The AGE of GLASS

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Chair of IYOG 2022

Pliny the Elder recounted that it all began on a beach, in a natron merchants camp


C· PLINII SECVNDI
NATVRALIS HISTORIAE
LIBRI TRIGINTASEPTEM,
A Paulo Manutio multis in locis emendati.
CASTIGATIONES SIGISMVNDI GELENII.
VENETIIS,
Apud Paulum Manutium, Aldi F.

… and the next morning

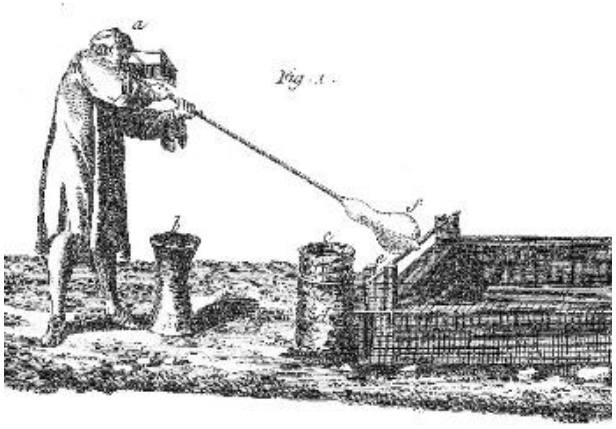
INTERNATIONAL YEAR OF GLASS 2022

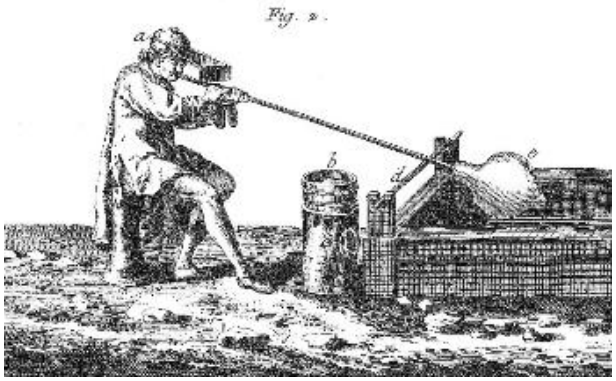
Transparent and hard glass beads appeared

Glass was born…..

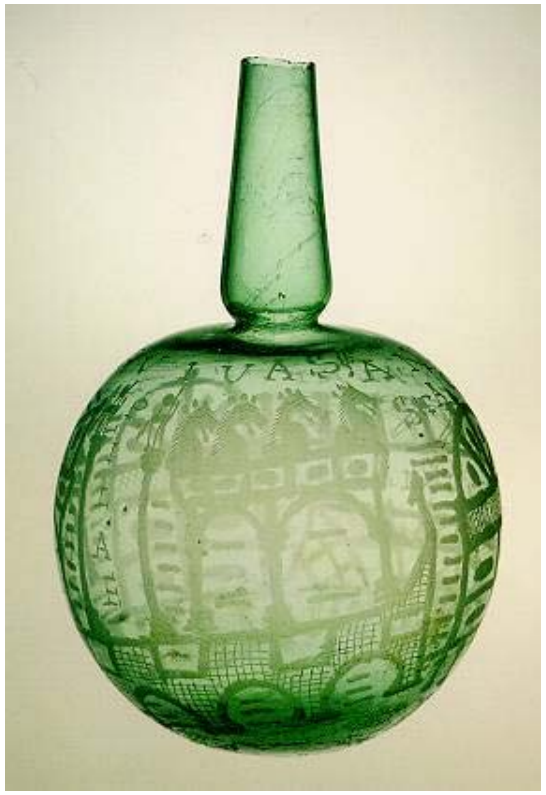
From Egypt to Babylonia

Glass blowing was invented in Tire/Sidon S II b.C

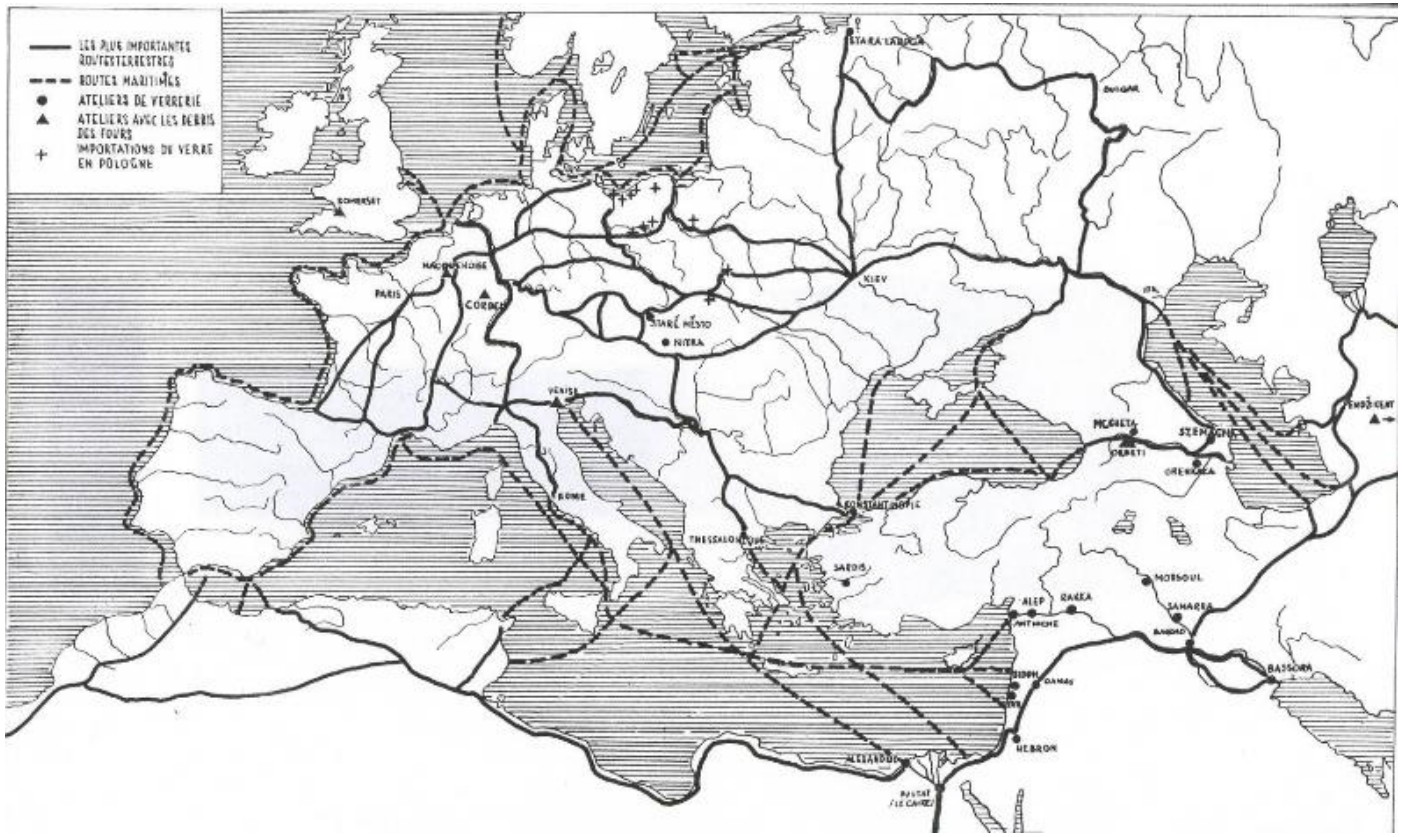




Glass industry is born in Rome ….



And the expansion to the whole Roman Empire



Augusta Emerita, 25 a.C.

Glass industry with Adriano

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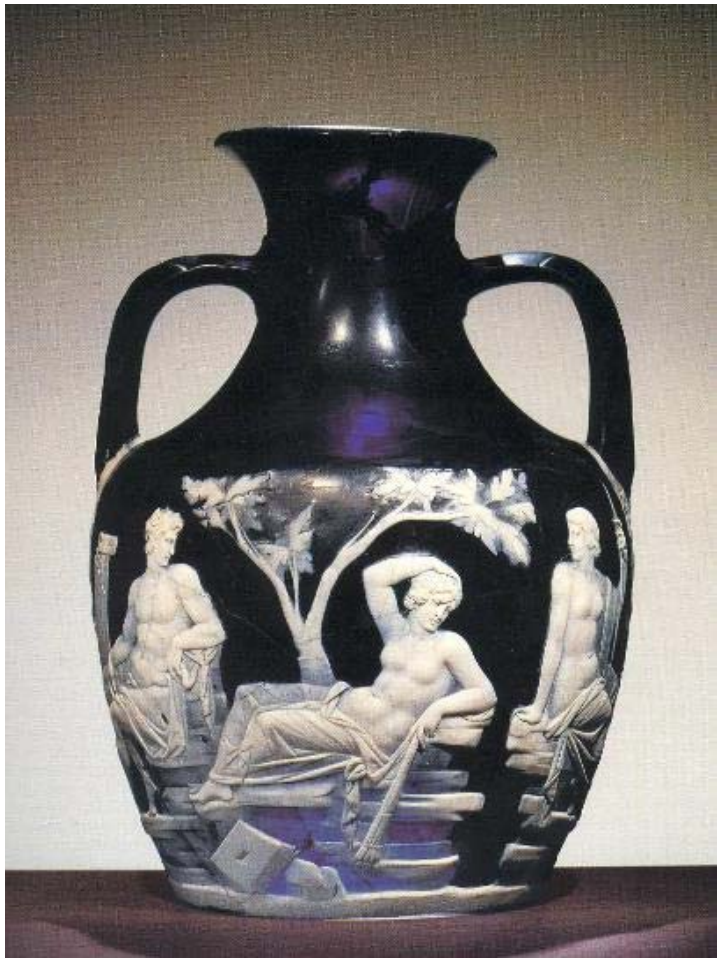
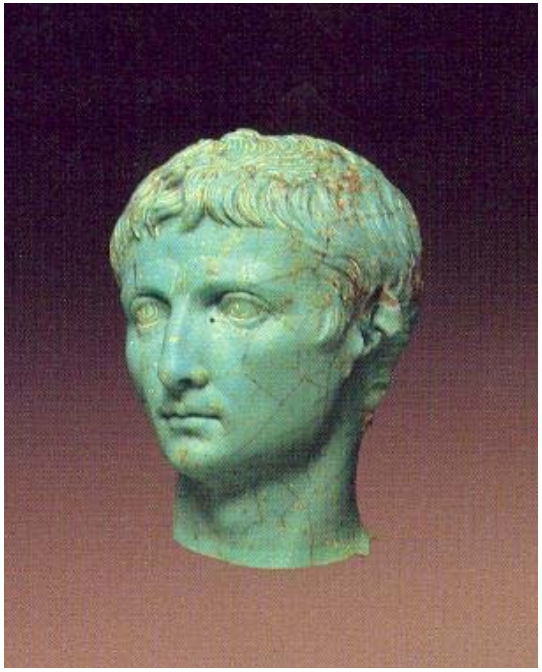
Reaching the heights of glass art

Bowl S.I b.C



Portland vase
S II a.C



Augusto S I a.C

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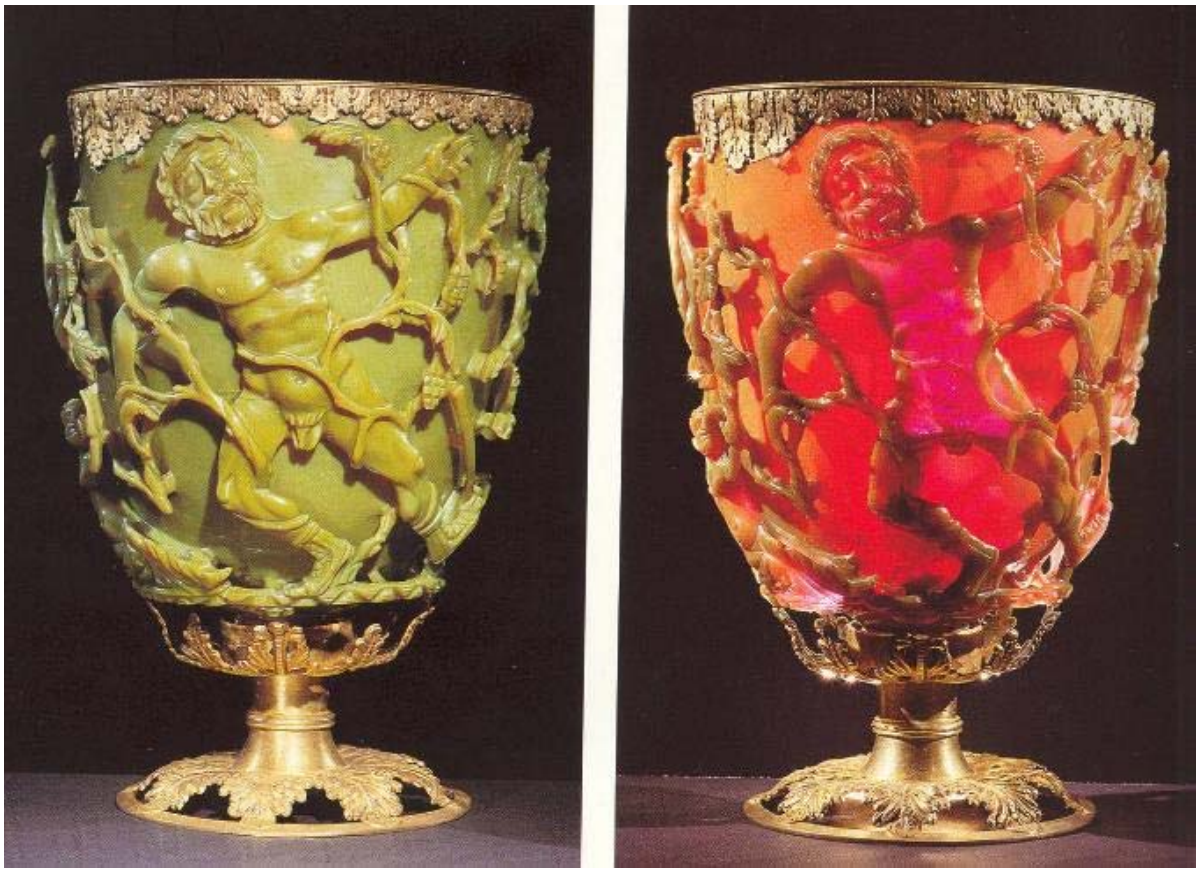
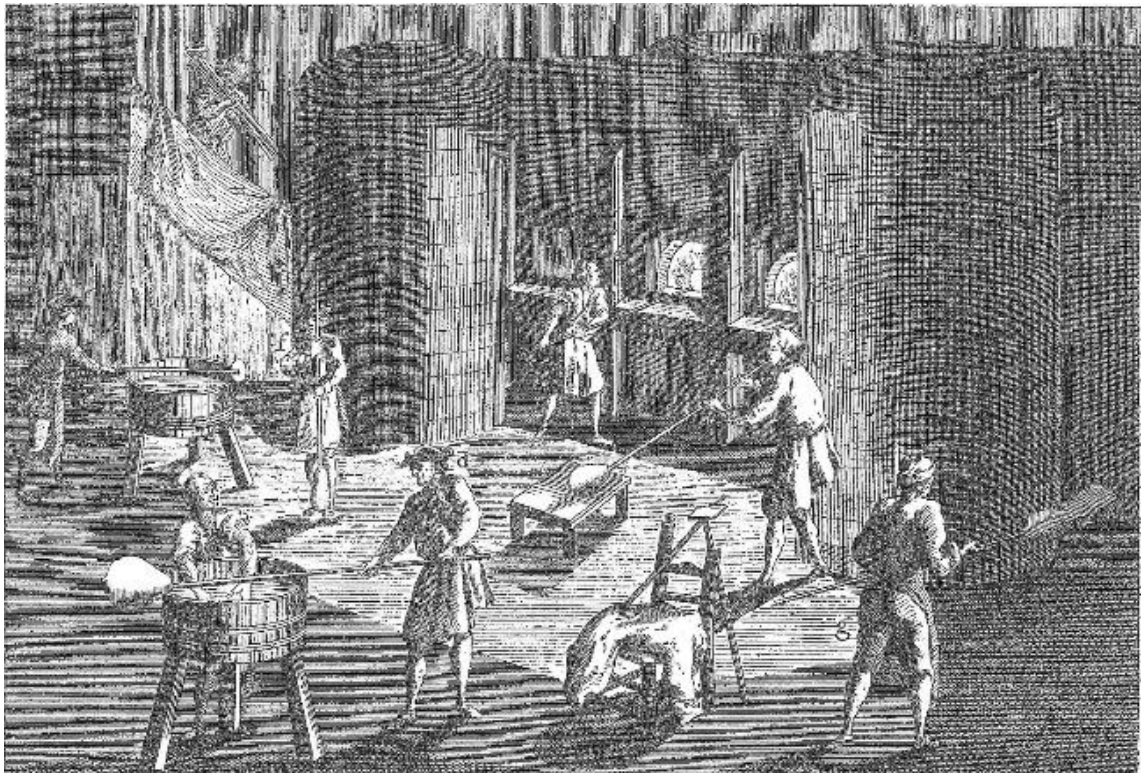


Licurgo vase S. IV a.C

Moving forward, techniques advanced from blown glass…



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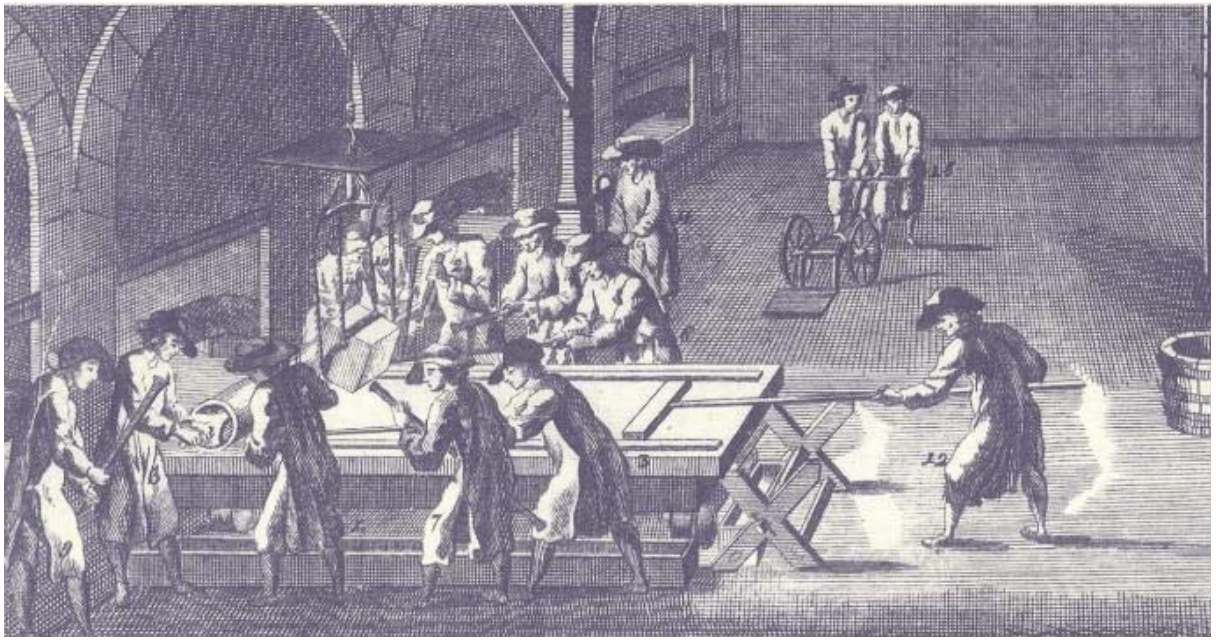
To flat glass ….
from the splendour of Gothic …



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To Mies Van der Rohe glass house …

… to carbon neutral glass skyscrapers of transparent and sustainable cities

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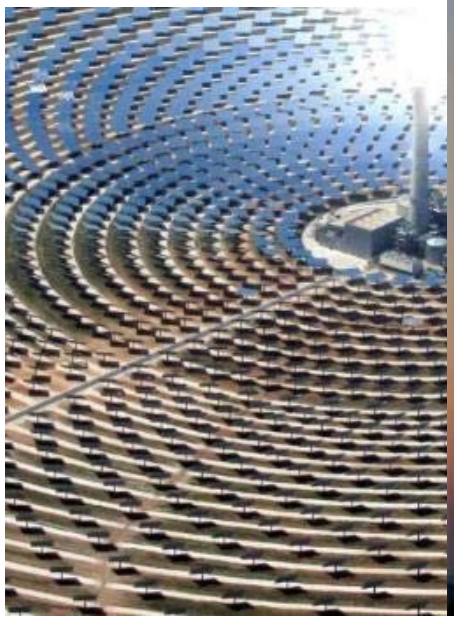
Clean energies towards sustainability



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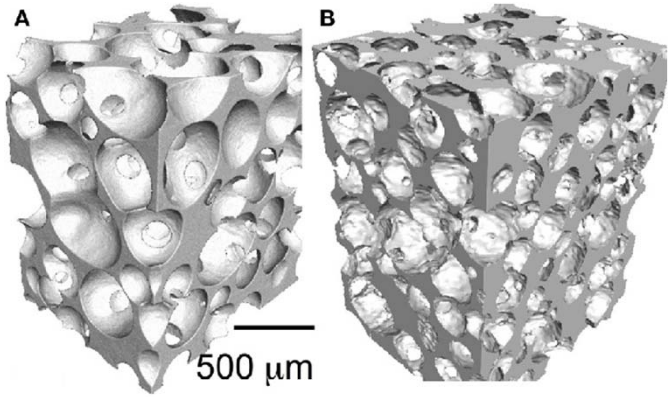
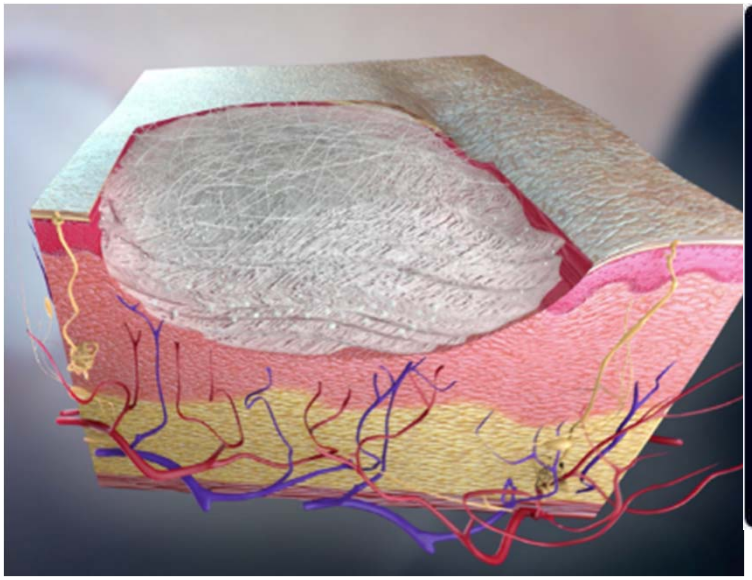
Glasses for health and well-being





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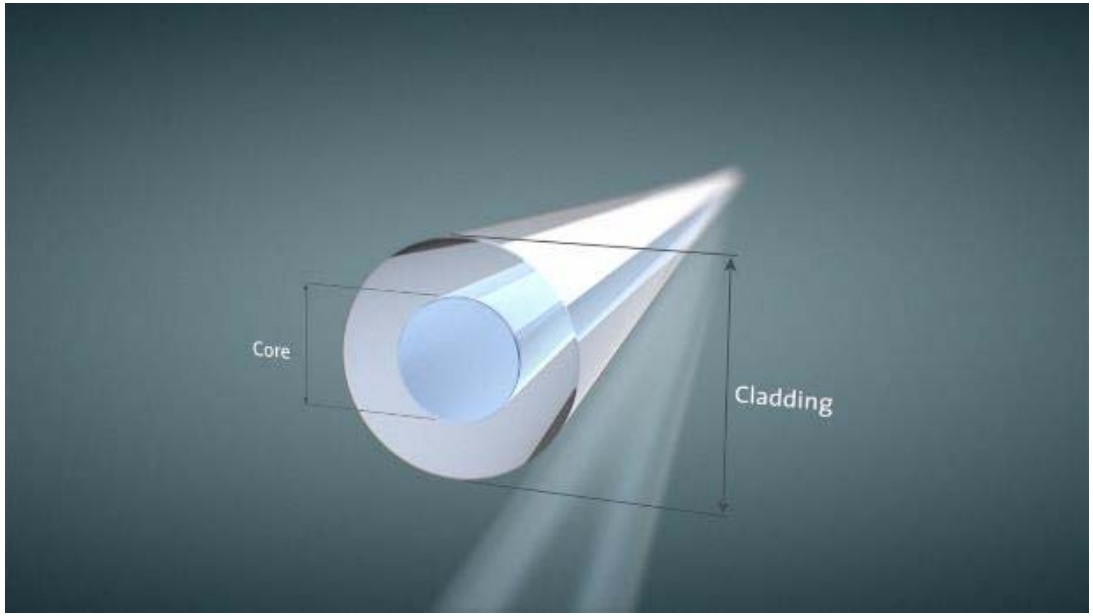
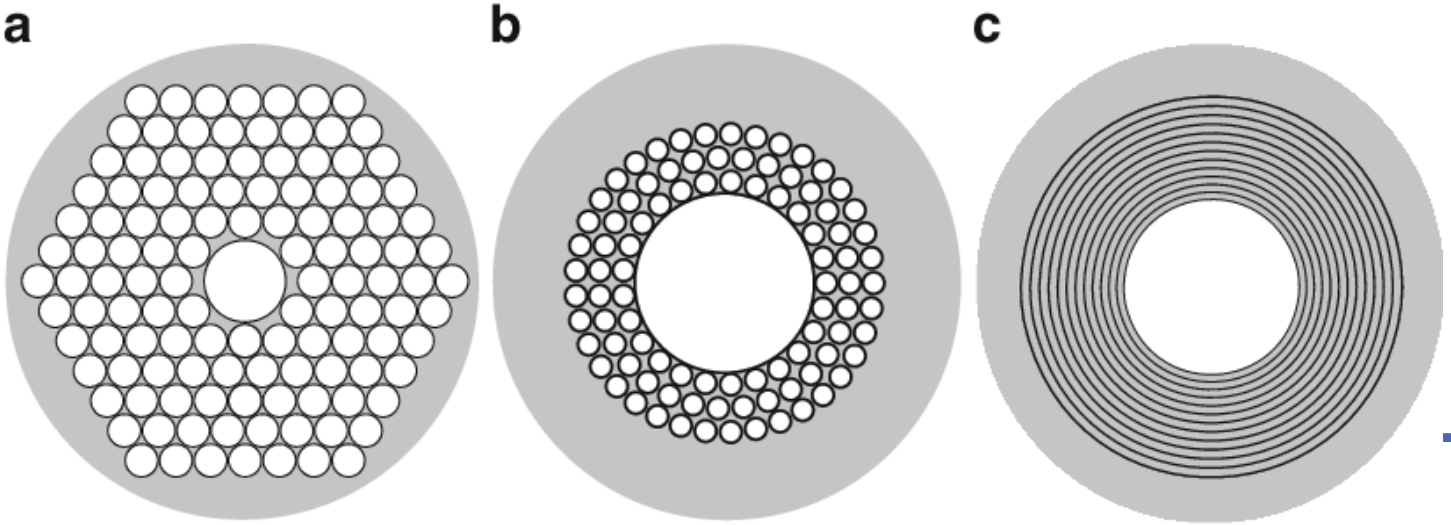


Optical fibres, the hidden, invisible base of the Revolution of Communications



INTERNATIONAL YEAR OF GLASS 2022

Internet transforms Communications triggering GLOBALIZATION processes

These are the arguments to justify we are entering in the

AGE OF GLASS

Conceptualization of the **UN International Year of Glass 2022**

David Pye and Manoj Choudhary presented the proposal to ICG in 2018

ICG
International Commission on Glass

Accepted the challenge

Spanish ambassador at UN, Agustin Santos accepted to lead the IYOG

INTERNATIONAL YEAR OF GLASS 2022

ICG

International Commission on Glass

COMMUNITY of GLASS ASSOCIATIONS

GLASS

SUSTAINABLE DEVELOPMENT GOALS

INTERNATIONAL YEAR OF GLASS 2022

The international journal of science / 4 November 2021

nature

Glass is the hidden gem in a carbon-neutral future

Recycling glass does not degrade it, and manufacturing it can be carbon-free. So why are countries still burying glass in the ground?

Shattered glass from an explosion in Beirut in 2020 is sorted for recycling.

Glass can be recycled infinitely without losing any of its properties. Why, then, are most countries — with the exception of those in Europe — still burying most of their glass as landfill by the tonne? In 2018, the United States alone offloaded almost 7 million tonnes of glass into landfill sites, accounting for 5.2% of all solid municipal waste, according to the US Environmental Protection Agency.

The push to cut plastics use is accelerating the search for new materials, especially for containers that can hold liquids. But glass is an existing material that could be the star of a net-zero carbon economy.

Worldwide, glass manufacturing produces at least 86 million tonnes of carbon dioxide every year. But most of this can be eliminated when glass is recycled, and existing technologies could turn glass manufacturing into a mostly carbon-free process. What needs to happen is for countries to stop sending glass to landfill sites, and to make glass recycling mandatory.

Glass is made by heating limestone, sand and soda ash to 1,500 °C. This heat comes from natural gas, and it accounts for between 75% and 85% of the carbon emissions from glass manufacturing. The remaining emissions are a by-product of the chemical reactions between the raw materials. But some of these materials can be replaced with crushed recycled glass, known as cullet. When cullet is melted, no CO_2 is released. And furnaces don't have to burn so fiercely to melt glass as to melt the raw materials, offering further carbon savings. According to the European Container Glass Federation (FEVE), an industry group

> "Communities and companies should be helped to create infrastructure to collect glass and recycle it."

emissions, and that, too, needs to be understood.

When it comes to glass recycling, Europe is the world's most advanced region by some margin, and has ambitions to be even better. Researchers could study how Europe's recycling scheme came about, its strengths and weaknesses and whether there are lessons for other countries. Three-quarters of glass used for containers such as bottles is collected for recycling across all 27 member states and the United Kingdom. As a result, new glass made in the European Union already contains some 52% recycled material. The glass-container industry has set itself a target of collecting 90% of all waste container glass in the EU by 2030.

But other countries are not where they need to be. Moreover, data on glass recycling are difficult to find, partly because most countries are not reporting what they are doing. There seems to be no international body that

Glass ≡ Sustainability

INTERNATIONAL YEAR OF GLASS 2022

The history of optical glass

Rome: Nero watched the circus shows using not a lens, but a flat green mirror (emerald plate?), which would act as sunglasses.

Arabs: Abbás Ibn Firnás, Andalusian scientist of the Umayyad period. First optical calculations w/polished lenses, XII century a.C.

S XIII: In 1249, the English philosopher-friar **Roger Bacon** made the first report about the use of glasses to improve vision.

SXIV: **Alexander della Spina**, Franciscan monk, began the fabrication of corrective lenses, developed in Venice in XIII-XIV

In **1451**, the German **Nicholas of Cusa** proposed the use of concave lenses, thinner in the center than at the edges, to improve distance vision.

First known painting showing a person wearing glasses, 1352. Fresco painted by Tomas de Modena in Treviso

INTERNATIONAL YEAR OF GLASS 2022

The history of optical glass

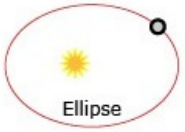
1604: Jansen (Holand) builds the first astronomical telescope
1609: Galileo makes the first diverging ocular telescope
Boosting manufacturing large lenses

The history of optical glass

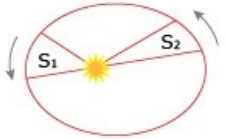
Tycho Brahe + Kepler → **Kepler's Laws of Planetary Motion**

Newton's laws of motion and the **universal law of gravitation (1687)**

1st Law

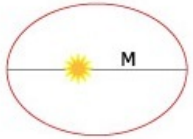


2nd Law



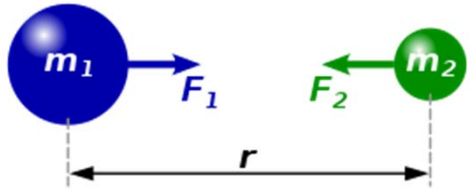
Equal area in the same time
area S1 = area S2

3rd Law



P: period (the time for one cycle)
M: length of the major axis

P^2/M^3 is the same for all planets



$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

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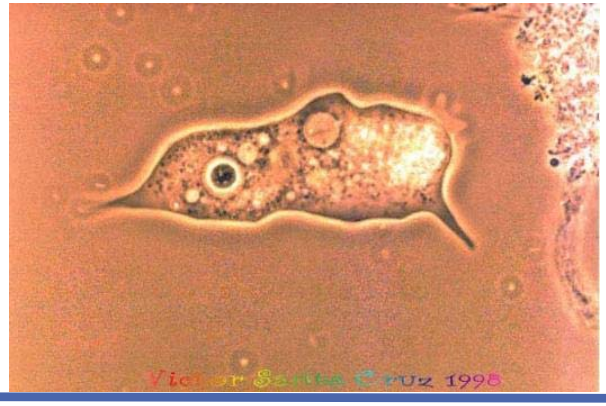
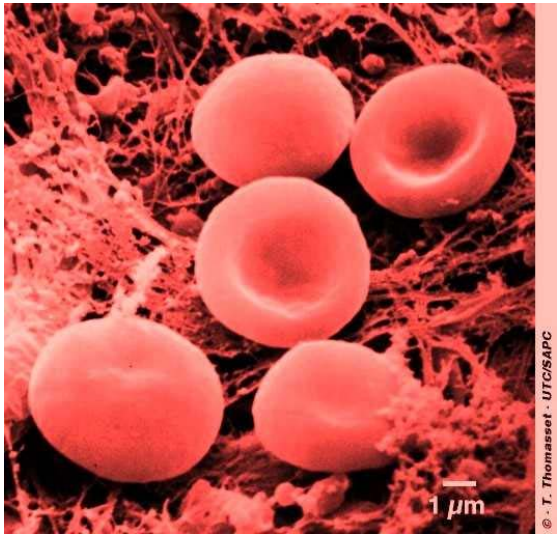
The history of optical glass

S XVII Van Leeuwenhoek developed the microscope

Leavens



Amoebae



Red blood cells

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The history of optical glass

Optica from Newton (1704): fundamentals of modern optics
Boosting the manufacture of lenses, mirrors and prisms

Low quality glasses: impurities, inhomogeneities, bubbles

Development of Chemistry + development of fusion technologies

Kunckel (1689): Na, K, Ca, Sn, Pb, B, Si, P, As, O, S
(Cu, Au, Mn, Fe, Co)
Harcourt (1871): Li, Be, Mg, Cd, Al, Ti, Sb, V, Mo, W, U
(Ni, Cr)

Guinard (1803): mechanical stirring
Faraday (1830): fining in Pt crucibles
Harcourt (1844): melting in Pt, combustion w/o gases
Schott (1900): special refractary, fused silica

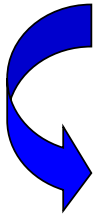
The history of optical glass

Guinard: starts the optical glass industry
Fraunhoffer: refracting telescopes and microscopes

Biology: optics development engine

Jena 1860: C. Zeiss (optical instruments) + E. Abbe (physicist)
physical and geometrical optics

"The future of the microscope and its optical quality is in the hands of glassmakers"



1876 Otto Schott (chemist and glassmaker): varying compositions, properties vs. compositions, melting technologies.

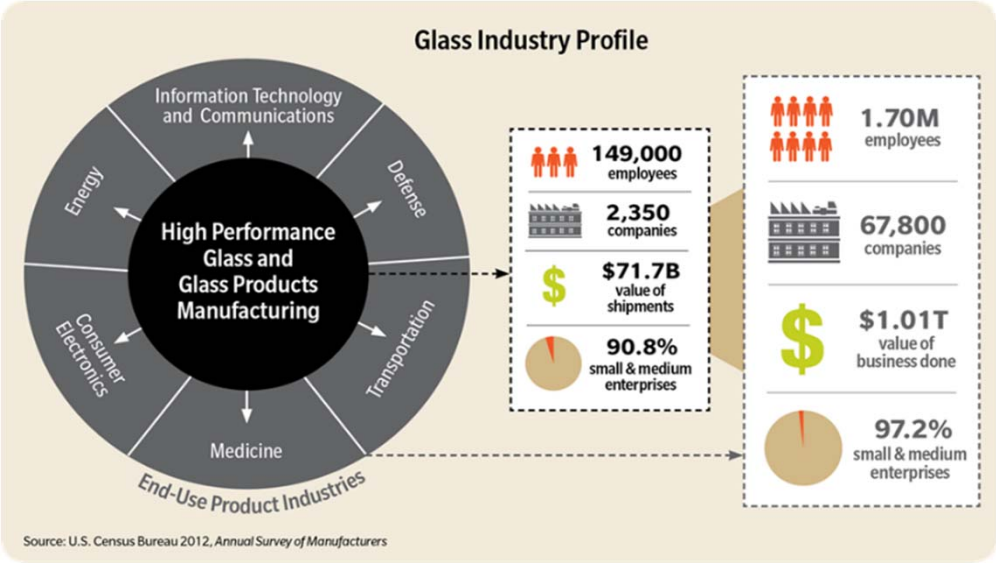
1884 Jenaer Glaswerk Schott und Genossen (catalog of 76 glass compositions)

The history of optical glass

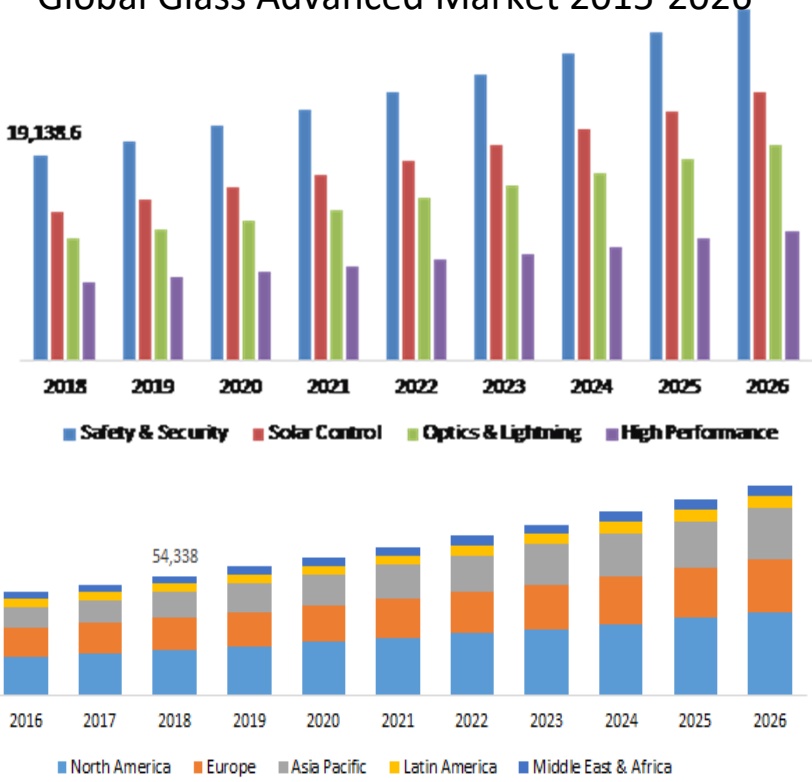
Physics + Chemistry + technology: first high-tech materials

Science and technology of materials is born

Optics: engine for development of glass science and technology



Global Glass Advanced Market 2015-2026



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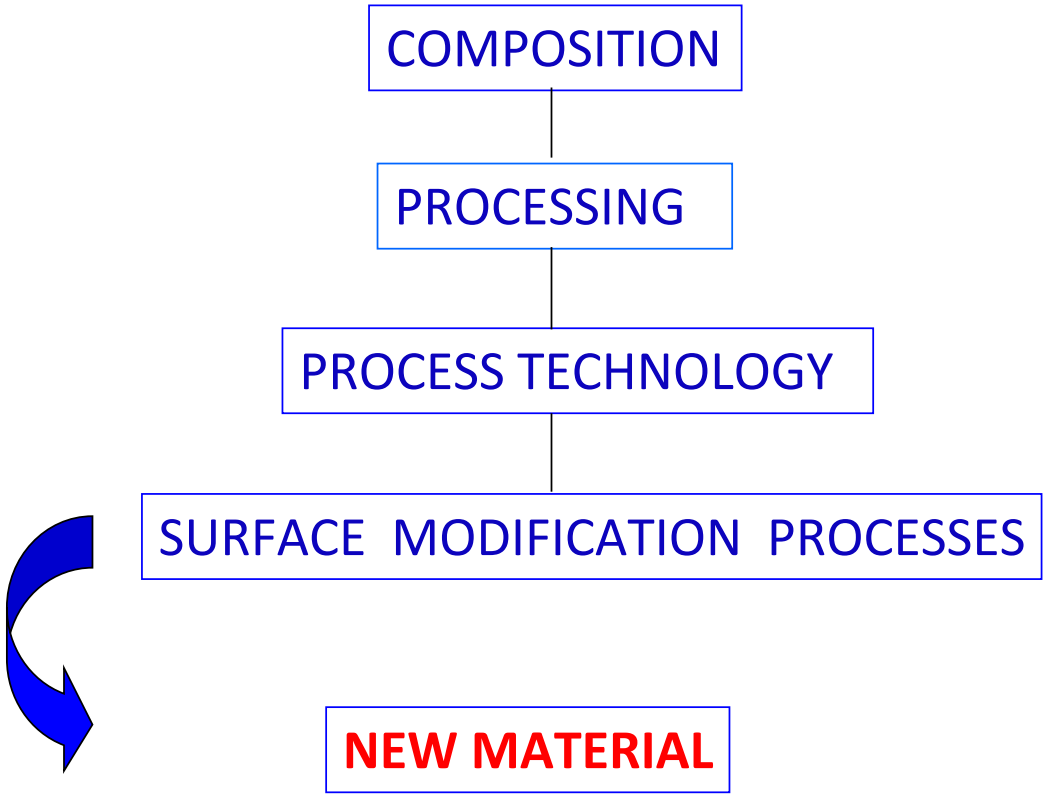
Trends in the development of new glasses



Trends in the development of new glasses

New compositions	chalcogenides fluorides phosphates /fluorophosphates metallic glasses
New processes	Fibering CVD, Sol-gel Critical cooling Glass-ceramics
Coatings and surface treatments	Reflective/antireflective Mechanical/chemical/corrosion protection Electrooptical/electronic /photonic Photocatalytic/bactericide Multifunctional properties

Optical and lasers glasses

LL NatLab – NIF – National Ignition Facility

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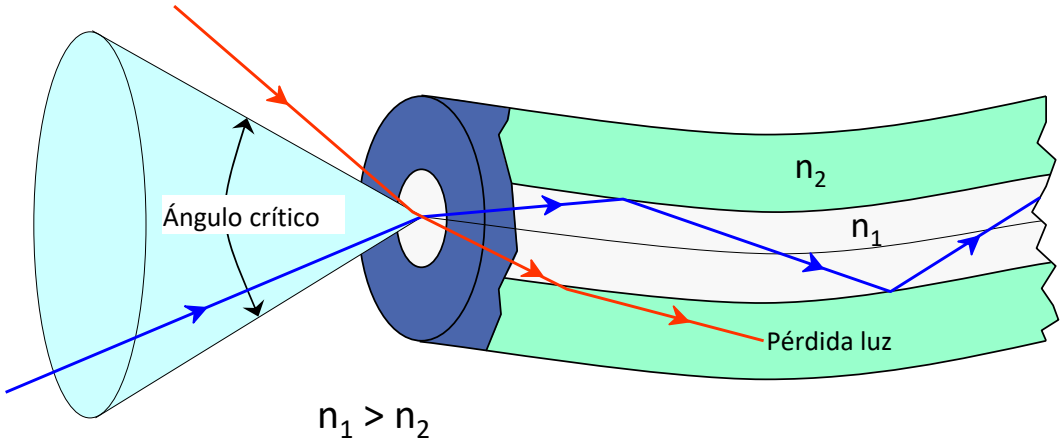
Optical fibres

- Transport of light flexible shafts and large angles
- Changing profile image
- Active and passive guides
- Discrete waveguide modes
- Telecommunications



$n_1 > n_2$

Total Internal Reflection : sen $\theta = n_2/n_1$

A.N. = n_0 sen$\theta = (n_2^2 - n_1^2)^{½}$

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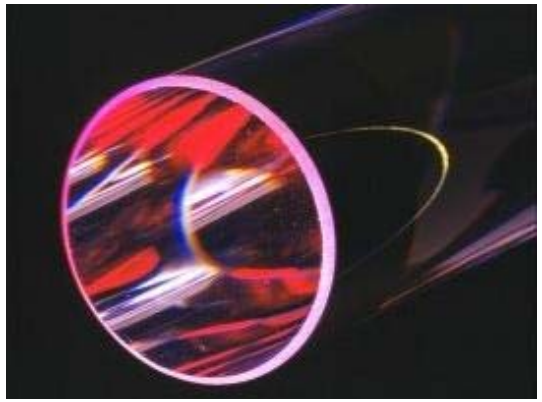
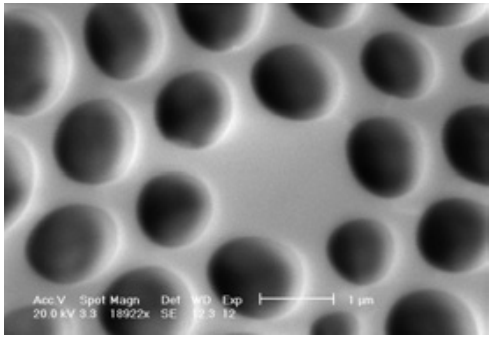
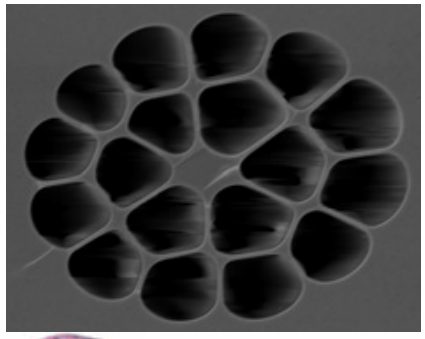
Optical fibres innovations

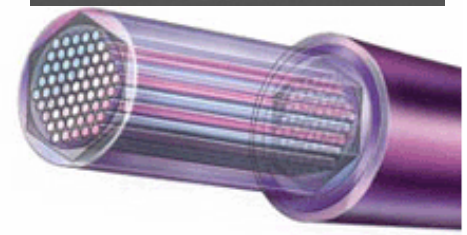


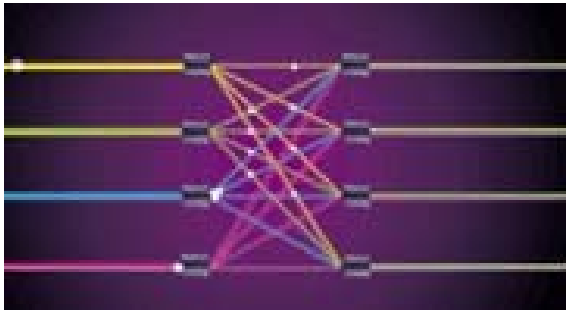
Hollow fibre from tube



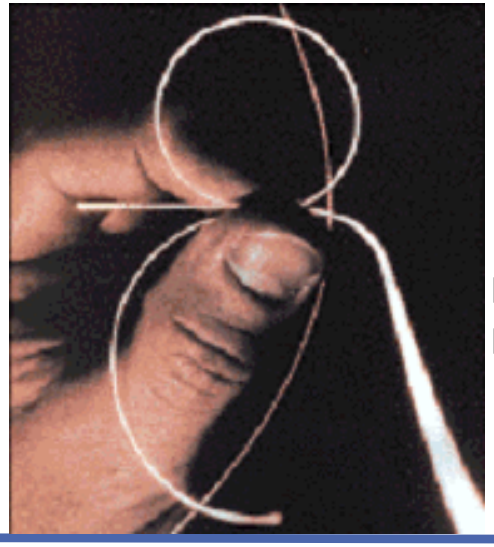
Microestructured fibres







Coupled CCD systems
Fibre + semiconductor



Fibre + laser: Scalpels 1 μm^2
Non-invasive microsurgical

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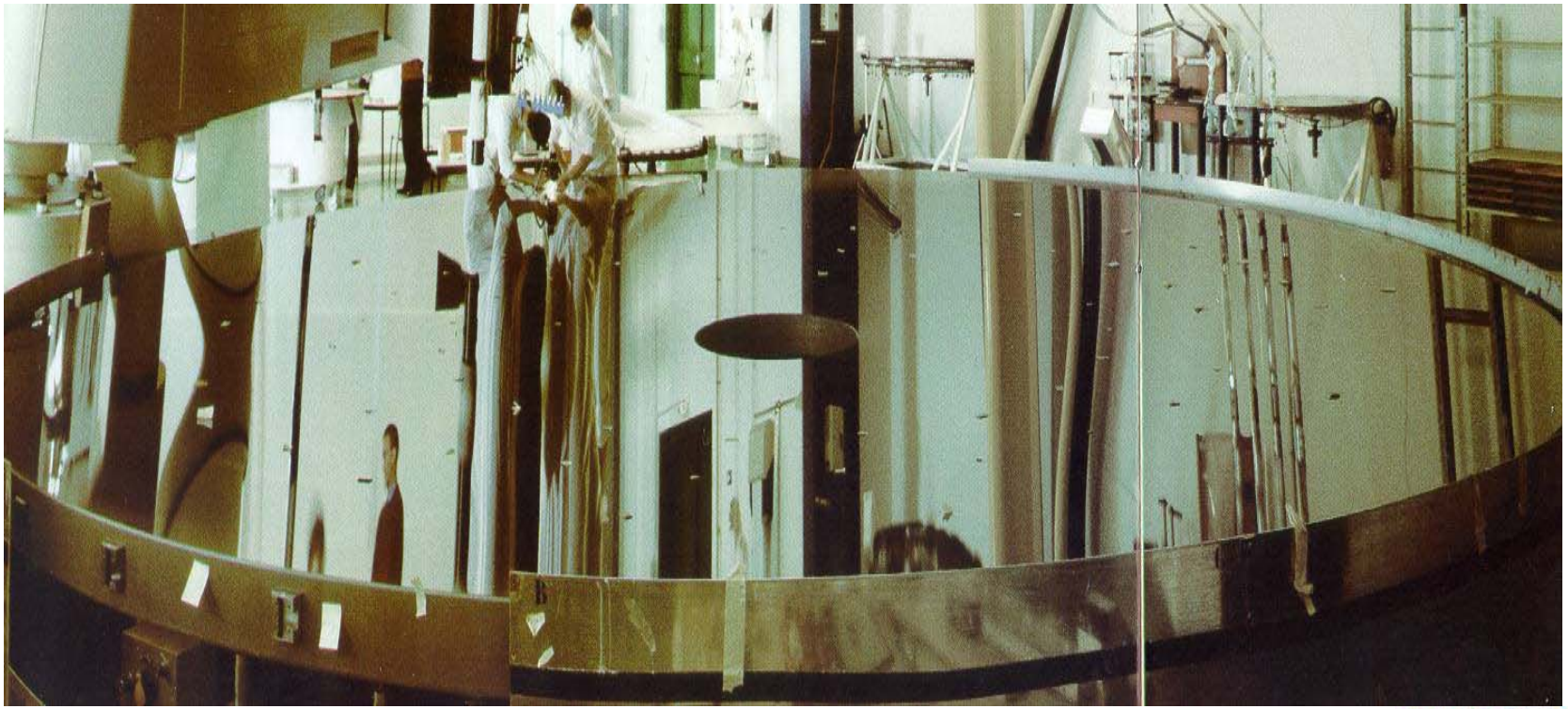
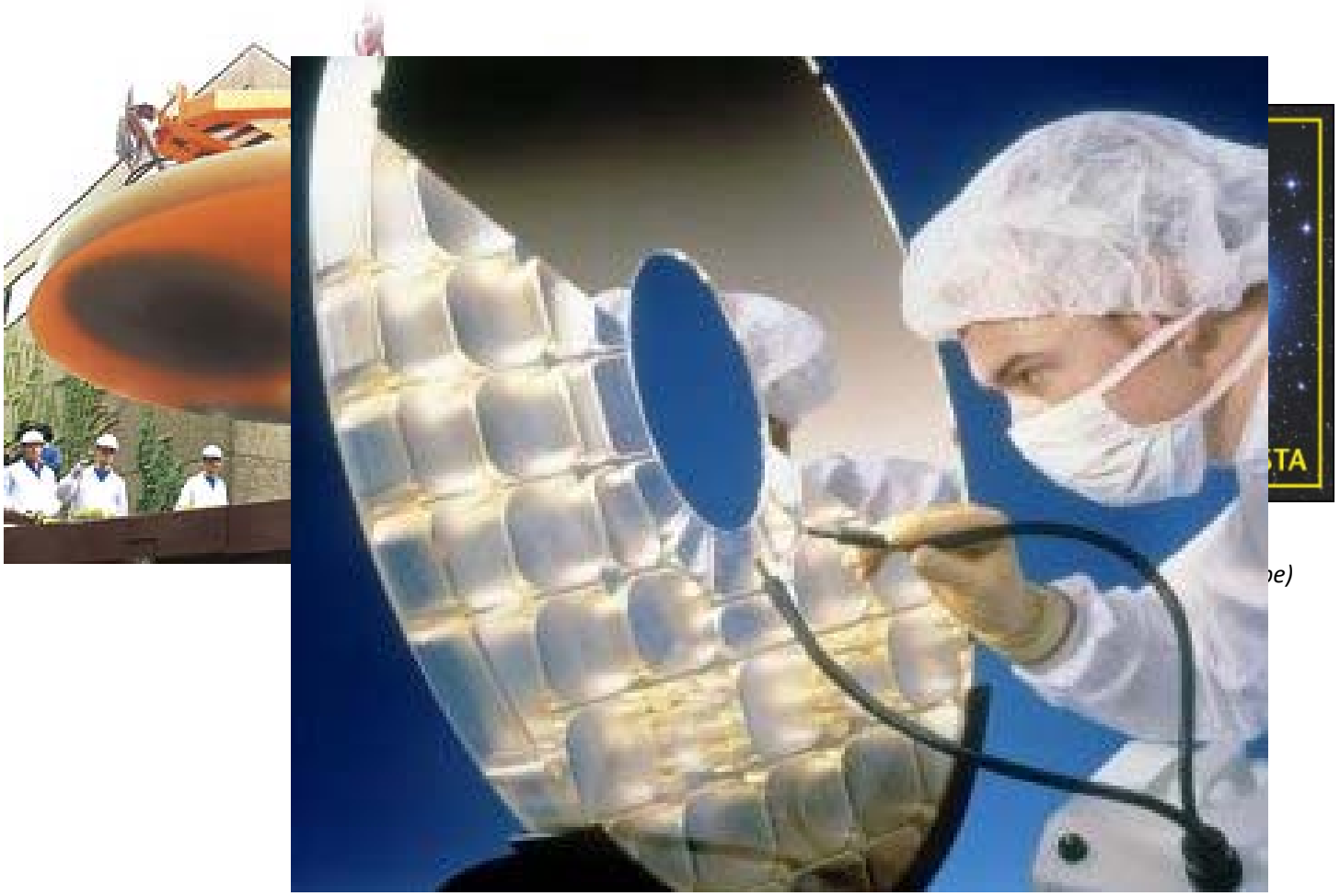
Internet transforms Communications triggering GLOBALIZATION processes

Transparent Glass-ceramics

1968 SCHOTT ZERODUR®: glass-ceramic introduces a new era of telescope mirror substrates for astronomy



Zerodur de □ =10 m (m □ 2 Tn), □ =0, roughness <10 nm, Δn < 10^{-6}



Spacial telescope James Webb (JWST)

From Galileo telescope to the James Webb

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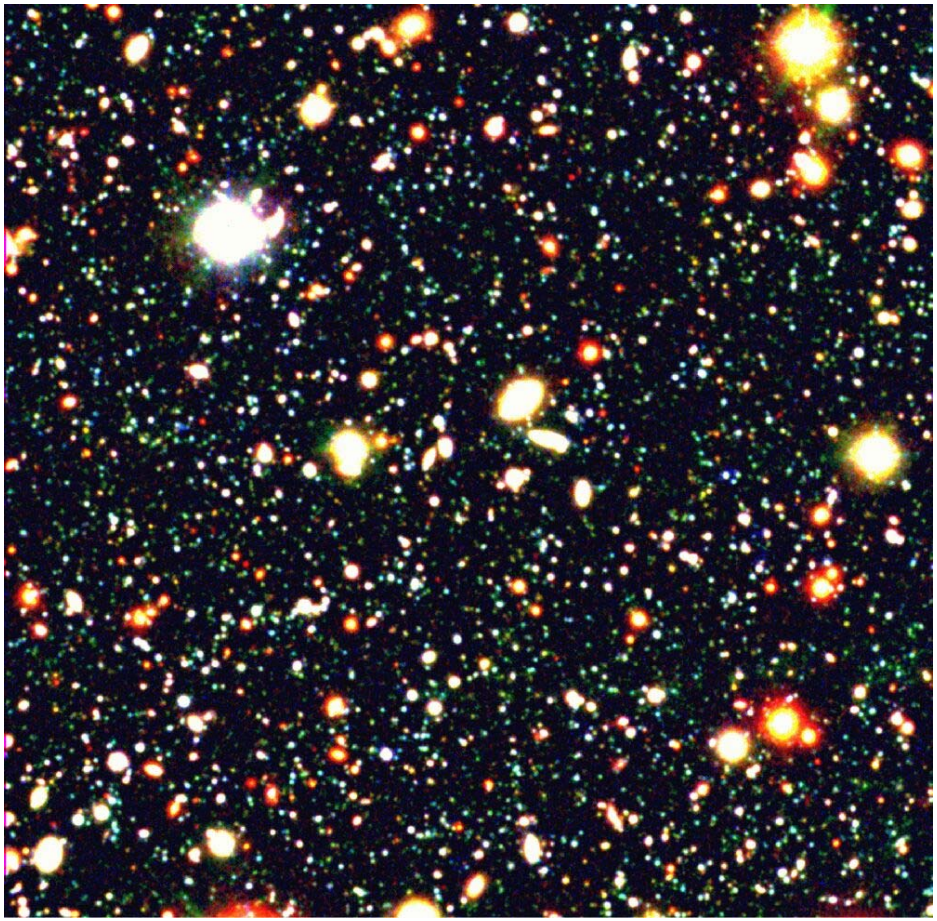
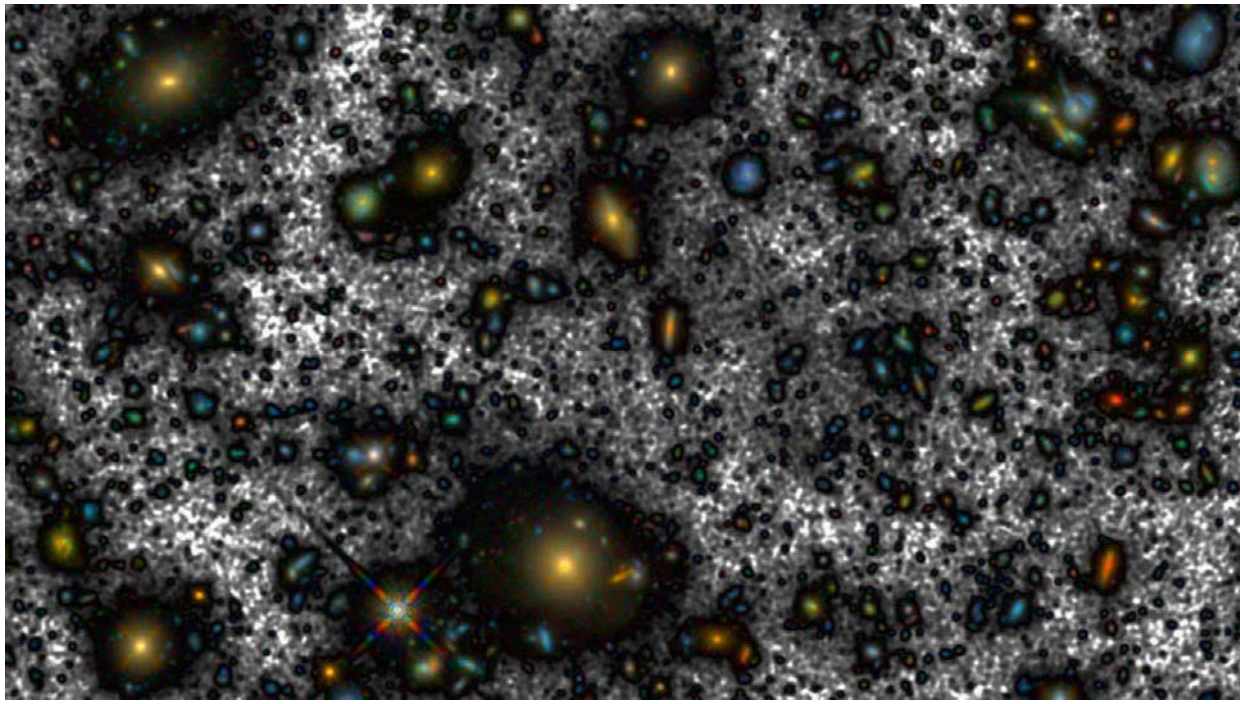
On February 17, 1600, **Giordano Bruno** burned on a pyre in the heart of Rome, accused of being a heretic by the Inquisition. Among his sins was having proclaimed that the universe is infinite and is populated by infinite stars that are like the Sun, with worlds inhabited by animals and intelligent beings.

This Platonic vision of an infinite, static and immutable universe persisted for four hundred years. At the beginning of the 20th century, Einstein presented his theory of general relativity, which gave the universe stability against its self-gravity. When the idea that the universe is expanding is added, we arrive at the cosmological theory accepted by the academy: the **Big Bang**.

To predict the future of the universe, it is necessary to know its origin by obtaining better and better photographs of the deep sky. The race had begun.



William Herschel Deep Field (La Palma), 2020
12 months observations from 3 telescopes



Ultra Hubble Deep Field 2021.
HUDF is the result of combining hundreds of images taken with the Wide Field Camera 3 (WFC3) of the HST during over 230 hours of observation which, in 2012, yielded the deepest image of the Universe taken until then. The current image, the deepest in 2021, was obtained through new processing techiques

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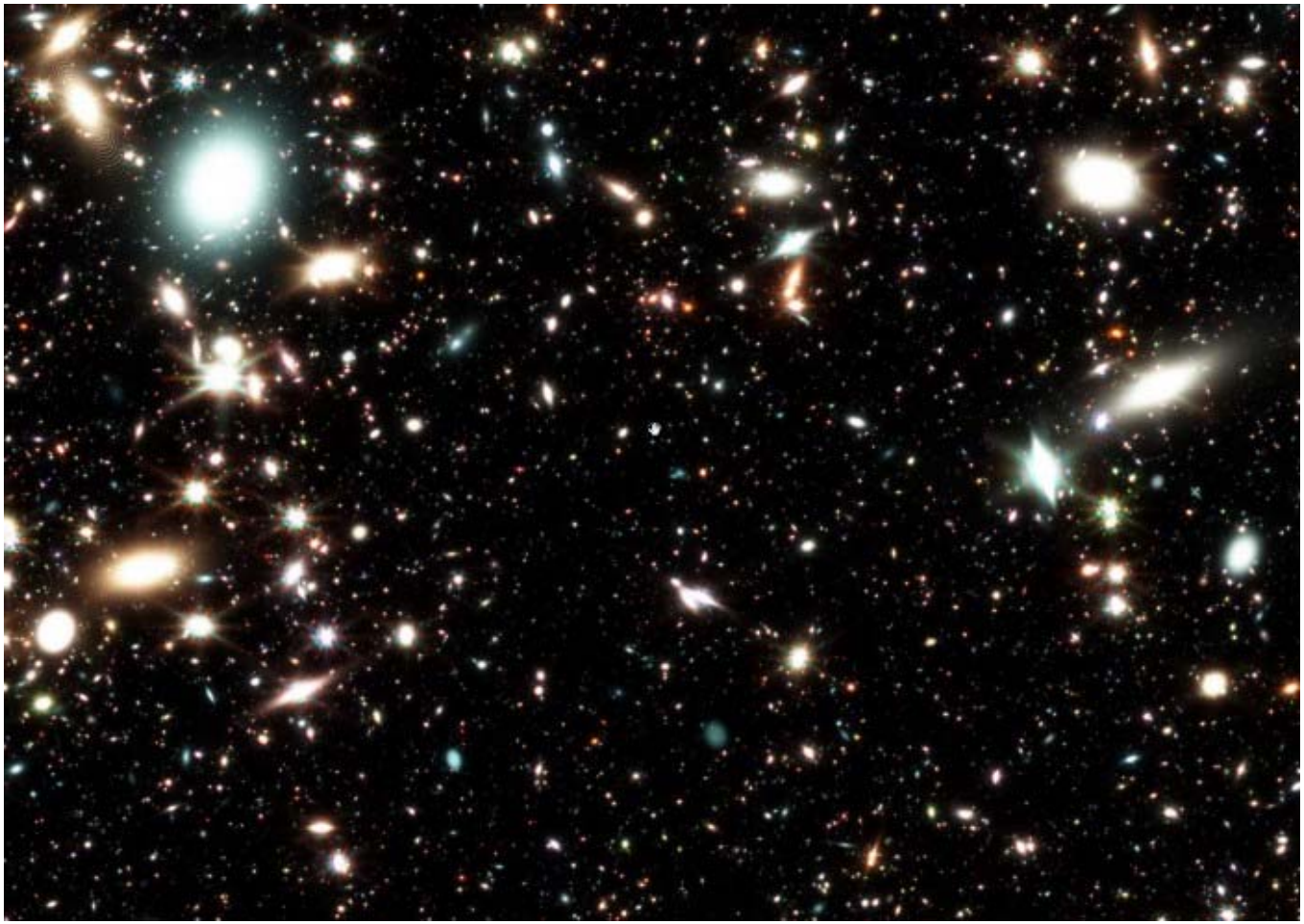


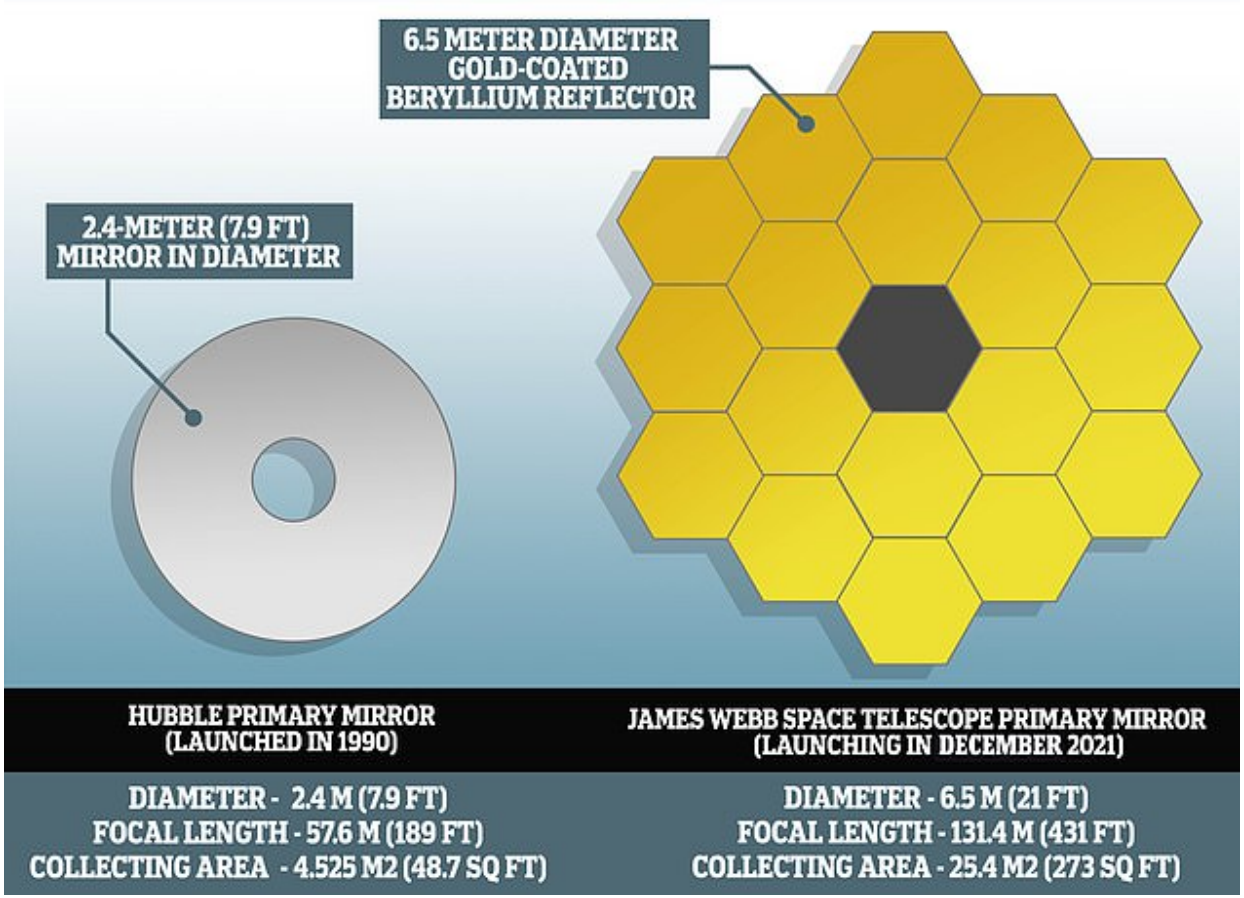
The galaxy cluster SMACS J0723.3-7327, known as SMACS J0723 for short, is among a set of galaxy clusters that James Webb is imaging for various gravitational-lensing surveys.

SMACS J0723 is at 4600 millions years ago.

11TH July 2022

INTERNATIONAL YEAR OF GLASS 2022

James Webb vs Hubble space telescopes



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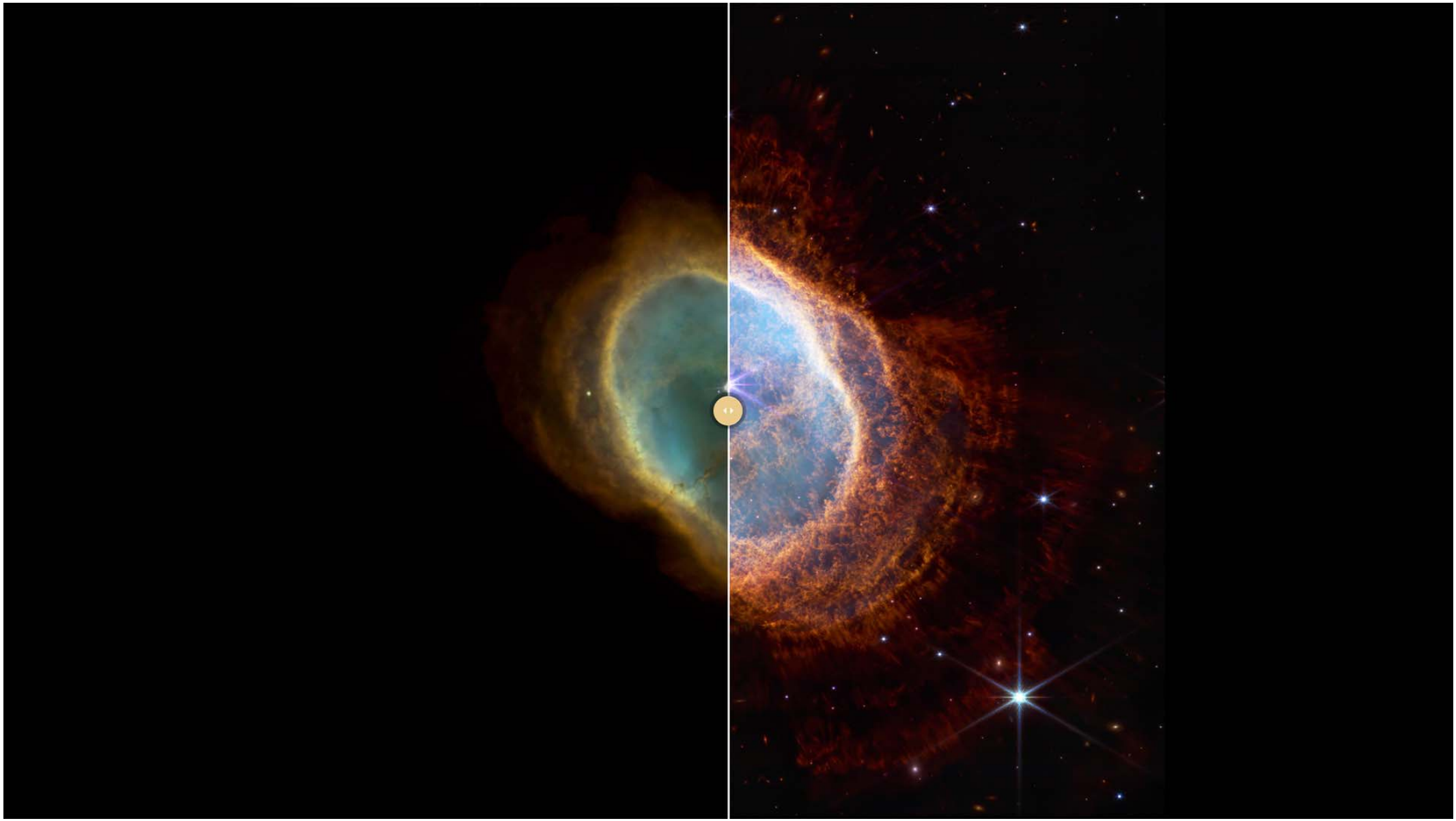

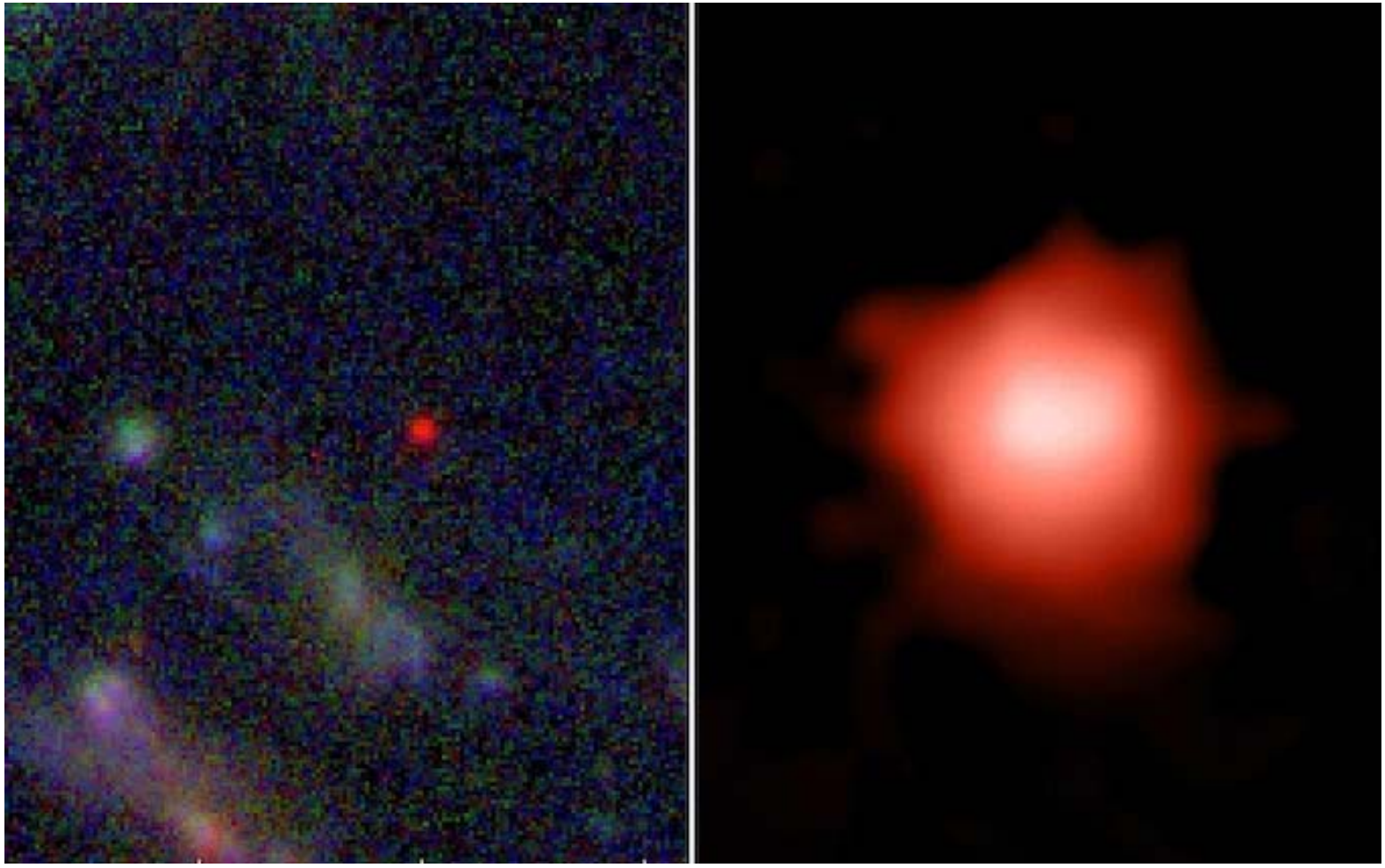

The **GLASS-z13** galaxy photographed by the James Webb NASA, ESA, CSA and STSCI.

This red dot is 13.500 million years old and is the oldest galaxy ever observed.

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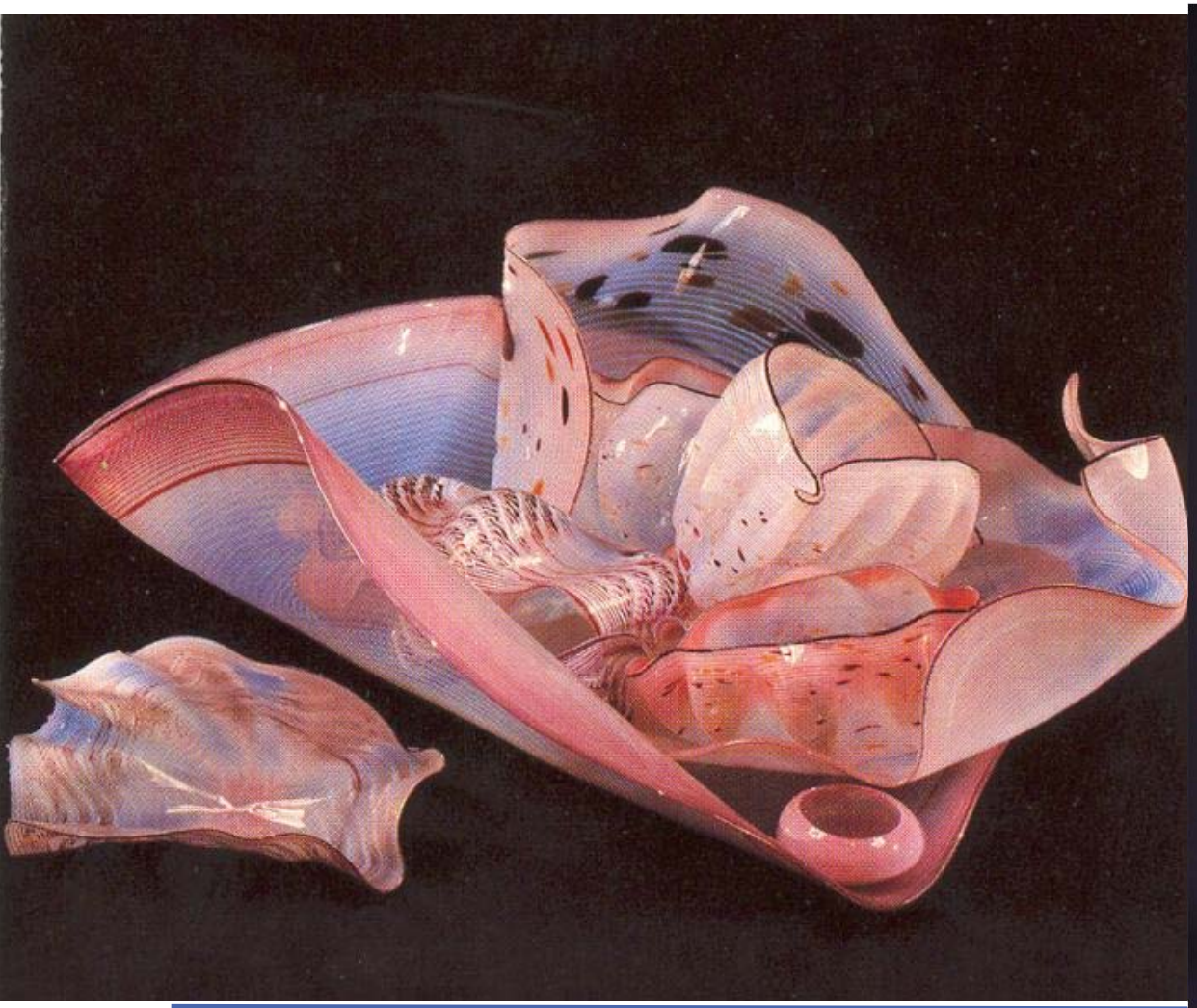

WELCOME TO TRANSPARENCY

WELCOME TO SUSTAINABILITY

WELCOME TO THE AGE OF GLASS