Using the geometry developed by Euclid and others, the Greeks developed a good understanding of the geometry of the earth-moon-sun system
- Their cosmology, developed by Aristotle and others, was earth-centered, and assumed celestial objects to be perfect and unchanging

Astronomical Science -- Chinese

Armillary Sphere: Beijing Ancient Observatory

- Chinese astronomers built sophisticated (and beautiful) instruments for observing the sky
- They made careful observations of the sky – especially unexpected phenomena
- They kept records, over more than 2000 years, which are still used today

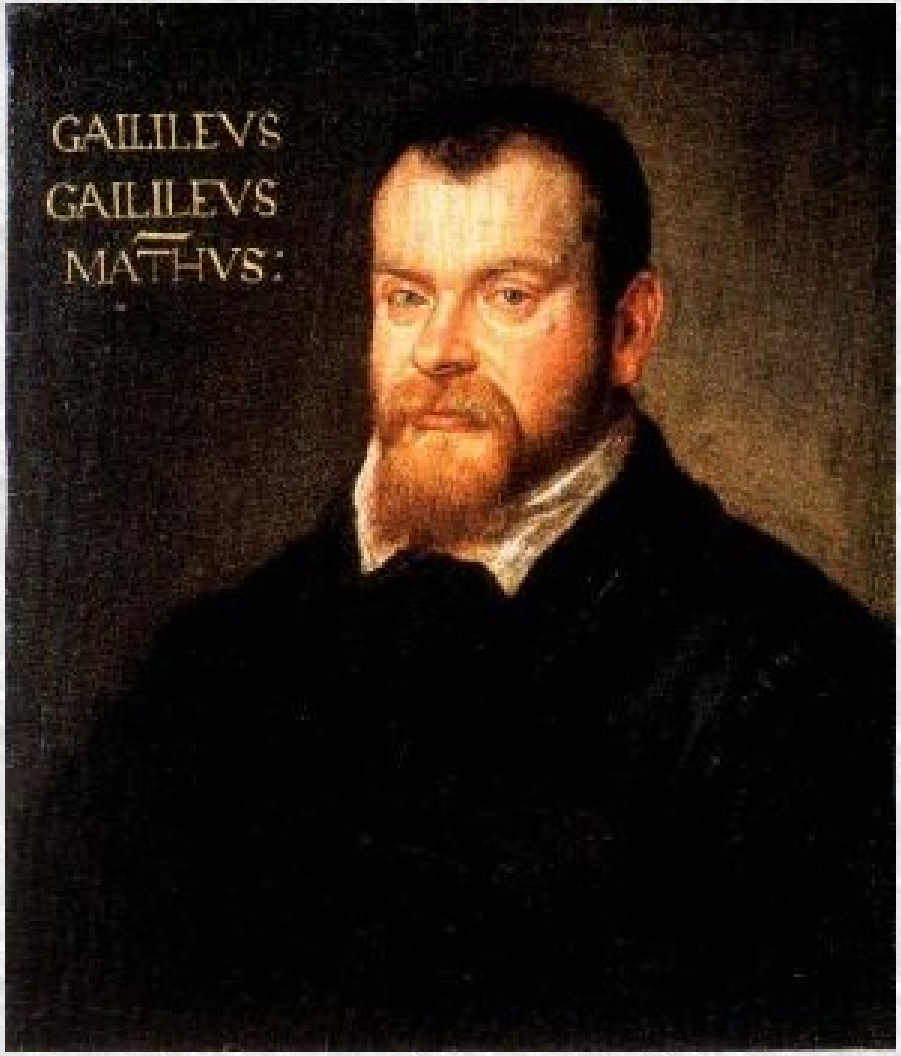
Astronomical Science -- Islamic

Ulugh Beg and his observatory
In Samarkand: USSR Postal Service

- Islamic astronomers preserved astronomical knowledge through the European “Dark Ages”
- They built sophisticated instruments, and used them to make careful, sustained observations
- They made significant contributions to the mathematics needed in astronomy and the other sciences

The Birth of Modern Western Astronomy

Copernicus, Tycho, Kepler, Galileo, Newton



National Maritime Museum, UK

- Galileo, the motivation for IYA, developed and used the first astronomical telescope
- His observations of the moons of Jupiter showed that not all objects orbit the earth
- His observations of Venus supported the sun-centered model of the solar system
- His observations of the moon and sun demonstrated their non-perfect, non-Aritotelian nature

Astronomical Research Today

NASA/ESA/HST

- Astronomers use large, expensive telescopes on the ground and in space to observe and study the nature of the universe and celestial objects in it
- They compare their observations with powerful computer simulations to understand the universe, and develop and test new theories about its nature and origin

Astronomy is Not Just Done by NASA!

Gemini Observatories

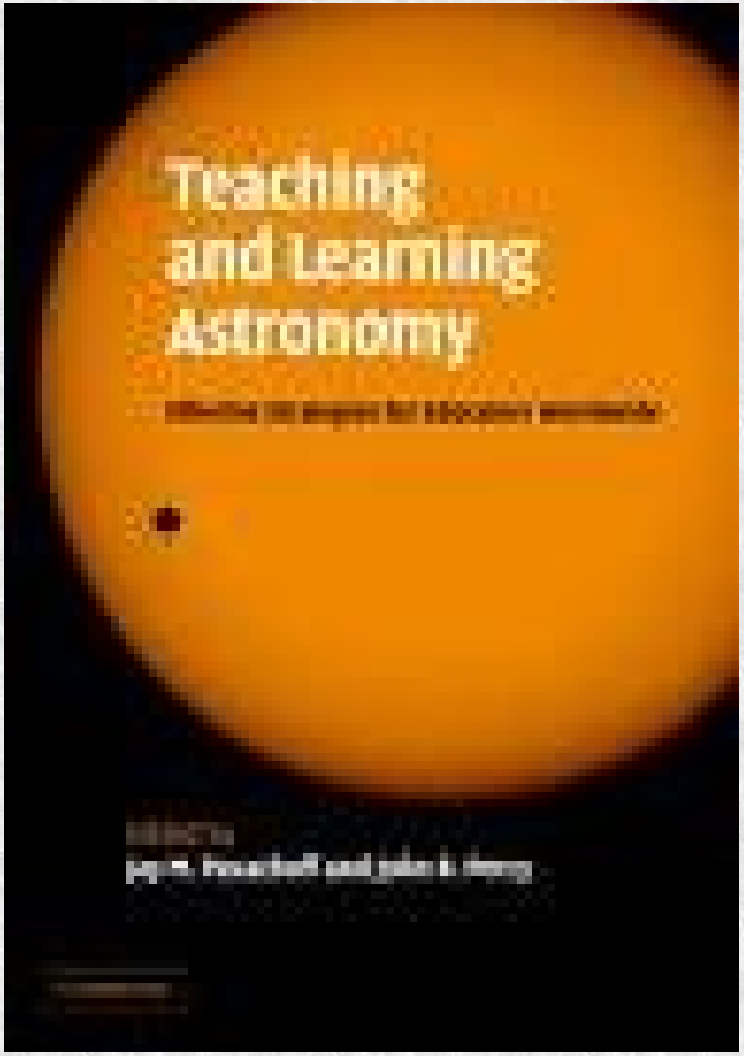
- There's a misconception that most astronomy is done by NASA (and ESA) with the HST
- Astronomy is done with ground-based telescopes operated by many countries, including Canada
- Space astronomy is also done by the European, Russian, Japanese, Chinese, Indian, and Canadian space agencies

Astronomy Today – A Broader Picture

NASA

- Modern astronomy continues to excite and inspire people of all ages
- People are also interested in the cultural and practical aspects of astronomy
- There are powerful connections between astronomy, the arts, history and philosophy
- Astronomy education and outreach to non-astronomers are important!

Astronomy Education



- In grade 6 and 9: but few teachers have any background in astronomy, or astronomy teaching
- In university: “astro 101”
- The public: amateurs make important contributions here

Astronomy and the Arts

Tafelmusik Baroque Orchestra's Galileo Project

Tafelmusik Baroque Orchestrra

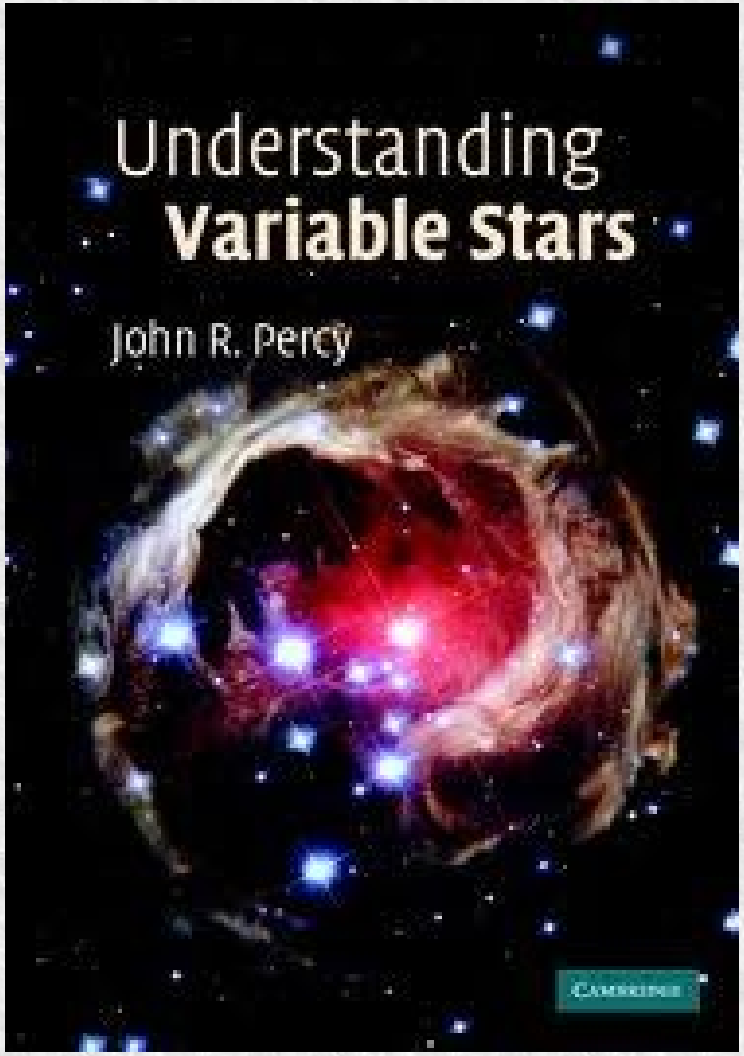
- The Galileo Project is a stunning multimedia program about science and music in Galileo's time; it includes music, narration, images, and choreography
- It has been performed in Canada, the US, and Mexico, in Asia (including a Chinese adaption) and will tour Australia in October (Australian Aboriginal content to be added)

Big Science, Small Science

Reverend Robert Evans, Australia

- “Big Science” including astronomy can be very expensive, with telescopes and satellites costing a billion dollars
- “Small Science” astronomy can be done by schools, amateur astronomers, or developing countries for a few thousand dollars
- You can do “citizen science” through the Ontario Science Centre!

Observing Variable Stars



- Skilled amateur astronomers contribute significantly to astronomical research by measuring variable stars
- The American Association of Variable Star Observers, through which much of this is done, is celebrating its 100th anniversary in 2011

Diversifying Amateur Astronomy

Mary Lou Whitehorne: RASC

Ralph Chou
U Waterloo

- Most amateur astronomers in North America are grey-haired white males!
- We must develop ways for all Canadians, especially young people, to continue their interest in astronomy
- Happily: the RASC national president, and the president of the Toronto branch, are not gray-haired white males!

Diversifying Professional Astronomy

- The University of Toronto Department of Astronomy and Astrophysics was, for many years, mostly older white males
- Recent hires have been much more diverse
- Our graduate students come from diverse backgrounds

And We're Not So Smart!

- Most North Americans do not understand the causes of seasons, and the phases of the moon
- About half of North Americans believe in astrology, young-earth creationism, and that space aliens have landed (and kidnapped millions of people)

Astronomy in Developing Countries
The Work of the International Astronomical Union

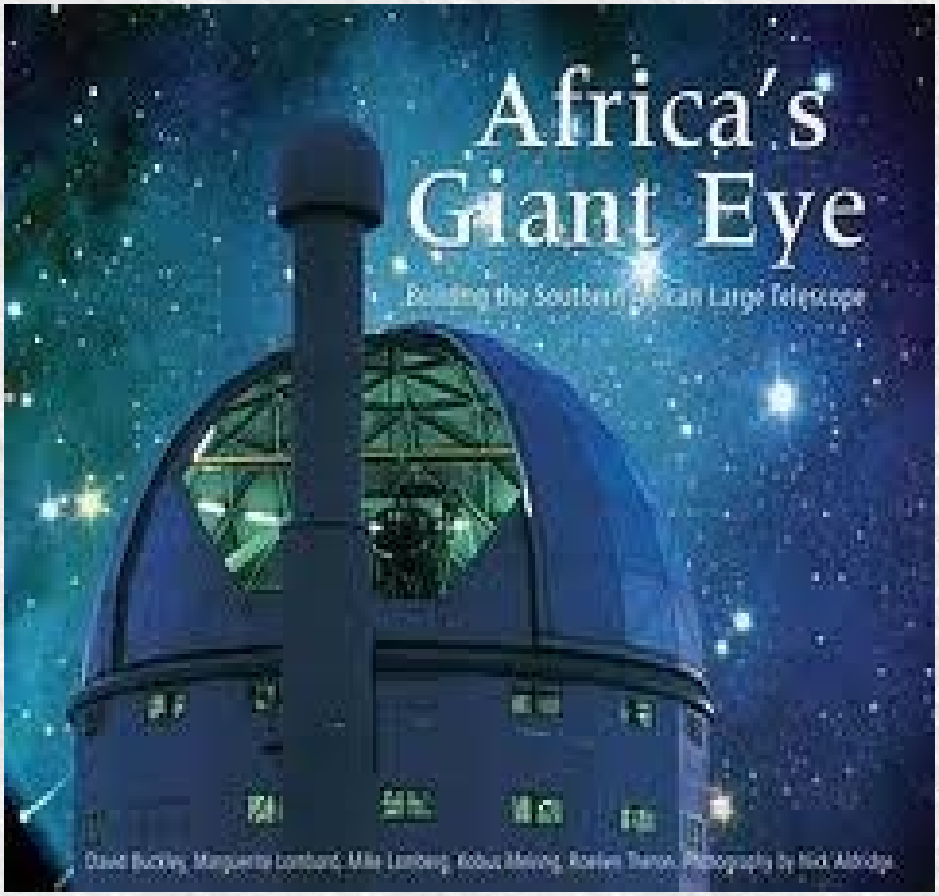
- The International Astronomical Union, founded in 1919, exists to promote and safeguard astronomy ... through international cooperation
- Its Commission on Education and Development has several flagship programs:
- *International Schools for Young Astronomers*
- *Teaching for Astronomical Development: education is the first step to science and technology*
- *World-Wide Development of Astronomy: taking the first steps toward the teaching of astronomy – and beyond*

“The Lone Astronomer”

Mazlan Othman: UN OOSA

- In many countries or areas, only one astronomer is the resource for universities, schools, amateur astronomers, and the public
- Mazlan Othman was Malaysia's first astrophysicist, developed university and school astronomy curricula, founded the Kuala Lumpur Planetarium, was Director of the Malaysian Space Agency, and is now Director of the UN Office of Outer Space Affairs

The Southern African Large Telescope



Southern African Large Telescope

- SALT: One of the world's largest telescopes, but cost-effective: a copy of a simple design
- According to Nelson Mandala: a symbol, to African youth, that they can participate in frontier science and technology
- Astronomy can attract young people to science and technology!

Astronomy in China Today

LAMOST: Chinese Academy of Sciences

- China was one of the first countries to launch a satellite, and is increasingly active in space science and technology
- China is engaged in major ground-based astronomical projects
- The recent reform of science and China combines some of the best of Chinese and western approaches

Astronomy in India Today

Jayant Narlikar: IUCAA

- India's Inter-University Centre for Astronomy & Astrophysics, founded by cosmologist Jayant Narlikar (left) is a leading research institute with an excellent public education and outreach program
- Some of Canada's satellites are launched by the Indian Space Agency!

Role Models!

Astronomy is done around the world by people of both genders, and many cultures









The Stars belong to Everyone

Orion: Besser Museum

- Everyone can be excited by the universe, and by our cosmic origins
- Everyone can be a knowledgeable stargazer
- Everyone can do astronomy

Epilogue

- *“Astronomy is the stuff of dreams and youthful fascination. This is true for us in the developing countries as much as in countries like the USA. Our youth are interested in astronomy and space as much as youth elsewhere. And when you in the developed countries achieve your dreams, we hope not to be too far behind you”.* -- Mazlan Othman
- And the same is true of youth everywhere, including in underserved communities.