

# Lentz Microscopy and Histology Collection

Peabody Museum of Natural History at Yale University

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## Introduction

This collection consists of a broad range of microscopical instruments and preparations illustrating the history of microscopy from the seventeenth century to the present time. The collection begins with optical devices that preceded the microscope. The collection of simple and compound microscopes contains the major types of instruments that illustrate the evolution of the microscope over a period of 400 years. Another section contains examples of other optical devices such as spectacles, telescopes, binoculars, navigating and surveying instruments, and cameras that, besides the microscope, evolved from the simple magnifying lens. The collection also contains examples of the equipment necessary to prepare, view, and project histological slides and images. These objects include microtomes, lantern slide projectors, and projection microscopes. Some examples of non-optical and technological instruments are included.

Microscope slides form a major part of the collection and comprise one of the most complete collections in America, if not in the world. There are examples that illustrate the evolution of slides from 1700 to the present time. A large portion of the collection documents the development of histology as a discipline. These include the earliest histological slides and nineteenth century slides, slide sets, and cabinets of all the tissues of the body. In addition to histology, there are examples of slide preparations in pathology, microbiology, embryology, botany, mineralogy, *materia medica*, and neuroanatomy. There are also slides of diatoms, insects, invertebrates, vertebrates, and other subjects that were especially popular for the entertainment of the public during Victorian times. In all, there are over 4,000 slides in this collection including the earliest and many of great historical and scientific significance.

The collection covers the entire spectrum of microscopes, instruments, and slides used to prepare and view structures, especially those comprising the human body, that cannot be seen with the naked eye. The history of histology in scientific investigation and the microscope slides that illustrate this history have been largely ignored in American museums, so that this collection fills a gap in documenting one of the most important eras in the history of science and medicine. The collection is being donated to the Historical Scientific Instrument Collection at the Peabody Museum of Natural History at Yale University.

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## History of Microscopy and Histology up to the 20<sup>th</sup> Century

A brief history of microscopy is presented here so the objects in the collection can be viewed in their historical context. Objects that appear to be lenses date from ancient Egypt, Greece, and Mesopotamia. These were made from polished crystal, often quartz, and may be ornaments instead of lenses. The Nimrud lens in the British Museum was found at the Assyrian palace of Nimrud in modern-day Kurdistan and is dated to 750-710 BC. The earliest historical references to magnification date back to ancient Egyptian hieroglyphs in the eighth century BC that depict "simple glass meniscal lenses." The ancient Greeks and Romans were aware of the magnifying effect of glass spheres filled with water. Lenses were used as "burning glasses" to start fires in sacred temples and to cauterize wounds. The word lens comes from the Latin name of the lentil, because a double-convex lens is lentil-shaped. Corrective lenses were said to have been used by Abbas Ibn Firnas, living in Spain in the 9th century, who had devised a way to produce very clear glass. These glasses could be shaped and polished into round rocks used for viewing and were known as reading stones. The earliest evidence of a magnifying device, a convex lens forming a magnified image, dates back to the *Book of Optics* by Ibn al-Haytham (Alhazen, 965-1040), Arabian mathematician, optician and astronomer at Cairo, in 1021. English Franciscan Friar Roger Bacon (c1214-1294), in his 1267 *Opus Majus*, noted that letters could be seen better and larger when viewed through less than half a sphere of glass. "If one looks at letters or other minute things through the medium of a crystal or glass or other lens put over the letters, and if it is the smaller portion of a sphere of which the convexity is towards the eye, and the eye is in the air, he will see the letters much better and they will appear larger to him . . . and therefore this instrument is useful to old men and to those having feeble sight." Reportedly, spectacles were in use in China by the rich and elderly at the time of Marco Polo's arrival in 1270 or 1271, although the Chinese credited their invention to Arabia in the eleventh century.

Early recorded evidence demonstrates that spectacles first appeared in Pisa, Italy about the year 1286. Magnifiers or reading stones held in the hand or in a stand were probably used by monks to assist in illuminating manuscripts between the eleventh and thirteenth centuries. These were primitive plano-convex lenses initially made by cutting a glass sphere in half. As the stones were experimented with, it was slowly understood that shallower lenses magnified more effectively. At some point, someone thought of connecting two of the glass or crystal magnifiers together so they would sit on the bridge of the nose. Most likely, this first pair of eyeglasses were invented by a lay person who wanted to keep the process a secret in order to make a profit. Two monks from the St. Catherine's Monastery, Giordano da Rivalto and Alessandro della Spina, provide the earliest documentation to support this belief. On February 23, 1306, Giordano mentioned them by stating in a sermon "it is not yet twenty years since there was found the art of making eyeglasses which make for good vision, one of the best arts and most necessary that the world has." He coined the word "occhiale" (eyeglasses) which was later also used for telescopes and microscopes in Italy. Friar Spina's 1313 obituary notice mentions, "when somebody else was the first to invent eyeglasses and was unwilling to communicate the invention to others, all by himself he made them and good-naturedly shared them with everybody." Salvino D'Armato Degli Armati of Florence was at one time thought to be the inventor of eyeglasses but this claim is now thought to be false. At that time Venice, Italy was one of the most advanced centers for the medieval glass industry, its guild of crystal workers officially created in November 1284. The use of spectacles and the method of making them rapidly spread over Europe. These early spectacles had convex lenses that could correct both hyperopia (farsightedness), and the presbyopia that commonly develops as a symptom of aging. Nicholas of Cusa in 1451 is believed to have discovered the benefits of concave lens in the treatment of myopia (nearsightedness).

The simple (single lens) microscope probably originated in the sixteenth century. Spectacles were in use since the end of the thirteenth century so that there was an awareness of the magnifying properties of glass lenses. The earliest microscope consisted of a short tube of opaque material with a magnifying lens at one end and a flat glass plate at the other end on which the object to be examined was placed. It was known as a *vitrum pulicare*, or “flea glass,” because it was used to view fleas and other small insects. An early observer reported that aside from the great advantage accruing to mankind from a just appreciation of the flea, the learned men of the time declared that, with this wonderful machine, they had discovered many new monsters; and one savant affirmed that he had seen the devil himself.



It seems likely that spectacle makers or scholars experimenting with multiple lenses discovered the telescope and the compound microscope. Girolamo Fracastoro (1478-1553), an Italian physician, wrote in *Homocentricorum* (1538) “If anyone looks through two spectacle lenses, one placed on top of the other, he will see everything much larger and closer.” The microscope and telescope developed together as both consist of two or more lenses held in a tube. Credit for the first compound

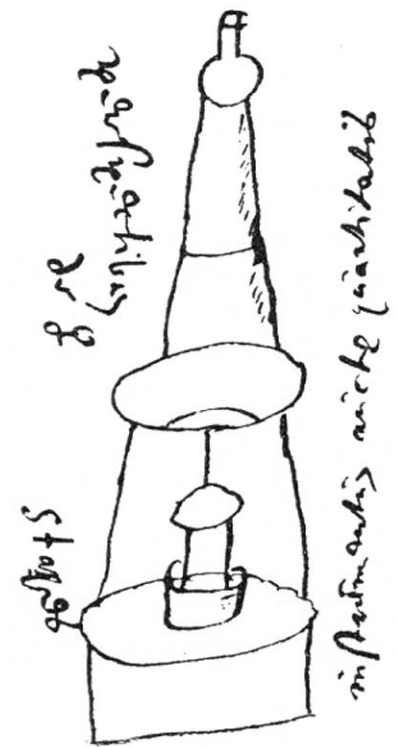
microscope is usually given to Hans Jansen and his son Zacharias (c1580-c1638), spectacle makers in Middelburg, Holland, around the year 1590. Middelburg was a center of lens crafting in Europe at the time. There is also some evidence that the compound microscope was invented by Cornelius Drebbel (1572-1633), an inventor and optician born in Holland and working in England, between 1611 and 1619 (A. Turner, 1987). The word “microscope” was coined in 1625 from the Greek words *μικρόν* (*micron*) meaning “small”, and *σκοπεῖν* (*skopein*) meaning “to view” by Giovanni (Johann) Faber (1574–1629), a member of the Accademia dei Lincei in Italy, a group of scientists that included Galileo Galilei. Galileo, better known for his work with the telescope, was one of the first scientific users of a microscope.



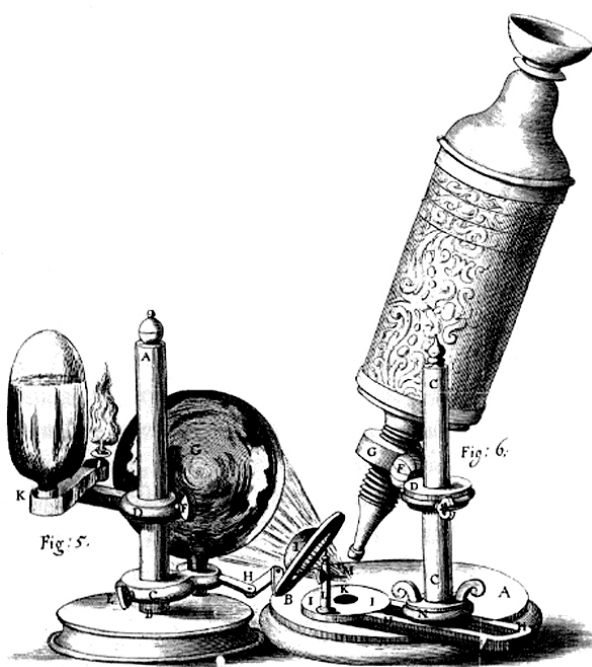
Photograph of microscope in Middelburg, Holland, attributed to Zacharias Jansen, c1595. The microscope is made of tin and is 2 inches in diameter and  $10 \frac{7}{8}$  inches long when closed. It consists of two drawtubes which can slide in and out of an outer casing tube. Lenses are in the ends of the drawtubes; the eyepiece lens is bi-convex and the objective lens is plano-convex. The microscope is hand-held and can magnify 3 to 10 times. To focus the microscope, a drawtube is slid in or out of the outer tube.

In the seventeenth century, most microscopes were made in the form of a cylindrical tube supported by a small tripod. The pattern continued in various forms for 200 years. Besides Drebbel, other early designers were Richard Reeves (1641-1689) in London, Giuseppe Campani (1635-1715) and Eustachio Divini (1610-1685) in Italy, Louis Joblot (1645-1723) in France, and Willem Homberg (1652-1715) in Holland. Around 1660, Robert Hooke (1635-1703) designed a side-pillar microscope, manufactured by Christopher Cock, that could be inclined and had a field lens, stage, coarse and fine adjustment, and an illumination system. This advanced design was not widely adopted until a hundred years later.

Several important scientific discoveries were made using the microscope in the seventeenth century. Francesco Stelluti's (1577-1652) drawing of a bee in *Persio Tradotto* (1630) is the first printed illustration of observations made with the compound microscope. In 1661, Marcello Malpighi (1628-1694), regarded as the founder of microscopic anatomy and the first histologist, using a Divini microscope discovered capillaries in the lung, thereby proving William Harvey's theory of the continuous circulation of blood published in 1628. In 1665, Robert Hooke published his *Micrographia: or Some Physiological Descriptions of Minute Bodies*



Drebbel's microscope, 1619



Hooke's microscope, from *Micrographia*

developed until the middle of the nineteenth century. With the preparations then available, resolution was at best five microns, although with a modern thin histological slide, the resolution is considerably better.

In 1658, Athanasius Kircher (1602-1680) claimed he could see "worms" in the blood of plague patients. This is thought to be the first attempt to use a microscope for diagnostic purposes. The illustration below shows a tripod microscope being used to examine a patient. It is

Made by Magnifying  
Glasses with

*Observations and Inquiries thereupon.* This book which included the first use of the word "cell" in describing the structure of cork, generated wide public interest in the new science of microscopy. Antonie Philips van Leeuwenhoek (1632-1723), beginning in the latter part of the century, made extensive observations using simple microscopes with high quality lenses. His discoveries included the first observations of protozoa, bacteria, spermatozoa, cardiac muscle, the banded pattern of muscle fibers, and nucleated red blood cells from fish. Despite these significant discoveries, the microscope largely remained a "toy" and source of entertainment and amusement for the upper classes until the middle of the nineteenth century. The objectives of the period suffered from chromatic and spherical aberration and low resolution making them less useful for scientific investigation. Another major limiting factor was the nature of the objects to be viewed. Thin sectioning was not



the first known illustration of the use of a microscope for clinical examination in medicine. The tripod microscope is shown in enlarged form on the left and was designed by Joseph Campani of Bologna. The person on the right is using the microscope to examine a wound on the leg of a recumbent patient. A woman holds a candle and a mirror to provide illumination. A second observer on the left is viewing a specimen by holding the microscope up to the sun (Acta Eruditorum, 1686, p 372). It is interesting to speculate about what the examiner observed and what use was made of the observation. Nonetheless, this demonstration shows that there was a realization that the microscope could reveal structures not readily apparent to the naked eye and that this could have some relevance to medicine.



Sliders were the original carriers of objects for microscopical observation, described as early as 1691 by Filippo Bonanni (1638-1723), an Italian Jesuit scholar. Sliders are rectangular slabs, beveled at one end, usually made of bone, ivory, or ebony with round compartments cut out. Specimens were placed between two round pieces of mica and held in the compartments by brass rings. The compartments could be viewed and successively moved under the objective. Common objects for viewing were insects and their parts, plants, and minerals.

At the end of the seventeenth century, the most prominent instrument makers in London were John Yarwell (1648-1712) and John Marshall (1663-1725). Both made tripod microscopes. Marshall also made a side pillar microscope with a fish plate in which the circulation of blood in the tail fin of a small fish could be observed. The fish plate, in which Malpighi's observations could be repeated, became a standard microscope accessory for nearly 200 years. In 1702, James Wilson (1655-1730) improved the screw-barrel microscope, a simple microscope that was popular because it was inexpensive and could be carried into the field. Edmund Culpeper (c1660-1738) is credited with creating the "Culpeper-type" compound microscope around 1725. It uses the same motif as the earlier tripod microscopes but made two improvements. The stage was raised above table level making it more accessible. A concave mirror was inserted below the stage allowing for illumination of specimens from below. Culpeper's model was made and improved by Edward Scarlett (1677-1743). The Culpeper-type microscope was reproduced by many makers with modifications and improvements for the next 100 years. In 1738, Benjamin Martin (1704-1782) introduced the drum microscope which was modified and improved by a number of instrument designers. Versions of this microscope were made into the twentieth century. An important advancement in design was devised in 1743 by John Cuff (1708-1772) at the suggestion of Henry Baker, a well-known eighteenth century microscopist who found then current microscopes difficult to use. The Cuff-type microscope has a composite side pillar that gives rigidity, a delicate fine focus, and unobstructed access to the stage. Later in the century, George Adams (c1708-1773) and his son and the Jones brothers (William and Samuel) continued improvements on the Cuff design, including a flat tripod-style foot and functional limbs with adjustable stages, condensers, and mirrors. There was not a great deal of improvement in lens design during this period, but the mechanics of the compound microscope were advancing rapidly.

The first half of the nineteenth century was marked by great improvements in microscope design and function. In the mid-nineteenth century, there were three pre-eminent optical instrument makers in London. They were Andrew Ross (1798-1859), Hugh Powell (1799-1883), and James Smith (d1870). Andrew Ross began business in 1830. During the period from 1837 to 1841, Ross worked in partnership with the renowned microscopy pioneer and optics theoretician Joseph J. Lister (1786-1869). Lister perfected achromatic lenses corrected for spherical and chromatic aberration. Objectives and condensers were being built with multiple lenses that had increasing degrees of optical correction. A notable consequence of these improvements in lenses was the elevation of histology into an independent science. Now that they were no longer plagued by optical error, microscopes revealed previously unseen details in tissues of all types, greatly advancing the medical knowledge base. In fact, Lister was the first to accurately observe and report the true appearance of red corpuscles present in mammalian blood. The joint efforts of Lister and Ross helped transform the microscope from a toy or parlor oddity into an important scientific tool in medical diagnosis and biological research.

Histology is the study of the structure and composition of the tissues of plants and animals. Tissues are assemblies of cells in which one type is predominant and carries out a specific function within the organism. The term histology was created by the German scientist August Mayer (1787-1865) in 1819 and was based on the Greek root words *histos* (tissue) and *logos* (study). *Histos* originally meant any woven material. Marie François Bichat (1771-1802), a French anatomist and pathologist, was the first to introduce the notion of tissues as distinct entities comprising organs in 1800. Without the use of a microscope, he distinguished 21 kinds of "textures" or tissues that enter into different combinations in forming the organs of the body. He also maintained that diseases attacked tissues rather than whole organs. For this work, Bichat is often considered the founder of both modern histology and pathology. Histology as a separate discipline began in the first half of the nineteenth century as investigators began to examine the tissues of the body with microscopes. In 1827, Hodgkin and Lister, using Lister's improved objectives, published the first

reasonably accurate microscopic descriptions of tissues. Most advances in microscopic anatomy were made in Germany by scientists such as Johannes Purkinje (1787-1869) and Johannes Müller (1801-1858). In 1839, Theodor Schwann (1810-1882) extended Matthias Schleiden's (1804-1881) theory that all plants are composed of cells to animals, stating that all living things are composed of cells. The cell theory became the foundation of modern histology.

In 1858, Rudolph Virchow articulated what became the accepted form of the cell theory, *omnis cellula e cellula* ("every cell is derived from a cell.") He founded the medical discipline of cellular pathology, namely, that all diseases are basically disturbances of cells. It followed that if cells comprised the organism and could grow and divide and that diseases arose in cells, cells were extremely important subjects for research and teaching. Rapid advances were being made at the time in describing tissues, cells, and cell constituents. Besides the improvements in microscope objectives, these advances were made possible by improvements in tissue preparation. Sliders evolved into an all glass slider, a glass slide with mica cover, and a standardized glass slide with thin cover glass. Other important developments in the nineteenth century were the discovery and development of fixatives, embedding media, microtomes for making thin sections, stains, and Canada balsam as a mounting medium.

With the increased importance of histology, the subject was introduced into medical school curricula and professorships of histology were established. The first textbook of histology was published by Albert von Kölliker (1817–1905) in 1852. John Quekett published the first volume of his lectures on histology in 1852. Microscope makers developed relatively inexpensive student microscopes. Slide makers began to offer sets of histological and pathological slides for teaching purposes. Laboratories required adequate instruments for projection of images. In the second half of the century, the photographic positive on a glass plate was developed. These plates could be projected onto a screen or wall from an instrument developed in the seventeenth century called a magic lantern, which passed a beam of light through the slide and an enlarging lens. When an adequate source of illumination in the form of the carbon arc lamp became available in the latter part of the century, the magic lantern was used for educational purposes in histology laboratories. Because the early magic lanterns used oil or kerosene lamps as a light source, the projectors were still called lantern slide projectors even after electric lamps became available. With the development of adequate illumination, projection microscopes were used to project the image of a histological slide onto a screen. The solar microscope was developed around 1740 by John Cuff. It differs little from the projection microscopes of the early twentieth century except that the source of illumination is the sun instead of a carbon-arc magic lantern or lamp. The camera obscura, known in antiquity, was the precursor of the magic lantern, camera, and projection microscope.

In 1886, the physicist Ernst Abbe (1840-1905) working with Carl Zeiss (1816-1888) and Otto Schott (1851-1935) in Germany produced apochromatic objectives based on scientific optical principles and lens composition. These advanced objectives provided images with reduced spherical aberration and free of chromatic aberration at high numerical apertures. At the end of the century in 1893, August Köhler developed Köhler illumination, an important technique in optimizing microscopic resolution power by evenly illuminating the field of view. Although many further advances in microscope design were made in the twentieth century, by the end of the nineteenth century the microscope had been perfected to the point where it achieved its theoretical limit of resolution of 0.2  $\mu\text{m}$ .

## Early Optics and the Precursors of the Microscope

### Ancient Glass

Bactrian Crystal Bead, 500-200 BC

Ancient Roman Glass Sphere, c200 AD

### Mirror

Mirror disc, Greek, fifth to fourth century BC

### Magnifiers

Reading Glass Replica

Magnifying Glass on Stand, 19<sup>th</sup> Century

Venetian Magnifying Glass, 17<sup>th</sup> Century

Nuremburg Quizzing Glass, 17<sup>th</sup> Century

Long-handled Reading Glass, 18<sup>th</sup> Century

Aynsworth Thwaites Magnifying Glass, c1750

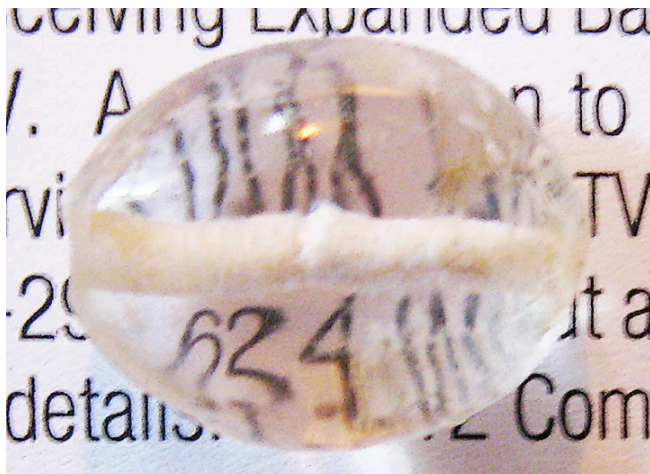
Horn Pocket Magnifier, 1829

Coddington Magnifier, c1840

Stanhope Manifier, c1870

Burning Glass

Optics is the branch of physics that involves the behavior and properties of light, including its interactions with matter and the construction of instruments that use or detect it. A lens is an optical device with perfect or approximate axial symmetry which transmits and refracts light, converging or diverging the beam. The word lens comes from the Latin name of the lentil, because a double-convex lens is lentil-shaped. There are early references to magnifying lenses, burning glasses to start fires, and magnifying effects of glass globes filled with water. The earliest known lens is the 3000 year old Nimrud lens found in 1850 at the Assyrian palace of Nimrud. The quartz crystal lens is 1.25 cm in diameter, slightly convex, and has a focal length of 12 cm. Opticians



believe it was deliberately ground as a lens but archeologists think it was an ornament or a piece of inlay for furniture. It has been suggested that some of the extremely fine and intricate gold work from ancient Mesopotamia, Greece, and Roman Empire would have required the use of magnifying lenses. It is not unreasonable to assume that sometime in the ancient past someone, holding a piece of transparent crystal or glass thicker in the middle than at the edges, looked through it and discovered that it made things appear larger. Shown here is the magnifying effect of a small Bactrian quartz crystal bead, 500 to 200 BC.

Microscopes and most other optical instruments utilize glass lenses to produce a magnifying effect. Glass is produced from a mixture of silica ( $\text{SiO}_2$ ), lime ( $\text{CaCO}_3$ ), and soda ( $\text{Na}_2\text{CO}_3$ ). Glassmaking originated in Mesopotamia in the third millennium BC and soon thereafter in Egypt. The earliest glassmakers produced beads and amulets. During the 1st century BC glass blowing was discovered on the Syro-Palestinian coast, revolutionizing the industry. Around 100 AD, clear glass was discovered through the introduction of manganese dioxide. Therefore, it seems unlikely that glass magnifying lenses could have existed before that time. If there were magnifiers, they would have been quartz crystal. It appears, though, that the use of glass or crystal as magnifying devices did not become widespread until the eleventh century with the use of "reading stones."



The optical industry of grinding and polishing glass lenses began with the invention of spectacles in the late thirteenth century.

One of the earliest known magnifying devices used by the ancient Greeks and Romans was a glass globe filled with water. The earliest written record of magnification dates to the first century AD, when Seneca the Younger (3 BC-65 AD) wrote: "Letters, however small and indistinct, are seen enlarged and more clearly through a globe or glass filled with water." This effect is illustrated by this Roman water-filled glass vessel (c200 AD). The magnification is approximately 3X. This observation did not lead to the widespread use of glass for lenses because the magnification was attributed to the water, not the glass.



Roman Glass Sphere

One of the earliest optical instruments is the mirror, an object that reflects light in a way that preserves much of its original quality subsequent to its contact with the mirror. The first mirrors were probably pools of still water or water collected in a vessel. The earliest manufactured mirrors dating to 6000 BC are pieces of polished obsidian found in Anatolia. These were followed by polished copper or bronze mirrors in ancient Mesopotamia, Egypt, and China. In classical antiquity, mirrors were made of solid metal (bronze, later silver) and were too expensive for widespread use by common people. Due to the low reflectivity of polished metal, these mirrors also gave a darker image than modern ones, making them unsuitable for indoor use with the artificial lighting of the time. Metal-coated glass mirrors are said to have been invented in Sidon (modern-day Lebanon) in the first century AD. The invention of the silvered-glass mirror is credited to German chemist Justus von Liebig in 1835. Although mirrors are most commonly used for personal grooming or admiring oneself, concave mirrors were also used in ancient Greece and China for starting fires. Much later they came to be used in scientific instruments such as telescopes, sextants, and microscopes.



Mirror disc, Greek, fifth to fourth century BC

This is a mirror disc, Greek, fifth to fourth century BC. It is a flat disc 6.3 inches (16 cm) in diameter made of cast bronze, now oxidized. There is a corroded iron fragment riveted to the disc with two bronze rivets, indicating an earlier iron handle. The disc is bent with several dents.



The precursors of microscopes were simple magnifying glasses and spectacles. Around 1000 AD, the reading stone, actually a magnifying glass, was developed. The reading stone was a segment of a glass sphere that could be laid against reading material to magnify the letters. It assisted presbyopic monks in copying and illuminating manuscripts and was probably the first reading aid. The Venetians learned how to produce glass for reading stones, and later they constructed lenses that could be held

in a frame or stand in front of the eyes instead of directly on the reading material. The earliest examples of single-lens, hand-held reading devices date back to the twelfth century and were simple affairs with bone or brass handles. Placing a small lens in a tube in the first part of the sixteenth century resulted in the simple (single lens) microscope. Spectacles appeared in Italy at the end of the thirteenth century and were formed by joining two lenses side by side with a bridge. The spectacle industry began in Venice and Florence and later spread to the Netherlands and Germany. The earliest compound (two or more lenses) microscopes and telescopes were developed at the end of the sixteenth century by lenscrafters who manufactured the lenses used in spectacles and magnifying glasses.



The reading glass shown is modern. The lens stand is six inches high. The lens is 2 ½ inches in diameter. The base and top part of the stand are brass. The folding feet of the base have a raised vine decoration. Nineteenth century.

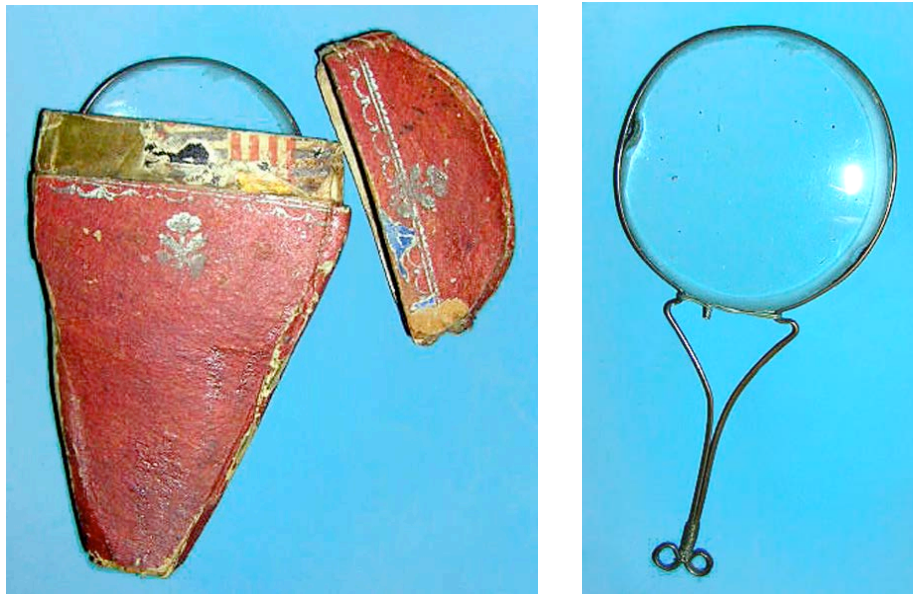


### Venetian Magnifying Glass, Seventeenth Century



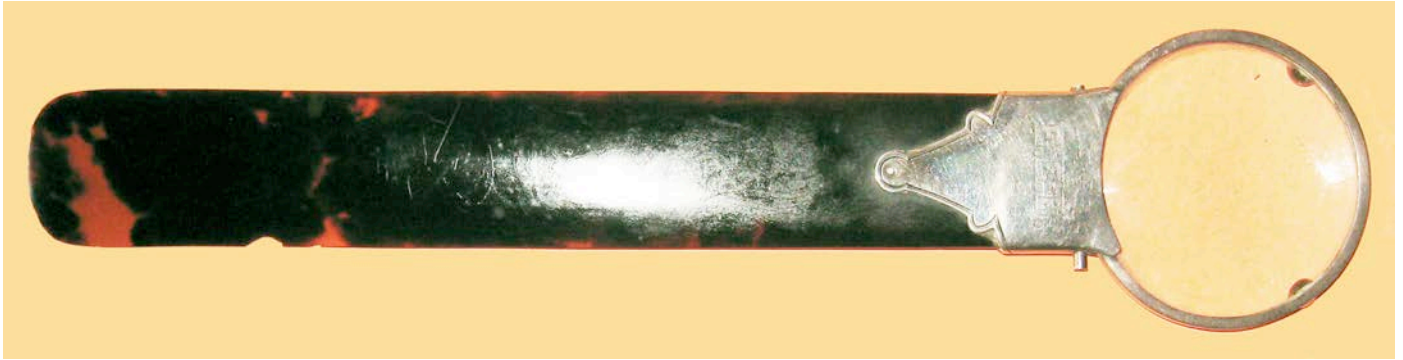
This is a magnifying lens of Venetian manufacture, probably seventeenth century. The lens is oval, 65 x 75 mm. The lens is enclosed by a rim and folds into a case. The rim and case are made of buffalo horn. A portion of the edge of the lens is missing. An identical magnifier, formerly from the Fritz Rathschuler collection, is in the collection of Leonardo Del Vecchio in the Luxottica Eyewear Museum, Agordo, Italy.

### Nuremburg Quizzing Glass, Seventeenth Century



This rare seventeenth century Nuremburg quizzing glass is another example of a single-lens, hand-held reading device. The single magnifying lens on a handle acquired the name quizzing glass in the eighteenth century when men in a parlor used a hand held magnifier to surreptitiously spy ("quiz") on women. This early eye spectacle is made of a convex lens and copper wire frame with a handle. The lens is 50 mm in diameter and the overall length is 4 ¼ inches. The original press paper case has gilt tooled decoration and is lined with early printed paper. Nuremburg, Germany was the center of production for inexpensive quizzing glasses between 1600 and 1725. The quizzing glass later developed into a fashionable accessory designed and worn as a piece of jewelry. Many quizzers were sent to the 13 Colonies to be used as fire starting glasses in the 1700s.

### Long-handled Reading Glass, 18<sup>th</sup> Century



This is another example of an early type of magnifying device. It consists of a magnifying glass in a silver frame attached to a tortoise shell handle. This item could be used as a page marker, a page turner, and as an aid for reading. It was most likely used with a very large bible, dictionary, or atlas. The metal parts are silver, the handle is tortoise shell. The silver has several hallmarks and the initials "EEB." It is probably eighteenth century. The diameter of the reading lens is three inches. Overall length is 14 inches.

### Thwaites Magnifying Glass, c1750

This is a magnifying glass by Aynsworth Thwaites who is best known for making turret clocks. John Thwaites was a clockmaker at the beginning of the seventeenth century and from this extended family Aynsworth Thwaites founded the business, now known as Thwaites & Reed, in Rosoman Street, Clerkenwell, London in 1740 and continued there until 1780. The magnifying glass is three inches in diameter and folds into a brass case. The case is inscribed "AYNS<sup>TH</sup> THWAITES N<sup>o</sup> 4 ROSOMAN STREET CLERKEN WELL." This instrument is in fine condition noting only a worn finish and a small chip in the glass at one edge. This is a fine eighteenth century glass by an important instrument maker. c1750.



Thwaites Magnifying Glass



### Horn Pocket Magnifier, 1829

Pocket magnifiers were used from the time of their invention to the present time. This is a pocket magnifying glass with a horn case and swivel lens that is inscribed "1829 Smith W + W M." It measures 2 ¼ inches in diameter and ½ inch thick. The lens swivels out and is intact but there is a crack in the horn surrounding the glass.



Horn Pocket Magnifier

### Coddington Magnifier, c1840

A Coddington magnifier is a magnifying glass consisting of a single very thick lens with a central deep groove diaphragm at the equator. As a result, the image is formed by the central part of the lens reducing spherical aberration. This allows for greater magnification than a conventional magnifying glass although the area seen through the lens is reduced. This type of magnifier was introduced by Henry Coddington (1798-1845) in 1819. This is a Coddington magnifier shown here disassembled to illustrate the Coddington lens. The housing is brass and has a hole for a handle, which is missing. "Coll P & S N Y" is written in script on the body. The College of Physicians and Surgeons obtained an independent charter in 1807 and was later merged with Columbia College. The initials HC and a symbol are scratched onto the body. The magnifier is small, being 28 mm in diameter and 23 mm high.



Coddington Magnifier

### Stanhope Magnifier, c1870

The Stanhope hand magnifier was invented by Charles, the third Earl of Stanhope (1753-1816). This modified Stanhope type magnifier consists of a single very thick plano-convex lens 40 mm in diameter. It is held in a band of nickel silver that has a short handle. The lens is ground so when its flat face is placed on a surface, it is just in focus. c1870.



Stanhope Magnifier

### Burning Glass

A burning glass or lens focuses the parallel light rays from the sun onto a small focal point, heating up the area and resulting in ignition of the exposed surface. Burning lenses, usually globes filled with water or mirrors, were known in the ancient world, and used to cauterize wounds or start sacred fires in temples. In more recent times, glass lenses were used by explorers, pioneers, hunters, and those in the fur trade to start fires. This is an example of a burning glass meant to be carried into the field. The biconvex lens is five inches in diameter and composed of glass with a blue tint. It has a 6 x 10 inch leather case sewn with a leather cord at the bottom. At the top, there is a broken leather drawstring and a loop that may be a belt loop. The glass is free of chips and scratches. It has been tested and will start a fire. Probably late nineteenth/early twentieth century.



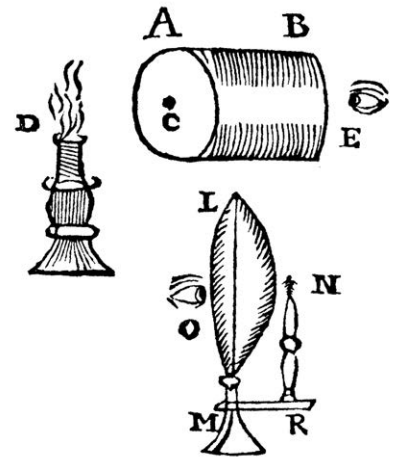
Burning glass and Case

# Microscopes

## Simple Microscopes

Flea Glass Simple Microscope, c1750  
Optical Compendium, c1700  
Replica of Leeuwenhoek Simple Microscope, 1665  
Simple Horn Microscope on Stand, c1700  
Culpeper Screw-Barrel Microscope, c1710  
Culpeper Screw-Barrel Microscope on Stand Replica, c1720  
Simple Compass Microscope, Lieberkuhn Type Replica, c1780  
Withering Botanical Microscope, c1785  
Aquatic Microscope, c1790  
Naturalist Microscope, c1795  
Simple Microscope with Spring Object Holder Replica, c1800  
Botanical Field Microscope, c1820  
Dissecting Microscope, R. Field, c1855  
Linen Prover, c1885  
Peep Egg Viewer, Last Quarter Nineteenth Century

The first simple microscope probably originated in the first part of the sixteenth century and consisted of a short tube of opaque material with a lens at one end, and at the other a flat glass plate on which the object to be examined was placed. The instrument was called a *vitrum pulicare*, or flea glass, and later *microscopium pulicare*, or flea microscope, because it was used to view fleas and other small insects. A second type of flea glass consisted of a hand-held lens with a spike in front on which the specimen is placed. These simple microscopes are shown in Athanasius Kircher, *Ars Magna Lucis et Umbrae*, 1646. With the invention of this instrument, a natural world unseen by the naked eye was revealed. The public soon realized the attractions of the simple microscope. Today, while many people carry a shiny smartphone or ipod in their pocket, 300 years ago they may have carried an elegant acorn microscope or compendium like the following two instruments. In the seventeenth and eighteenth centuries, the simple or single lens microscope was a more useful instrument for scientific observations than the compound microscope. The latter suffered from chromatic and spherical aberration and it was not until around 1830 when improved lenses were developed that the compound microscope became scientifically useful.



### Flea Glass Simple Microscope, c1750

This instrument is a type of flea glass, also called an acorn microscope because of the shape of the cap. It is also a miniature compendium because it contains the two types of microscopes illustrated by Kircher in 1646. It is made of ivory with some parts blackened. It is small, being about two inches high and one inch wide at the base. A center disk is threaded at both ends to accept the cap and the tubular base. A simple microscope in the form of Leeuwenhoek's microscope is located on the surface of the disk. It consists of a very small lens in a mount and a small vertical pin upon which the specimen is placed. The eye is placed very close to the lens to view the specimen. The base of the instrument is in the form of a flea glass. The bottom plate of



## Simple Microscopes

the tubular base can be unscrewed and serves as a cell for objects. The base contains a lens at one end that serves as a condenser. Inside the base is a smaller black, slightly conical tube with an eye lens and a field lens. The base with its insert can be held in the hand to view objects placed in the base cap. The insert can also be used as a live box by unscrewing the lens and putting an insect inside. The instrument probably dates from the middle of the eighteenth century although the design is earlier.



**Flea Glass/Acorn Microscope, c1750**

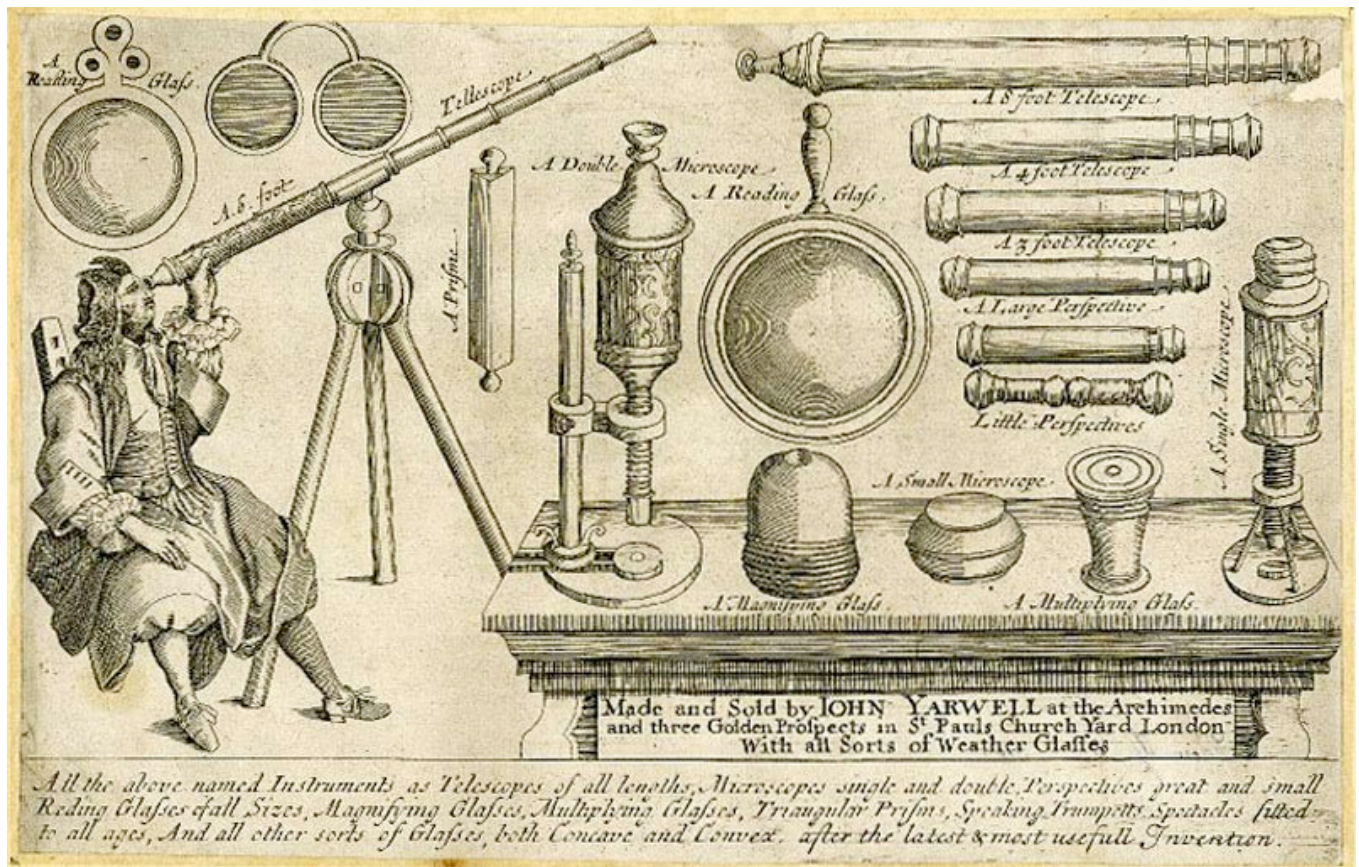
**Optical Compendium, c1700**





## Simple Microscopes

This is an extremely rare bone optical compendium, English, c1700. The parts which screw together are left to right: cap, kaleidoscope and live box, simple flea glass magnifier, telescope lens and fixed microscope lens and specimen spike, telescope lens, and cap. The “kaleidoscope” is a multifaceted prism that produces a kaleidoscopic effect when viewing an object. This part is the “multiplying lens” in Yarwell’s trade card shown below. The magnifier contains an eye lens and a field lens and fits inside the kaleidoscope which serves as a live box. The next part contains one of the telescope lenses and at the other end a flea glass with a small fixed lens and fixed specimen spike. The last section contains the other telescope lens and screws into the previous piece to form the telescope. The compendium is five inches long and one and one eighth inches in diameter at the widest part. The instrument is in excellent condition with two hairlines. All pieces screw together easily and are functional.



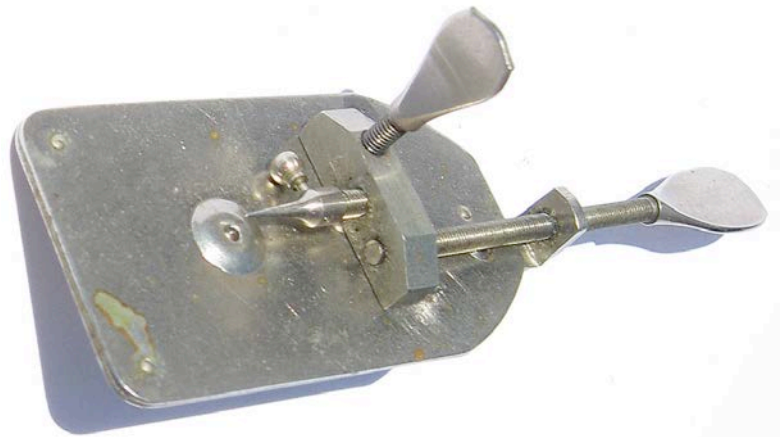
Trade Card of John Yarwell, 1683, Science Museum, London

These compendiums are difficult to date as the makers are not known. However, it appears they were made from the second half of the seventeenth century to the early nineteenth century. They are said to have been sold in large numbers at the end of the seventeenth century and were the instruments that popularized microscopy. John Yarwell’s 1683 trade card in the Science Museum, London, illustrates the instruments (not drawn to scale) he marketed. Among them are “a magnifying glass” in the shape of an acorn, “a small microscope,” “a multiplying glass,” and “little perspectives,” one of which resembles a compendium. Instrument makers, such as Yarwell and Culpeper, who made both small microscopes and telescopes most likely made these compendiums. Bone and lignum vitae instruments are probably the earliest. Later instruments were made of ivory, walnut, and brass. An identical compendium is in the Raymond V. Giordano Collection (*Singular Beauty* No. 27) and very similar ones in the National Maritime Museum, Greenwich, England, the Jacques Fouretier Collection, France, and the Billings Collection.

### Bausch & Lomb replica of simple microscope by Antony Van Leeuwenhoek

Antonie Philips van Leeuwenhoek (1632-1723) was a Dutch tradesman and scientist from Delft, the Netherlands. He is best known for his work on the improvement of the microscope and for his contributions towards the establishment of microbiology. Although Leeuwenhoek's studies lacked the organization of formal scientific research, his powers of careful observation enabled him to make discoveries of fundamental importance. In 1674 he began to observe bacteria and protozoa, his "very little animalcules," which he was able to isolate from different sources, such as rainwater, pond and well water, and the human mouth and intestine. In 1677, he described for the first time the spermatozoa from insects, dogs, and man. Leeuwenhoek studied the structure of the optic lens, striations in muscles, the mouthparts of insects, and the fine structure of plants. In 1680, he noticed that yeasts consist of minute globular particles. He extended Marcello Malpighi's demonstration in 1660 of the blood capillaries by giving the first accurate description of red blood cells in 1684. A friend of Leeuwenhoek put him in touch with the Royal Society of England with which he communicated most of his discoveries by means of informal letters from 1673 to 1723. He was elected a fellow in 1680 and his letters were published in the Society's Philosophical Transactions.

The microscope of Leeuwenhoek is an extremely simple device, consisting of a single, high-quality lens of very short focal length. His microscopes could magnify up to 275X and resolve down to 2 microns. This was greatly superior to the compound microscopes of the time until the development of achromatic lenses in the 1830s. The reason for this difference is that although the single lens produces some aberration, the aberration is magnified by the multiple lenses in the compound microscope. The entire instrument is only 3 ½ inches long. The lens is mounted in a tiny hole in the brass plate that makes up the body of the instrument. The specimen is mounted on the sharp point that sticks up in front of the lens, and its position and focus can be adjusted by turning the two screws. The microscope is held close to the eye for viewing. It requires good lighting and great patience to use. He manufactured hundreds of instruments, of which nine or ten originals survive.



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A number of replicas of Leeuwenhoek's simple microscope have been produced. This functional example was made by the Bausch & Lomb Optical Company in 1933. It bears the inscription "Replica of microscope by Antony Van Leeuwenhoek about A.D. 1665." Two metal plates are riveted together and secure the glass-bead lens between them. The specimen pin is on a threaded shaft that travels through a bracket on the back of the plate in order to raise and lower the specimen in front of the lens. The focus is another threaded screw that goes perpendicularly through the specimen shaft in order to shift the specimen closer or farther from the lens. One of these Bausch & Lomb replicas was owned by Stanhope Bayne-Jones, Dean of the Yale Medical School from 1935 to 1940, and is now in the Billings Microscope Collection.

### Simple Horn Microscope on Stand, c1700

This type of magnifier or simple microscope was popular among naturalists and the interested public in the seventeenth and eighteenth centuries. This example is made of turned



## Simple Microscopes

horn and consists of a circular base and an upright pillar supporting a biconvex lens in a collar and pierced for the object support. It is fitted with a movable wooden rod that carries a steel specimen spike. It is 9 cm high and the lens is 17 mm in diameter. Focus is achieved by moving the specimen mount in or out while holding the instrument before the eye. Magnification is about ten times. Its origin is unknown but a similar horn stand in the Giordano collection is from Holland and a horn hand microscope in the Science Museum, London is Italian. The specimen rod and spike are replacements. The horn stand is in excellent condition.



**Simple Horn Microscope on Stand, c1700**

### **Culpeper Screw-Barrel Microscope, c1710**

This is a rare, original screw-barrel microscope by Edmund Culpeper. The screw-barrel microscope was invented by the Dutch mathematics and physics professor Nicolas Hartsoeker (1656-1725) as early as 1689. The microscope was developed in response to a growing demand for a small, portable instrument that was practical to carry into the field, easy to use, and feasible to mass-produce at a reasonable cost. James Wilson in England published a description of it and made improvements in 1702 and it became known as the Wilson screw-barrel microscope. Edmund Culpeper (c1660-1738) was an important maker of scientific instruments. He trained as an engraver under Walter Hayes and took over Hayes's premises in Moorfields in London, before 1700, where he specialized in making mathematical instruments. He diversified into making small, simple microscopes from ivory and brass. In 1725, Culpeper turned to tripod-mounted compound microscopes, introducing major changes and improvements in their mechanical and optical systems. Such instruments were made by various makers over the next hundred years and are known as "Culpeper-type microscopes."

## Simple Microscopes

The screw-barrel microscope consists of a small cylinder with an external thread at both ends. The optics consist of an objective lens in a brass mount and screwed onto one end of the threaded body, and a condenser lens for specimen illumination screwed onto the other end. The sample to be examined is inserted through the opening in the side of the tube and is held in place by a spiral spring within the tube. Focusing is accomplished by screwing the outer tube in or out, which moves the specimen closer or further from the magnifying objective.

This instrument is made of bright brass with good lacquer retention. The main body with condenser in closed position measures 2 1/2 inches long and 1 inch in diameter. The finely turned ebony handle is 3 inches long and screws into the bracket on the bottom of the microscope. It includes four numbered object lenses with brass caps (all beads intact). There is a magnificent four-celled brass slider for aquatic specimens (wet cells). This slider is doubly stamped "E C" on one side and exhibits Culpeper's rosette pattern on the end of the other side. There is a fish skin case containing four very early sliders. There are also two glass tubes of varying diameter for viewing large aquatic specimens. The green velvet-lined sharkskin case measures 6 x 3 x 2 inches.



**Culpeper Screw- Barrel Microscope, c1710**



### Accessories for Screw-Barrel Microscope, c1704-1725

This collection consists of an extension tube and objectives for a screw-barrel microscope and a group of sliders. The screw-barrel microscope could be converted to a compound microscope by attaching an extension with an eye lens to the objective end of the screw-barrel (see Culpeper Screw-Barrel Microscope on Stand Replica, c1720). The microscope was held by a handle on the screw-barrel or, in some cases, was mounted on a stand. This extension tube is made of ivory and consists of two tubes. It is 88 mm long closed and 102 mm extended and has an eye lens and a locking screw. Focus is achieved by sliding the eye tube. The extension is in fine condition with a stable crack.

There are seven numbered ivory objectives. The objective lens is mounted in a cell of ivory consisting of a central, hollow cylindrical portion surrounded by a wide flange (30 mm). The outside of the cylindrical portion is threaded to enable it to be screwed into the end of the barrel of a screw-barrel microscope. A brass cup holding the lens fits into the cylindrical portion and is held in by a brass circlip. One objective has its bead lens and two have their caps. (One objective is with the "Objective Collection.")

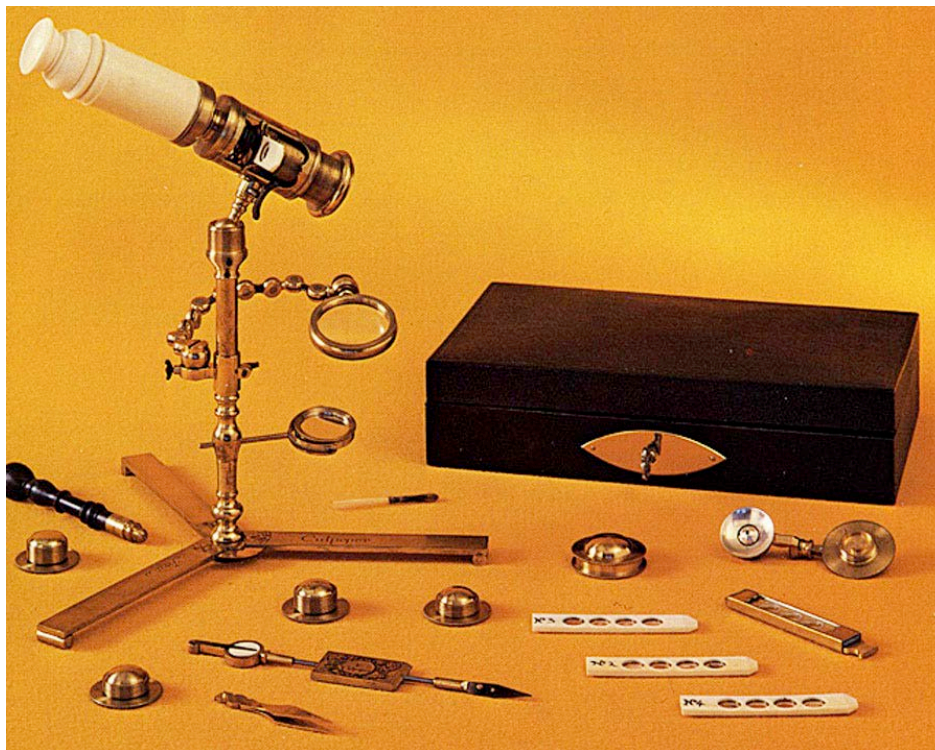
There are six numbered ivory sliders and one brass slider for wet specimens. The sliders are 2 inches long and  $\frac{3}{8}$  inches wide and have three cells. The ends are beveled so the slider will slip easily into a spring stage on the microscope. Specimens are placed between two round pieces of mica called talcs and held in the compartments by brass rings. All specimens are intact. The brass slider lacks its sleeve.

James Wilson (1665-1730) introduced the screw-barrel microscope to the Royal Society in 1702. Possible makers of these accessories are Wilson, Edmund Culpeper (1670-1738), and Edward Scarlett (c1677-1743) who were the first opticians to make and sell screw-barrel microscopes. The objectives closely resemble objectives made by Wilson (Clay and Court, Figs. 21, 22). The sliders are identical to those accompanying the Culpeper screw-barrel microscope in this collection and those by Wilson in the Museum of the History of Science, University of Oxford and dated c1704. Based on the lettering, the objectives and sliders were made by the same maker, most likely James Wilson. The extension may be of a later date.



### Culpeper Screw-Barrel Microscope on Stand Replica, c1720

This is a Replica Rara replica of a Culpeper screw-barrel microscope on a pillar and stand. It is provided with a tube with an eye lens that screws over the objective mount converting the instrument into a compound microscope. Microscope enthusiasts sometimes added a substage mirror and lieberkuhn lenses to these microscopes at a later date. The brass tripod foot is an adaptation of a 4 ½ inch sector. A turned pillar rises 6 ¼ inches from the sector center, terminating in a ball and socket joint with a slot cut away to permit upright position of the microscope. The modified Bonanni stage has a steel spring, two brass plates, and a third curved brass plate and leather pad to hold a slider or glass tube. A ¾ inch condenser lens exists at the screw barrel end; a 1 ¼ inch condenser lens is mounted on the stand by a knuckle jointed arm. The 13/16 inch single concave mirror on a gimbal attaches to the pillar. The screw barrel brass body consists of a threaded screw and hollow sleeve. The compound body is made of ivory. The compound body contains one ocular at the proximate end. The screw-barrel has six simple lenses and one lieberkuhn lens. The compound body contains one objective. Coarse adjustment is by means of a long screw and also with a draw tube for the compound instrument. Accessories include brass tweezers, pencil brush, case for lieberkuhn lens, ebony handle, extension of opaque objects, stage forceps, forceps plate, brass animalcule cage, and four ivory sliders. The black Moroccan skiver leather covered wooden case, 8 9/16 " l x 5" w x 2 1/8" h, is lined with dark green velvet. The compound microscope closed is 5 ¾ inches long. The microscope on stand in horizontal position is 7 ½ inches tall. "Culpeper Fecit" is engraved on two folding arms of the sector stand. Engraved along the hollow screw-barrel sleeve is "Culpeper Fecit." and on the forceps plate, while on the other, Culpeper's name is surrounded by a garland emblem. The sector stand has an ornamental motif at the base center. The simple lens mounts bear engraved numbers 1 through 6. The Replica Rara stamp and serial number is located on the underneath side of a sector foot. The extremely fine Replica Rara, now Science Heritage Ltd., microscopes in this collection were donated by Dr. James B. McCormick.



Culpeper Screw-Barrel Microscope on Stand Replica, c1720



### Simple Compass Microscope, Lieberkuhn Type Replica, c. 1780

This is another fine replica made by Replica Rara. This type microscope has two arms connected by a hinge at the bottom. One arm holds the specimen and the other the eye lens. It is called a compass microscope because of its similarity to a draftsman's compass. It is provided with lenses introduced by the German anatomist and physician, Dr. Johann Lieberkühn in 1740. These objective lenses have a concave polished silver mirror around the lens. This allows light to be reflected from the cup-shaped mirror onto the specimen so that it is well illuminated from the eye side. These lenses became standard equipment for 150 years and became known as lieberkuhns. Both the lieberkuhn lens and the instrument's portability enhanced the use of the microscope for botanical field work.



Simple Compass Microscope, Lieberkuhn Type Replica, c. 1780

The object is held with forceps which inserts into a brass fitting on the hinged compass arm. The forceps is turned by an L-shaped brass handle. The body, consisting of a brass circular ring, is mounted on a curved brass arm 3 inches long. A brass eyepiece, coated black on the eye side, screws into the circular ring. Four lieberkuhn lenses screw into the eyepiece. Each lens is matched in focal length with its coin silver concave mirror. Fine focusing is achieved by turning the knurled knob to adjust the distance between the compass arms. Accessories include a hand magnifying lens, in a lignum vitae mount, and brass tweezers. The rectangular mahogany case, 7 ½" l x 2 7/8" w x 1 11/16" h, is fitted and lined in chamois leather. The overall length with handle is 6 ¾ inches. The Replica Rara stamp and serial number is located on the inside surface of the hinged compass arm.

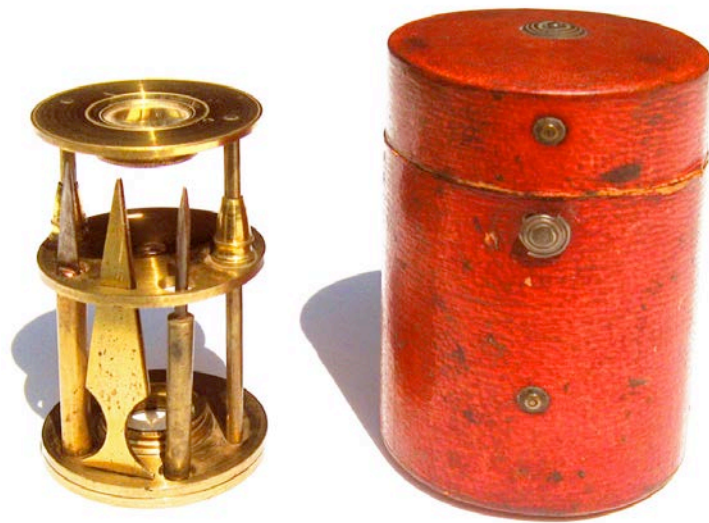
### Withering Botanical Microscope, c1785

William Withering (1741-1799) was an English botanist, geologist, chemist, and physician. He is best known for his use of extracts of foxglove (*Digitalis purpurea*) to treat dropsy (edema), a condition associated with heart failure and characterized by the accumulation of fluid in soft tissues. For this he is considered the father of clinical pharmacology. In 1776, he published the landmark botanical treatise *A Botanical Arrangement of All the Vegetables Naturally Growing in Great Britain*. In the book, Withering described a portable simple botanical microscope that he designed. The microscope was popular and variations on the design, including improved models created by Withering, survived throughout the nineteenth century.

This is an all brass example of the original cylindrical form of the Withering simple microscope. The microscope measures 63 x 35 mm and consists of three rings on two supports. The upper ring holds the biconvex eye lens, the middle is the stage, and the lower is the base. An extra end plate that can be unscrewed from the base contains a lens and can be used as a hand magnifier. Focusing is achieved by simply sliding the stage up and down on the brass supports. Illumination of the specimen depends on ambient light. The accessories are a pair of brass

## Simple Microscopes

tweezers (appears to be a replacement), a pin probe, and a scalpel. The stage and base have openings to hold the accessories.



The microscope fits into the original maroon, velvet lined card case with decorative buttons and secure push-button clasp. It bears the trade label for "SYKES Place du Palais Royale A Paris" and the number and price appear on the inside of the lower plate. H. Sykes was an English optician living in Paris and marketing instruments there in the late eighteenth century. He reportedly made bifocals for Benjamin Franklin in 1779. This microscope dates c1785.

## Aquatic Microscope, c 1790

One of the great classic designs of mid-eighteenth century microscopes is the "Ellis Aquatic microscope" developed in the 1750's by John Cuff and John Ellis. Pond life was a popular source of material for observation with the microscope throughout the eighteenth and nineteenth centuries. John Ellis (1710-1776) was an English naturalist who worked and traveled in America and the West and East Indies. He designed a microscope for the purpose of observing the movements of tiny water creatures contained by a watch glass on the stage. The first model was made for Ellis by John Cuff in 1752. The novel feature of the microscope is that the arm can swivel from side to side allowing the user to follow the wriggling movements of aquatic organisms. This design soon became one of the most popular naturalists' microscopes and was sold by many instrument makers, notably Adams and Dolland, into the nineteenth century. The Ellis aquatic microscope can also be regarded as the forerunner of the dissecting microscope.



## Simple Microscopes

This microscope is an example of the original form of the Ellis-type aquatic microscope. The cylindrical pillar screws into a boss on the top of the mahogany case. The simple lens objectives are fitted into a ring at the end of a bar at the top of the pillar. Focusing is achieved by adjusting the height of the sprung-brass stage relative to the objective. The principle design advantage is that both the lens arm and the stage can be moved from side to side so the user can follow the movements of aquatic organisms. Included are two objectives, tweezers, a black/white disc, concave glass specimen dish, live/aquatic box, bug-spike, two wooden sliders, and a concave mirror. The case is 3 ½ x 5 ¼ inches and the microscope is 6 ¼ high attached to the case. c1790.



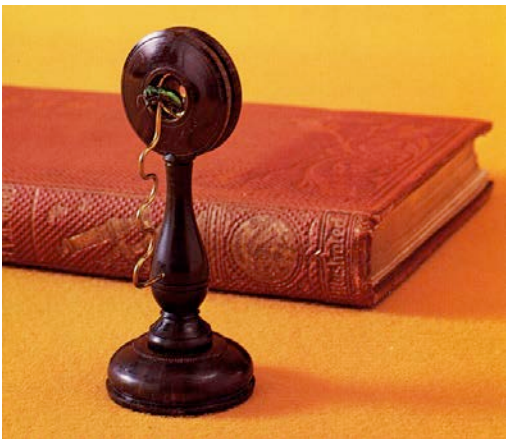
**Aquatic Microscope**



**Naturalist Microscope**

### **Naturalist Microscope, c1795**

This instrument is a small flea/entomological/botanical microscope that can be folded and carried into the field. This simple magnifier has two stacked plano-convex lenses, an ivory handle, and forceps that fit into a knurled nut that slides in a grooved brass plate for focusing. The lens arm and handle fold against the plate. When folded, the instrument fits into a leather-covered cardboard case. Although not signed, it is similar to the naturalist microscope described by the firm of William and Samuel Jones of London in 1798. The microscope is four inches long extended and magnifies approximately 10x. c1795.



### **Simple Microscope with Spring Object Holder Replica, c1800**

This is a Replica Rara replica of a Continental simple microscope made of fruitwood and dating to the late eighteenth and early nineteenth century. Some of these devices were manufactured by “toy makers” among whom were the wooden toy craftsmen of Nuremberg, Germany. The microscope is formed by three turned wooden components: the simple round base, pillar, and an objective lens holder. A pointed brass needle serves as the specimen mount. The coil of brass wire from which the point extends

## Simple Microscopes

can be moved by delicate finger pressure to adjust the lens focus. The simple biconvex lens is mounted in the depression of a turned wooden ocular and secured in place with a brass ring. In use the microscope is held between the thumb and forefingers. Fine focus is achieved by depressing the spring needle specimen mount while holding the instrument before the eye. Overall microscope height is 3 1/8 inches.

### **Botanical field microscope, c1820**

This simple microscope is a fine pocket microscope that was taken into the field to study botanical or entomological specimens. A pillar screws into the top of the reddish-brown card case. The stage attaches to the pillar and has openings for an ivory disc and live/aquatic box, forceps, and sliders. Stage adjustment is by rack and pinion. The stage pivots to accommodate the forceps for insect or flower viewing. At the top of the pillar, an arm holds a rotating turret of three lenses. This differs from most instruments of this type that have three separate swing lenses. There is a one-sided mirror below. The accessories include stage forceps, black/white ivory disc, and a live box/aquatic cell. Although this microscope is unsigned, it is of the highest quality for this type of microscope. c1820.



**Botanical Field Microscope**

### **Dissecting Microscope, R. Field, c1855.**

The dissecting microscope developed from the aquatic and botanical microscopes. The dissecting microscope is very similar to the earlier forms but differs in that it has a larger stage allowing for better manipulation of the specimen. The ends of the stage are slanted to serve as a hand rest. Later, larger wings were attached to the sides of the stage. This example, c1855, has a trade label in the case "R. FIELD & Co." The stand is made of polished mahogany and stands 4 7/8 inches tall on its 8 1/8" x 4 inch base. The brass column is 5 3/8 inches tall overall, with internal rack and pinion focusing and a single-sided mirror mounted at the base of the column and an arm to



## Simple Microscopes

hold the eye lens at the top. The original accessories include three screw-together simple objectives, brass live box, stage-mounted forceps, and stage-mounted bull's eye condensing lens.



**Dissecting Microscope**

**Linen Prover, c1885.**



brass with a lateral adjustment by screw and a pointer over a scale in inches. It is signed "J CASARTELLI & SON MANCHESTER" and RD No 523462. It shows signs of wear but is in good condition. c1885.

**Peep Egg Viewer, Last Quarter Nineteenth Century**

Peep egg viewers, so named because of their shape, were made for amusement during Victorian times and contained scenic views and objects such as dried flowers, insects, shells, or mineral crystals. They were part of the popular science that developed in England and parts of Europe after the Industrial Revolution due to the growing interest of the public in natural history and history. They were also used as souvenirs of popular attractions.

This peep egg viewer is a souvenir of Niagara Falls. It stands 11.5 cm tall and 6 cm in diameter. The peep egg is made of alabaster, so that light passes through the body of the device and no other source of illumination is required. The front is hand painted with flowers and an inscription "From Niagara Falls." The fixed viewing lens is 21 mm in diameter and magnifies the image about five times. The body is fitted with twin alabaster ball handles rotating an interior spindle with the objects mounted on cardboard. The objects are two scenes of Niagara Falls ringed by small colored stones and an arrangement of colored minerals. The viewer is in very good condition noting only some loss to the paint.



## Compound Microscopes, 1660-1900

Compound Tripod Microscope, Italian, c1660  
Compound Tripod Microscope, Italian, Second Half Seventeenth Century  
English Tripod Microscope Replica, c1680  
Marshall's Double Microscope Replica, c1700  
Culpeper Tripod Microscope, c1730  
Side-Pillar Microscope, c1750  
Compound Screw-Barrel Microscope Replica, c1750  
Nuremberg Sentry-Box Microscope, c1765  
Nuremberg Culpeper-Type Tripod Microscope, c1770  
Cuff-Type Microscope by George Adams, c1770  
Culpeper-Type Tripod Microscope, c1810  
Jones Most Improved Microscope, c1820  
English Drum Microscope, c1830  
Cary/Gould Pocket Compound Microscope, c1835  
Chevalier Student Microscope, c1840  
Ross Bar-Limb Microscope, c1849  
Ross Monocular Microscope, 1847  
Nachet-Type Pillar Microscope, c1870  
French Toy Drum Microscope, c1880  
Browning Polarizing Microscope, c1880  
English Wenham Binocular Compound Microscope, R & J Beck, 1880  
Zeiss Continental Micoscope, 1892  
Leitz Continental Microscope, 1888  
Watson & Sons Compound Microscope, 1898

The compound microscope and the telescope are believed to have been invented by Dutch lens crafters at the end of the sixteenth century. It is likely that a spectacle maker experimenting with two convex lenses found that one held over the other at a certain distance gave a greater magnification. By placing the lenses at the ends of a tube, the compound microscope was invented. Similarly, the original flea glass could have been converted into a compound microscope by simply replacing the glass plate at the end of the flea glass with another magnifying lens so that there were lenses at both ends of the tube. Except for the c1595 microscope attributed to Zacharias Jansen (c1580-c1638) in Middelburg, there are no surviving examples of the earliest microscopes. The microscope of Cornelius Drebbel (1572-1633), known from a 1619 drawing, is a tripod microscope in which the microscope tube is supported upright by legs.



**Compound Tripod Microscope, Italian, c1660****Compound Tripod Microscope, c1660**

This is a seventeenth century microscope, probably Italian, on a tripod base. The microscope is 5  $\frac{3}{4}$  inches (14.6 cm) high opened. The body tube is a single piece of turned lignum vitae that is externally threaded on the objective end. The body screws into a wooden mounting ring supported above the base by three turned ivory legs. There is an eye lens and an objective in the nosepiece of the body held in by brass rings. The outside surface of the objective lens is convex while the eye lens is plano-convex. It does not have a field lens dating it to 1660 or before. A wooden ring screws in over the eye lens reducing the opening and decreasing spherical aberration. There is also a wooden dust cap. Focus is achieved by turning the body in the collar. The circular base supporting the legs is 2  $\frac{1}{4}$  inches in diameter. A circular platform in the center of the base holds an ivory disc that acts as the sample stage. Illumination is by incident light. The base sits on three wooden buttons. The microscope produces a clear image of about 10X magnification with spherical and chromatic aberration. The microscope is in excellent condition. It is unsigned but possible makers are Giuseppe Campani (1635–1715), an Italian optician and

astronomer who lived in Rome, and Eustachio Divini (1610–1685), another prominent manufacturer of scientific optical instruments in Rome.

**Compound Tripod Microscope, Italian, Second Half Seventeenth Century**



**Compound Tripod Microscope, Second Half Seventeenth Century**

This is an early compound tripod microscope, probably Italian, second half seventeenth century. It is  $5 \frac{3}{8}$  inches (13.5 cm) high and the diameter of the base is  $2 \frac{3}{4}$  inches (7 cm). The body tube is made of lignum vitae and is secured to the flat round base by three turned bone legs. The base is made of a black wood that appears to be ebony and holds a bone disk for the specimen. The eye lens is embedded in a bone disk fitted into the top of the tube. A turned and ribbed bone nosepiece fits into an extension of the body tube with the objective lens secured by a brass circlip. It is not known if it has a field lens. Cosmetically, the microscope is in very good condition noting that the legs may have been re-glued. It does not produce a clear image and cannot be focused.



There is dust on the lenses and inside the body tube. It appears that the nosepiece should be able to be turned for focusing but it is fixed and no attempt has been made to force it.

### English Tripod Microscope Replica, c1680

Most seventeenth century compound microscopes were made in the form of a cylindrical tube supported by a small tripod. The design was first known in 1619 and the pattern continued in various forms for 200 years. This microscope is a replica of one probably made around 1680 by John Marshall. It is an exact replica of the original using the same materials and measurements accurate to a fraction of a millimeter. It was manufactured in 1975 by Culpeper Instruments, an English instrument maker, and Replica Rara Ltd., now Science Heritage Ltd., under the direction of Dr. James B. McCormick, a specialist in scientific instrument design and laboratory medicine, and with the critical review of Mr. Gerard L'E. Turner, a past President of the Royal Microscopical Society and Associate Curator of the Museum of Science at Oxford University. Production was limited to six instruments at a cost of \$6,000 each. The original microscope is in the Museum of Science at Oxford University. In order to avoid the replica being sold as an original, the gold embossing does not follow the original.



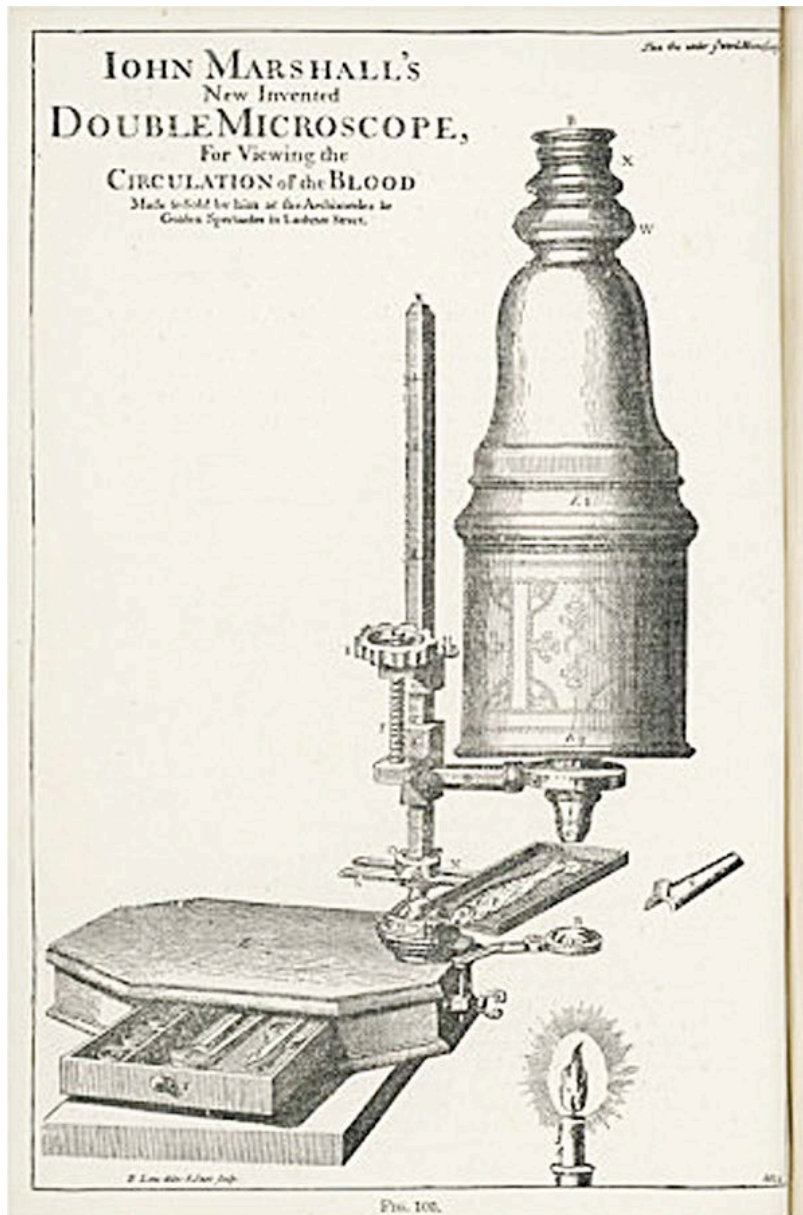
Replica of c1680 English Tripod Microscope



## Compound Microscopes

The barrel of the microscope consists of an inner pasteboard tube covered with vellum and an outer pasteboard tube covered with red morocco. The tubes are decorated with gold-impressed tooling. The wood used in the instrument is lignum vitae. The outer tube carries a wooden eyepiece with a lens. The outer tube can slide over the inner tube for coarse focusing. The inner tube is mounted on a circular turned and pierced base by three brass legs. The inner tube bears the nosepiece which holds the objective. There is a field lens at the top of the inner tube. For fine focusing, the nosepiece is screwed in and out of the collar. When not in use, the eyepiece is covered by a circular box top which holds four objectives. To observe a specimen in transmitted light, it is firmly affixed over the circular hole in the wooden stage and the microscope is then held up to a light source (the sun or a lamp) while the specimen is viewed through the ocular.

A circular ivory disc, black on one side and white on the other, fits into the opening in the base for viewing opaque objects. The microscope is stored in a Morocco leather and gold embossed pasteboard tube. For assembly, if two wooden pieces are to be screwed together, there are tiny grooves on each part that should be aligned to indicate the start point for screwing the pieces together.



At the end of the seventeenth century, the most prominent instrument makers in London were John Yarwell (1648-1712) and John Marshall (1663-1725). Apprenticed in 1662 to Richard Edwards a spectacle maker, John Yarwell became a Freeman of the Spectacle Makers' Company in 1669 and elected Master of the Spectacle Maker's Company in 1684. John Marshall (c1660-1723) apprenticed to John Dunnell of the Turners' Company and became free in 1685. He was a pioneer both in the use of commercial advertising and of the polishing of spectacle lenses in multiple groups. He was appointed optician to George I around 1715. A microscope nearly identical to this and signed I. Marshall was auctioned at Sotheby's, September 21, 2000, and previously by Christie's, October 4, 1995.

### Marshall's "Double Microscope" Replica, c1700

John Marshall (1663-1725) was one of the great seventeenth century opticians and microscope makers. Marshall apprenticed under a telescope maker, and started his own workshop around 1687. There he created mostly optical instruments

and machines for making these devices. He is credited with inventing a method of grinding multiple lenses simultaneously. Advertisements for microscopes came out of the Marshall workshop in 1688; and in 1693 Marshall introduced this intricately detailed compound microscope, the "Great Double Microscope." He popularized it by publishing an advertisement in the *Lexicon Technicum*, the first technical dictionary published in 1704. Marshall called his microscope the Great Double Microscope for two reasons: he wanted to illustrate the large size of the microscope and to reinforce the fact that it was a compound microscope. The microscope has several advances over existing microscopes of the era. These include a rigid support pillar; a stage supported on the same pillar; ball-and-socket joint at the base of the support; Hevelius screw focus; base-mounted condensing lens for transparent objects; and a graduated set of objectives.

Like the English tripod microscope above, this instrument was manufactured by Culpeper Instruments, an English instrument maker, for Replica Rara Ltd., now Science Heritage Ltd., and cost \$9,000 to produce. The microscope is large, standing over 24 inches extended and the body tube is four inches in diameter. Most of the barrel components are of lignum vitae of varying wood grain and color. The entire microscope is supported by a large brass pillar, which is hinged at the base by a large ball and socket that allows the instrument to be inclined. The top of the pillar is decorated with an acorn. The ball and socket is fastened to a finely-crafted octagonal wooden base of walnut with a maple top. Original microscopes are weighted with lead at the opposite end to balance the microscope. Inside the base is an oak drawer that serves to hold the objectives and accessories. The microscope has a main body tube made of cardboard and covered in green, gold-tooled vellum. The polished brass objective nosepiece is screwed to a dark lignum vitae base that itself is glued to the cardboard body. There are six inter-changeable objectives having a magnification range of 4x to about 100x. The top half of the instrument consists of a cardboard drawtube covered in gold-tooled leather. It is topped with an elaborately turned lignum vitae top piece containing the field lens and eye lens. To focus the instrument, the bracket holding the body tube can be moved up and down the side pillar to one of the marks representing the power of the lens in use, and then it is locked in position. Fine focusing is achieved by means of a Hevelius screw focus consisting of a threaded rod and a large, faceted knob. On the side of the wooden base there is a brass mount that supports a condensing lens for transparent samples.



Replica "Double Microscope" by John Marshall, c1700



## Compound Microscopes

The microscope has two stages. One has a rectangular plate that holds a glass insert for use with transmitted light. There is a half cylinder of lead, called a coffin, to hold down the body of a small fish to observe the circulation of blood in the tail fin. When the microscope is placed at the edge of a table, the specimen can be illuminated from below with a candle. The other stage, intended for reflected light observations, holds a brass insert for a black/white ivory disk and has an opening for the stage forceps. The stages are secured to the base of the pillar by means of two forked legs that are tightened by a nut positioned just above the ball and socket assembly. Other accessories are brass tweezers and an ebony specimen spike.



There are only 17 or so known Marshall Great Double instruments in existence, all except possibly one in museums. This high quality replica is more than sufficient to represent this great microscope.

### Culpeper Tripod Microscope, c1725-1730

Edmund Culpeper is credited with creating the "Culpeper-type" microscope around 1725. It uses the same motif as the earlier Campani-style tripod microscopes and the English tripod microscopes. Culpeper's design made two improvements to the tripod microscope. The stage was raised above table level making it more accessible. A concave mirror was inserted below the stage allowing for illumination of specimens from below. This avoided the necessity of holding the microscope bodily up to the light. This design is sometimes considered a regression from the pillar-style microscopes developed by Hooke and Marshall. However, the pillar-style may not

have been as widely adopted because the pillar did not provide enough stability for fine focusing, whereas the rotational symmetry about the optic axis of the Culpeper design provided better stability.

This is an impressive and attractive early compound microscope clearly attributable to Edmund Culpeper and dating to around 1725 to 1730. The microscope stands 14 inches high on a circular turned base,  $5 \frac{3}{8}$  inches in diameter, of lignum vitae. Three turned brass pillars which hold the  $3 \frac{3}{8}$  inches diameter stage and a concave mirror in a brass gimbal with a turned brass back are screwed into the base. The stage holds a small bulls-eye condenser in a gimbal at the edge, two stage clips, and a sub-stage clip presumably to hold a fish plate. An opening in the center of the stage holds a Bonanni spring stage. Into the stage are screwed three further shorter pillars that rise to hold a brass threaded collar. The lignum vitae base of the sleeve that holds the body tube screws into the collar. The sleeve is made of pasteboard with red marble paper applied to the inner surface and sanded white rayskin to the exterior.

The body tube slides into the sleeve. The base of the body tube is made of a turned disk of lignum vitae in the center of which is screwed a turned, tapered boxwood nose piece with a brass thread at the far end to accept the brass objective. The main body of the body tube is pasteboard with a green velum applied to the outside with gold tooling in the form of eight cartouches and one marker presumably for the lens focus position. Above the green velum of the body-tube is a ring of sanded and polished white rayskin that is a continuation of the outside sleeve. At the top of the body tube is a delicately turned lignum vitae collar into which screws the large field lens. Above this is the turned bell shaped top that contains the bi-convex eye lens. The eyepiece has a simple lens rim in lignum vitae instead of a brass dust cap as on most Culpeper microscopes.

Many parts of this microscope have a series of four dots impressed into them with a No. 4 written in ink inside the body-tube. The objective has four slots cut into it. There is a set of 12 black stained four-cell microscope sliders,  $\frac{1}{2} \times 2 \frac{7}{8}$  inches, in a case. There is a list on paper entitled "A List of wood & vegetable Cuttings &<sup>cc</sup>" with the specimens in each slider. A few specimens are missing. The microscope is contained within a solid oak case with some restorations and alterations. The key is present. In the base of the case is a single drawer that holds the sliders and the spring stage.

The microscope is in overall very good condition with minor shrinkage cracks to some parts of the lignum vitae. It produces a reasonably good image of about 200 times magnification with relatively low resolution. Coarse focus is achieved by sliding the body tube up or down in the sleeve. Fine focus can be obtained by screwing the sleeve with the body tube in or out of the collar. The green and gold vellum and the rayskin are in excellent condition giving the instrument an attractive appearance. Much of the coating of the mirror has been lost. The case has various restorations to it including a later set of hinges and lock. Some of the molding has been replaced at a later date. A handle at the top is missing.

Culpeper signed a few of his microscopes and sometimes pasted a trade card as a label inside the case. The construction and workmanship of this microscope are unmistakably Culpeper. The cartouches are identical to those found on labeled Culpeper microscopes. The upper pillars are set midway between, not in line with, the lower pillars. This construction is peculiar to Culpeper and was not used by other makers. This is the second form of the Culpeper microscope with split shagreen covers without brass rings and a flat stage without a central recess. It immediately followed the extremely rare first form with expanded eyecup containing objectives. The Culpeper microscope is a substantial and functional instrument and it is easy to see why it was such a popular form for over a hundred years.







Culpeper Tripod Microscope, c1725-1730

**Side-Pillar Microscope, c1750**

The side-pillar microscope consists of a pillar that is attached to a base and supports the body tube. The pillar microscope was first designed by Robert Hooke around 1660. They were made around the end of the seventeenth century by John Yarwell and John Marshall. Although the design was an improvement over the tripod microscope, the side-pillar did not gain wide acceptance until the mid-eighteenth century when the Cuff-type microscopes appeared. With the improvements made by the Adams's and the Jones Brothers, the inclined side-pillar became the forerunner of the modern microscope.

This instrument is an example of a side-pillar microscope. The microscope is 11  $\frac{1}{4}$  inches tall. A 4  $\frac{1}{2}$  inch high square pillar is attached to a folding tripod base. The nose of the body is screwed into an arm attached to the top of the pillar. The body tube is 6 inches long and 1  $\frac{3}{4}$  inches wide. A stage with a circular hole to accommodate a Bonanni spring stage is attached to the pillar. A flat steel spring in the clamp on the pillar allows the stage to slide on the pillar serving for focusing. There is a substage mirror (glass replaced) mounted on one of the legs of the instrument. The microscope has an ocular, a field lens, and one objective. The objective lens drops loosely into a brass cap which screws into the end of the cone nose of the body. The cap has a small aperture to act as a diaphragm for the objective lens. The eye lens is one inch in diameter and the eyepiece screws into the

body tube. The only accessory is a live box that fits into the opening in the stage. The microscope produces a sharp, low magnification image.

Nothing is known about this unsigned microscope and nothing exactly comparable to it has been identified. The all brass construction, substage mirror, and folding tripod base appeared in the first part of the eighteenth century. It bears some similarities to the Cuff-type side pillars of the second half of the eighteenth century and the Cary-type field microscopes of the first part of the nineteenth century. It also resembles some microscopes by Francis Watkins of Charing Cross, London who worked from 1747 to 1784. It also has some similarities to microscopes made in the eighteenth century in Holland. However, it is not nearly as elaborate as any of these microscopes and could be a transitional form. It is tentatively assigned a date of 1750 until further information is obtained.

**Compound Screw-Barrel Microscope Replica, c1750**

This Replica Rara replica, which converts to a solar microscope, is an unusual modification of the screw-barrel microscope. It was made by the Scottish instrument maker, William Robertson, who worked in Edinburgh from about 1730 to 1760. He issued a pamphlet describing this "New Catadioptric Microscope." The top part of the instrument with the attached mirror can be unscrewed from the tripod stand and used as a solar microscope.



## Compound Microscopes



The ornately engraved base plate, supported by three  $\frac{1}{2}$  inch feet, forms the mounting base for three scrolled brass legs  $4\frac{1}{8}$  inches tall. A brass ring receives the legs and is a seat for the turned wooden section on which the body sits. A modified Bonanni type stage is fixed with two brass plates on both sides of a central curved plate. A set of leaf springs are riveted to press against their respective set of brass plates located below. A  $\frac{15}{16}$  inch diameter plano convex lens screws into the brass and wooden mount in the optical axis. The plane oval mirror is on a gimbal hanging from the curved brass arm. The screw-barrel incorporates a  $1\frac{7}{8}$  inch plain brass tube and two open brass sleeves which slide over the inner tube. A brass tube,  $1\frac{3}{4}$

inch long, with a wooden eye piece, forms a compound body. It screws to the upper end of the screw-barrel body when a single lens is in place. The compound body wooden mount has a  $\frac{3}{8}$  inch diameter ocular. Any of the five simple objectives in brass mounts or the lieberkuhn lens screw into the screw-barrel sleeve. Coarse adjustment is obtained by sliding the middle sleeve on the inner tube; a thumb screw sets its position. The Cuff-like screw actually has a two start thread which gives rather rapid movement to the outer sleeve. Accessories consist of a fish tube, stage forceps, micrometer with a wire  $\frac{1}{60}$  inch, carrier for forceps or micrometer, pencil brush, 4 ivory sliders, and a pair of tweezers. The wooden case ( $10\frac{5}{8}$  inches h) with a decorative latch, has a bottom accessory drawer and 2 small top drawers. Simple microscope is  $8\frac{1}{4}$  inches tall; compound is  $10\frac{3}{4}$  inches. "W.R. Fecit" is engraved along the outer sleeve. Each objective is engraved with a Roman numeral 1 through 5. The Replica Rara stamp and serial number are engraved underneath the triangular base plate. The serial number is also etched underneath the brass mounting ring.

### Nuremberg Sentry-Box Microscope, c1765

Craftsmen in Nuremberg (Bavaria) Germany are famous for their superb wooden toys. Among these toys were wooden microscopes fashioned with pasteboard and soft wood such as fruitwood. These were made beginning around 1750 and continuing for a century, making dating difficult. Several styles were manufactured that were designed to mimic some of the brass microscopes of the period. There were four styles: Culpeper-type, sentry box-type, solar, and side pillar-type.



## Compound Microscopes

This is a wooden "Sentry-Box" type of compound microscope. It is constructed of a wooden oak box base with an enclosed single-sided mirror. Two side cut-outs provide space for inserting sliders. The pasteboard body tube attached to the top of the base consists of three sections separated by turned fruitwood ornamental rings. The bottom section is covered in paper imitating shagreen, the middle section by plain paper, and the top section with painted paper. The top section is a draw tube for focusing. Optically, this microscope has the typical three lenses of the eighteenth and nineteenth centuries; the eye, field, and objective lenses. The field and eyepiece lenses are mounted in the top body tube. The field lens is not original. The objective is mounted to the bottom tube. All three are held in place with metal rings. The eyepiece and objective can be protected with screw-on wooden dust caps. The height of the microscope is about 28 cm. The underside of the box base is monogrammed "IM." The design of this instrument was probably based on Benjamin Martin's "Pocket Reflecting Microscope" of 1738.



Nuremberg Sentry-Box Microscope

**Nuremberg Culpeper-Type Tripod Microscope, c1770**

In this case, the Nuremberg microscope is of the Culpeper type. This Nuremberg Culpeper-style compound microscope is supported by three turned wooden legs, attached to a round wooden base with three bun feet. The support tube is made of pasteboard, covered in fish skin. It has a Bonanni spring stage at its base for holding sliders. Two pasteboard body tubes fit inside the support tube. The outer one is covered with paper and has a turned wooden endpiece that provides mounting for the eyepiece and a flat piece of glass probably acting as a dust cover. The inner tube has at its end a tapered fitting for the objective and a field lens at the top. The body tubes are moved up and down in the support tube for focusing. There is a plano mirror in a tiltable wooden mount attached to the center of the base. Sometimes the bases of these microscopes were branded with the initials of the maker, but this example is not signed. The microscope is missing a screw-on dust cap for the objective. The lenses are not original. The microscope produces a good image of about 100X magnification.

**Cuff-type Compound Microscope by George Adams, c1770**

This important design was devised in 1743 by John Cuff at the suggestion of Henry Baker, a well-known eighteenth century microscopist who found then current microscopes difficult to use. It represents a considerable advance over the earlier tripod design. The novelty of the microscope is the composite side pillar that gives rigidity, contains a delicate fine focus, and provides unobstructed access to the stage. Although the pillar-style microscope was developed much earlier by Hooke and Marshall and had the advantage that the microscope could be inclined, the Culpeper tripod design was more popular, probably because it was more stable and cheaper to produce. The construction is of brass, except for the box-foot which is made of mahogany and which has a drawer containing the accessories. The main supporting limb is constructed of two pillars: one fixed and one sliding. The body tube has a conical collar that fits into the arm carried by the sliding upright pillar. The stage is attached directly below the body tube to the fixed pillar. The two pillars fit into a brass foot that is attached to the wooden base. A scroll support to the foot serves to increase the rigidity of the stationary pillar, as well as to form a handle for lifting the



## Compound Microscopes

instrument. Coarse focusing is achieved by unclamping the body tube and sliding the assembly up or down, while fine focus adjustments are performed by means of a small thumbscrew that acts by moving the sliding pillar in small increments.



**Cuff-type Compound Microscope**

The microscope is equipped with a concave mirror at the base that acts to concentrate illuminating light rays onto a sample mounted on the stage. The stage is in the form of a cross. One arm of the stage is attached to the fixed pillar, the opposite arm holds the condensing lens for focusing light on opaque objects, and the right arm carries either the fish plate for strapping down a small fish so that the blood circulation in the tail fin can be observed or the forceps for holding specimens. The large hole in the center of the stage can hold a live box (used to restrain small animals and large insects) or accommodate a Bonanni spring stage for holding sliders. The eye lens is in a screw setting at the top of the body tube. There are six objectives numbered 1 through 6 whose focal lengths range from 1 inch to  $\frac{1}{11}$  inch. These provide magnification from about 3X to 250X. Most accounts in the literature state that the chromatic and spherical aberration and low resolution of the objectives of the period made them unsuitable for scientific investigation. However, another major limiting factor was the nature of the objects to be viewed. With the preparations then available, resolution was at best five microns. Thin sectioning was not developed until the middle of the nineteenth century. When a modern histological slide is viewed with this microscope, all of the major structural details of the tissue are visible at a resolution of one micron.





The extensive and complete accessories are a fish plate, stage forceps, live box, condensing lens, cone diaphragm that fits under the spring stage, lieberkuhn reflector for illuminating opaque specimens, a sleeve that fits over the lower end of the body tube to hold the lieberkuhn, two hand magnifiers, tweezers, ivory talc box with talcs (mica) and brass clips, glass vial, concave glass for stage opening, flat glasses to place specimens on, and six sliders. The instrument is housed in a pyramidal mahogany cabinet with another drawer.

John Cuff (1708-1772) was one of the finest craftsmen of his time. Despite the popularity of his microscope, he was a poor businessman and went into bankruptcy. His microscope design continued to be made by other makers at least until the end of the century. George Adams Sr. (c1708-1773) and George Adams Jr. (1750-1795) were skilled and innovative opticians and makers of microscopes. The Adams's were Instrument Makers to George III and George Junior was later appointed Optician to the Prince of Wales. This instrument is signed "G. ADAMS At No 60 Fleet Street LONDON." It was made between 1760 and 1780 and represents the first satisfactorily useful microscope and which today produces adequate images at moderate magnification.

### **Culpeper Tripod Microscope, c1810**

The Culpeper-type microscope was manufactured and sold by many instrument makers in the eighteenth century and first part of the nineteenth. The microscope underwent changes in the types of materials used from pasteboard, rayskin, wood, and brass, through brass and wood, to all

brass. However, the basic pattern of the double tripod remained unchanged and all were stored in a wooden pyramidal box.



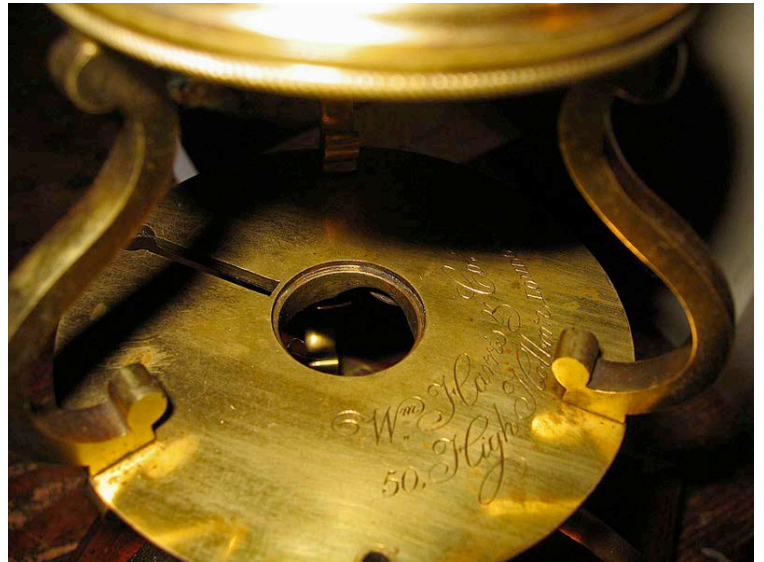
**Culpeper-type Tripod Microscope**

The Culpeper microscope reached the pinnacle of its development in the late eighteenth century. It was a decorative piece of craftsmanship made of shining brass with elegantly curved legs and a wealth of accessories, all housed in a shapely pyramid case of mahogany with a lock on the door and a handle at the top. This microscope is an elegant representative of the final form of the Culpeper-style microscope. It is remarkable for its excellent condition and completeness of components and accessories. It is 16 inches tall, and features scroll-style supports. The top set supports the body tube. The bottom set supports the round stage and is fastened to the square wooden base. It has rack and pinion focusing replacing the sliding action of the tubes of its predecessors. The eyepiece is a two lens Huygenian-type and screws into the top end of the inner tube. The objective screws into the end of a long brass nosepiece at the bottom of the inner tube.



## Compound Microscopes

The microscope comes with five objective lenses numbered 1 through 5. All lenses work perfectly considering the 200-year old age. The microscope has a stage bullseye condenser lens, and substage mirror. Two substage spring clips and a slot on the stage are for attaching accessories. The accessories in a drawer beneath the stage include a fish plate, fish tubes and wire, live-box, lieberkuhn and case with sleeve, stage-forceps, brass tweezers, Bonnani spring stage to hold sliders, substage cone, and stage glasses. Five bone sliders are present with a contemporary list of the objects. There is a bone double-ended canister containing micas and brass circlips. The microscope and stand fit in a mahogany pyramidal case. An unusual detail is that instead of a handle on the top of the case there is an Egyptian revival brass piece. It is rare to find a microscope of this age and type in such fine condition, and so completely accessorized.



The microscope is labeled inside the case and on the stage William Harris & Co, 50 High Holborn, London. Mr. Harris, after working for Sir David Brewster in Edinburgh until about 1800, began to produce instruments under his own name. In about 1800, he opened premises at 50 Holborn in London, marking his output as William Harris & Co. In 1840, the firm was renamed



William Harris & Son. This microscope probably dates from around 1810. Although an early nineteenth century instrument, its technology, style and performance are firmly rooted in the eighteenth century.

### Jones Most Improved Compound Microscope, c1820

William and Samuel Jones were skilled instrument makers in London in the late eighteenth century. The Jones brothers bought the stock of George Adams Jr. in 1795. They made a number of popular microscope models including the Improved and Most Improved brass compound microscopes, although these were of Adams's designs. The Most Improved Microscope incorporated all of the then-modern features found on compound microscopes of the period. The style continued to be made through the first third of the nineteenth century by other manufacturers. It was the best microscope prior to the introduction of achromatic lenses and represents the real beginnings of the scientifically practical modern microscope.

This English Jones Most Improved-type microscope is unsigned but the lid of the case bears the label



"JOHN ARCHBUTT, Mathematical Instrument Maker, Established 1795." It is a later example dating around 1820. It is made of polished brass and stands 18 inches high on its folding 3-leg base, with a 6 inch tall pillar and compass joint supporting the 8 inch long column. The deep full mechanical stage focuses by pinion drive on a rack cut on the front of the column. The 8 inch long body tube screws into the top of the bar limb and the objective lenses screw into the bottom of the bar limb. The double-sided substage mirror is mounted on an adjustable bracket on the column. The accessories include two eyepieces, an objective labeled "Aplanatic 1 Inch," an objective labeled "Aplanatic 1/4 Inch," slip-on lieberkuhns for the objectives, one lieberkuhn objective, one high power objective with screw on cap, stage-mounted bull's eye condensing lens, fish plate, live box, compressorium on brass plate, and stage forceps. The live box, compressorium, and stage forceps are later replacements. In the first part of the nineteenth century, the large, flat mahogany case, holding the folded stand surrounded by its accessories was very popular.

### Jones Most Improved Compound Monocular Microscope



**Jones Most Improved Microscope in case**

**English Drum Microscope, c1830**

This drum microscope is based on the original "Pocket Reflecting Microscope" designed by Benjamin Martin (1704-1782) in 1738. The word "reflecting" refers to the mirror below the stage that allowed light to be directed through transparent objects. The description "drum" probably derives from the drum-shaped section below the stage that incorporated the substage mirror. These microscopes were made throughout the eighteenth century and were very popular between 1820 and 1860 and continued to be made into the early twentieth century. Inexpensive microscopes were made in France as toys and exported in large numbers. This microscope was made around 1830.



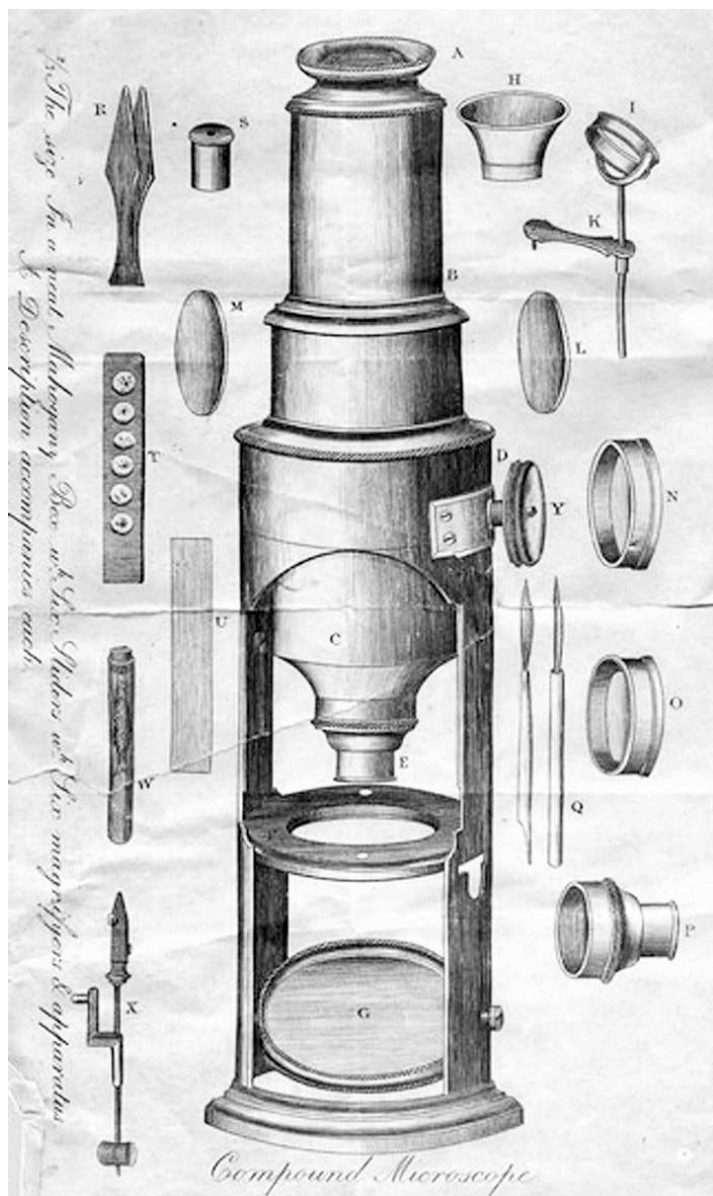
## Compound Microscopes

The microscope is made of brass and consists of a sliding body tube containing compound lenses and a base housing a stage for the sample and a concave substage mirror to provide illumination. Focus is achieved with a rack attached to the knob on the side of the base housing. The stage is fitted with slots to accept sliders. The stage has two fittings, one for the bulls-eye condenser and the other for the stage forceps. There is a pair of holes alongside the stage to carry a glass specimen phial. The microscope was made for viewing sliders and objects held in the stage forceps and containers, but it would accommodate the first small rectangular slides. The accessories comprise a complete kit of the instruments considered necessary for viewing specimens in the late 18<sup>th</sup> and early 19<sup>th</sup> centuries. There are six numbered objectives in cells and an objective with Lieberkuhn reflector for observing opaque specimens. The stage condenser and stage forceps are included. Other accessories are two live boxes, a hand magnifier, a fluid tray, a brass can for talcs and split rings, and tweezers. There are five ivory or bone sliders and four wood sliders. There is a small drawer within the case containing a dissecting needle on ivory handle, a scalpel on ivory handle, two glass pipettes, and small slip carrier made of card. Everything fits into a mahogany case lined with velvet. The microscope is unsigned. It is the same as one in the Billings Collection described as having Dollond characteristics. Peter Dollond opened an optical business in 1750 and was joined by his father John in 1752. John was appointed optician to King George III and the Duke of York. The firm made high-quality optical instruments and continues to this day as Dollond and Aitchison.



**English Drum Microscope**





DESCRIPTION  
OF THE  
**LARGE IMPROVED COMPOUND  
MICROSCOPE.**

A, B, C, represent the body of the Microscope, a middle glass and a double eye glass are contained in a tube which slides within the part A B; this tube may be occasionally drawn out a little way to increase the magnifying power; the body slides up and down within a short spring tube at D. F is a flat plate or stage for laying objects on. G is a concave mirror for reflecting the light upwards through any transparent object on the stage of the eye at A. E is one of the magnifiers, six of which belong to the Microscope; another is represented at P. H is a magnifier set in brass, it is to be held in the hand for viewing any of the larger objects. I is a convex lens set in a frame, the pin of the arm K which holds it, fits into a hole in the stage, it is used for condensing the light of the sun or candle on opaque objects. L is a flat ivory plate fitted to the stage, one side black the other white; it is used for laying opaque objects on, the white side for dark coloured objects, and *vice versa*. M is a concave glass for holding fluids; a flat glass is also sent in the box, both fitted to the stage. N is a brass box with a flat glass bottom for fluids; very useful for aquatic objects, as it will hold more than the concave glass. O is an inset box, small living insects are confined therein between a concave and a flat glass. Q is a handle fixed in a wood handle, it serves for turning about any object on the stage while under examination. R, a pair of tongues for taking up any small object. S, a small box for holding a little talc, and rings to replace objects in the slides. T, a slider for holding objects, six of which are sent with the Microscope. U, a slip of glass, used to lay any objects on, and particularly useful in viewing animalcules and the crystallization of salts. W, a glass tube to confine a small fish, water newt, or tad-pole for viewing the circulation of the blood. X is a part of forceps for confining objects, they are opened by pressing the small stubs between the thumb and finger; the other end of the wire is pointed for sticking objects on; a small ivory cylinder fixed to this end, it serves also as a handle to turn the forceps about, and also for laying any very small objects on.

The magnifying power of this instrument is, with the

No. 1	22,500	..	No. 4	1,600
2	8,100	..	5	900
3	3,600	..	6	450

With an extra power, 35 000 to

TO USE THE MICROSCOPE.

Screw the magnifier you intend to use to the bottom of the body at E; the readiest way of doing this is to draw the body entirely out of its spring tube; push one of the sliders with transparent objects between the stage and a spring plate which is under it; face the light, and while looking through the Microscope, turn the mirror so as to reflect the light upwards to the eye at A. The part C has the same Nos. engraved on it as the magnifiers, which must be set to correspond with the magnifier in use, then by turning the nut Y, a fine adjustment may be obtained. There is a certain direction of the mirror in which the object appears better than in any other, and which may be easily discovered with a little practice. In the examination of opaque objects, the mirror is of no use, but the surface must be enlightened as much as possible; this can be very well performed in this Microscope, by directing the rays of the sun, or a candle, through the convex lens I, on the object; for this purpose the lens is to be fitted to the stage, and if a candle be used, it must be placed so as to refract the light through the lens strongly on the object. A few trials will make it easy, as the lens may be turned any way, or raised and lowered in its frame. By day and without the sun this lens is of no use, so that opaque objects can only be enlightened by placing the Microscope in a good light, and it will not be possible to magnify them so much as when more light is thrown on in the way just described. This lens serves also to magnify any large flower, or other object.

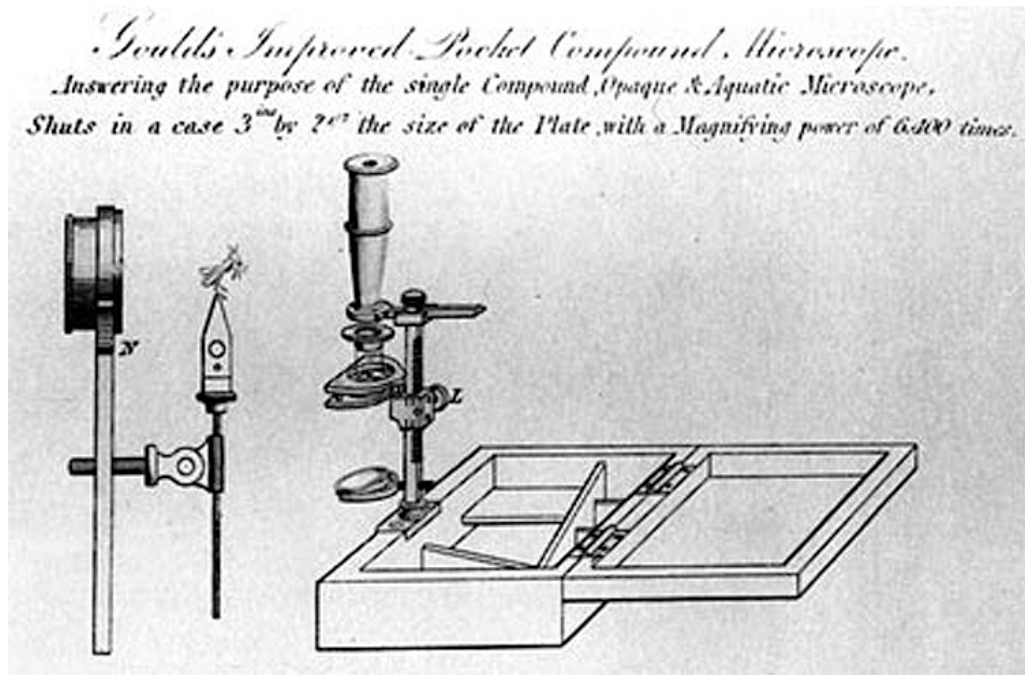
### Description and Instructions for the Drum Microscope

#### Cary/Gould Pocket Compound Microscope

William Cary (1759-1825) was a prominent maker of "Mathematical Instruments," including microscopes, located on the Strand, London. One of his apprentices, Charles Gould designed the popular Gould pocket microscope and published a booklet on it in 1827. After Cary's death, the firm was managed by Cary's nephews and continued using Cary's name. This is a small format, signed, Gould-type botanical microscope. It is signed on the racked upright "Cary, London." The pillar screws into the front edge of the flame Honduran mahogany case. The conical body tube has two eye lenses and a set of three interchangeable objectives of varying magnification. Focusing is achieved by rack and pinion movement of the stage. The semi-circular stage moves on a pivot for "aquatic" observation. The substage mirror is planar and detachable for storage, similar to the rest of the components for this microscope. This microscope can be assembled to

## Compound Microscopes

function as a compound microscope, simple microscope, or a flea glass using the forceps. The microscope is seven inches high in the compound configuration. c1835.



Cary/Gould Pocket Compound Microscope



**Chevalier Student Microscope, c1840**

The house of Chevalier in Paris won widespread fame in the nineteenth century as manufacturers of high-quality microscopes. The first instrument maker of the Chevalier family



was Louis-Vincent Chevalier (1734-1804) who established a shop in 1765. His son Vincent Jacques Louis Chevalier (1770-1841) inherited the firm in 1804. Vincent and his son Charles (1804-1859) were leading opticians who contributed greatly to the development of achromatic lenses (corrected for two colors). Together in 1823 they invented the first useful achromatic objectives by combining a number of small lenses, each of which had been corrected separately for chromatic aberration. In 1825, Vincent Chevalier made the "*Microscope Achromatique Perfectionne.*" In 1834 after separating from his father's business, Charles Chevalier brought out his "*Microscope Achromatique Universel*" which was the first commercially successful achromatic microscope. In 1826, the first permanent photograph was made using a sliding wooden box camera made by Charles and Vincent Chevalier. On the death of Charles in 1859, his son Dr. Arthur Chevalier (1830-1874) carried on the tradition of the family.

This is a student model microscope dating from around 1840 to 1850. Although microscopes of this type are usually unsigned, they are commonly attributed to the workshop of Charles Chevalier. A brass pillar with a cradle-joint at the top is screwed to a characteristically green-painted, iron tripod base. From the moveable part of the joint an arm extends carrying a round column. The stage, attached to the column, is a flat plate, having a central opening and small spring clips moveable up and down in sockets. There is a hole in the stage-plate for receiving the spring forceps and a socket for the condenser. A revolving disc of diaphragms, a Chevalier innovation, is attached to the underside of the stage. The

plane mirror is held in a circular brass frame and attached to a sliding tube fitting the column. The body tube is screwed to an arm having a square bar which fits into the round column. Focusing by turning the milled head is by rack and pinion moving the body tube. There is one eyepiece and one achromatic objective. The velvet-lined case has five drawers on one side. The microscope stands 14 inches high closed and is in excellent condition with most of the lacquer intact.



**Ross Bar-Limb Microscope, c1849**

Andrew Ross began business in 1830. During the period from 1837 to 1841, Ross worked in partnership with the renowned microscopy pioneer and optics theoretician Joseph J. Lister (1786-1869). Lister perfected achromatic lenses corrected for spherical and chromatic aberration. The joint efforts of Lister and Ross helped transform the microscope from a parlor oddity into an important scientific tool in medical diagnosis and biological research and elevating histology into an independent science. Both Ross and Lister were founding members of the Microscopical Society of London (later the Royal Microscopical Society).

**Andrew Ross Microscope**



One of the most important microscopes ever designed was the large “bar limb” model by Andrew Ross in the middle of the 19th century. Ross reached a pinnacle of design in both the stand and objectives that has rarely been equaled, even today. The microscope is quite large, standing 18 inches when closed. The model features a heavy Y-shaped, flat tripod base for support. The vertical flat pillars hold the limb by means of trunnions, and a bar attached to the top of the limb supports the optical tube which is moved by rackwork for coarse focusing. There is an unusual fine focus with a conical radial drive lever at the base of the tube. The stage, condenser, and mirror are attached to the limb.



The microscope features a full mechanical stage with X/Y positioning. A rotating slide platform accommodates slides and accessories. There are three substage condensers which fit into a slot under the stage. The first is one of two achromatic condenser lenses. A separate mechanical control adjusts the condenser height. A second is a wheel of stops and the third is a Nicol prism polarizer (invented in 1828). The analyzer fits in the tube. There is a 2 ½ inch diameter plano-concave mirror. There are five objectives with their original brass canisters; a 2 inch, 1 inch, ½ inch, ¼ inch, and 1/8 inch. The ¼ inch and 1/8 inch objectives have covered/uncovered correction collars. The correction collar was invented by Ross in 1837 and served to adjust for the differences in the thickness of the coverslips of the time. The microscope is pre-RMS thread standard, and has its own unique lens thread. The Royal Microscopical Society adopted a screw thread standard for objectives in 1858 that was adopted by virtually all makers thereafter. There are three eyepieces. Accessories include two live boxes, a micrometer that fits in the eyepiece, a stage forceps, a fish plate that fits on the stage, and tweezers. There is a separate condenser lens on a stand. The instrument is finished in lacquered brass with almost all of the lacquer present. The microscope disassembles for storage in its own mahogany case with brass carry handle. It is an excellent example of one of the finest and most important microscopes ever made.

This model is signed, "F. L. West, 39 Southampton Street, Strand, London. Francis West described himself as a successor to George Adams and supplied Ross instruments under his own signature. The microscope appears to predate 1850 when Ross added a complete substage assembly.



**F. L. WEST,**  
**Optician,**  
**39, SOUTHAMPTON STREET, STRAND, LONDON.**

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Microscopists, and the Public generally, are respectfully invited to an inspection of F. L. WEST'S Stock of Microscopes, comprising those of the most perfect construction to the simple and inexpensive instrument adapted to the first use of the Amateur; also to his ACHROMATIC OBJECT GLASSES for the Microscope, from one-eighth to two inches focus, of enlarged aperture, beauty of definition, and penetrating power.

MICROSCOPIC OBJECTS in Great Variety, of which a Large Stock is kept—Animal, Vegetable, Mineral, and Fossil. Anatomical Injections, &c., &c., with every novelty that may be produced in the Microscopic World, of the best Preparers, both British and Foreign.

All kinds of Apparatus and Material for preparing and mounting objects for the Microscope. Glass Cells of every size and shape, Glass Slips, Circles and Squares of thin Glass, Troughs, Capillary Tubes, Collecting Cases, Canada Balsam, Writing Diamonds, Mahogany Cabinets, &c., &c.

PRICES SENT ON APPLICATION.

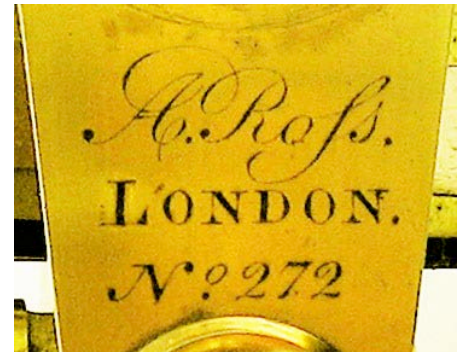
**INSTRUMENTS TAKEN IN EXCHANGE.**

Trade Card for F. L. West, 1855



**Ross Monocular Microscope, 1847**

This is an Andrew Ross portable microscope. It is signed on the bar "A. Ross, LONDON, No. 272" dating it to 1847. The microscope is equipped with two oculars, extension tube, unusual fine focus with a conical radial drive, bar limb mount with rack and pinion coarse focus having knurled pinion adjustment, manually rotatable mechanical stage, wheel of stops on dovetail fitting, and double mirror. There are two achromatic objectives with signed canisters, a one inch and a fine  $\frac{1}{4}$  inch, signed and dated 1853, with correction collar and lieberkuhn mirror. The microscope can be disassembled by hand into a compact mass. When fully assembled, it extends to 15 inches. The microscope is in excellent condition with almost all original lacquer and noting only two rough spots on the rack. The wooden case is contemporary but not original.

**Andrew Ross Monocular Microscope**

**Nachet-Type Pillar Microscope, c1870****Nachet Pillar Microscope**

This intriguing ball and socket pillar design began to appear in the 1860s. The microscope is unsigned but instruments of this type were made by Nachet in Paris. Camille Nachet (1799-1881) and his son Alfred (1831-1908) formed the company "Nachet et Fils" which was one of the most prestigious microscope manufacturers in Europe. Similar instruments were made by Edmund Hartnack. Edmund Hartnack (1826-1891) joined the firm of his uncle, Georges Oberhaeuser (1798-1868), in Paris in 1857, and assumed full control of the firm in 1860. These microscopes were imported by Queen & Co. in Philadelphia.

This small microscope has a circular, green-painted bronze base, and supports the 5 inch high tubular pillar with a ball and socket foot. The lower section of the pillar has a single mirror on a gimbal and pin and fixed stage. The stage has a central aperture. Beneath the stage is a revolving disc of diaphragms that may be moved from the right side or from the front. Above the stage is a sliding casing on a pillar with a U-shaped slide holder. The arm is attached to the pillar and has a ring front and a fixed tube with a milled-head pinion at the back. On the tube is a ring that carries a two-jointed arm with a condenser. The body tube is 5 ¼ inches long with a cone nose and rack at the back. The upper section with milled-edge ring is 1 ½ inches long. The single eyepiece screws onto the barrel and contains a field lens inside. There are three stackable, dividing objectives resulting in a variety of focal lengths. The instrument is 9 inches high when closed. The microscope is finished in lacquered brass. The lacquer coverage is 100% with no signs of wear. In fact, this microscope is close to mint.

**French Toy Drum Microscope**

This is a small French drum microscope often referred to as a "toy" microscope. It stands six inches tall closed and is constructed of brass. The microscope consists of a base, a cylinder with cut outs for a swinging mirror and the stage. The body tube fits into the top of the cylinder and focusing is accomplished by sliding the tube. There is an eye lens and three button objectives. These microscopes enjoyed widespread popularity between 1820 and 1880, and continued to be sold into the early

twentieth century. They were exported in large quantities to the United States. This microscope is in excellent condition with bright brass and no defects. It is stamped France on the body tube. It fits in an original wood case that also contains original tweezers. c1880.

### **Browning Polarizing Microscope, c1880**

The polarizing microscope was invented in 1828 by William Nicol (1768-1851). In a polarizing microscope, a polarizer filter which produces a plane of polarized light is placed in the light path beneath the sample. If the sample is anisotropic or birefringent, it will rotate the plane of polarized light. A second rotatable polarizer filter, called the analyzer, is located between the objective and eyepiece. When the analyzer is at right angles to the polarizer (crossed polarizers), it can detect the light rotated by the specimen. When an isotropic material such as air, water, glass, or most tissues, exists between the filters, all light is blocked. Many of the high end microscopes of the second half of the nineteenth century have accessory polarizers and analyzers (see the Ross and Beck microscopes). These were used for viewing birefringent materials such as horn, hooves, hair, bone, and minerals. These slides are usually marked "For Polariscope," meaning they were to be viewed using a microscope with polarizing filters.

John Browning (1835-1925) was an English inventor and scientific instrument maker. After taking over his family's business in 1856, Browning became a leading maker of scientific instruments, including spectrosopes, telescopes, microscopes, barometers, photometers, cameras, ophthalmoscopes, and electrical equipment such as electric lamps. In 1873, he installed the first electric light in London. As Optical and Physical Instrument Maker to Her Majesty's Government, he supplied telescopes to the Royal Observatory in Greenwich, London. He also wrote numerous articles and books on his craft. The Browning business flourished as interest in astronomy grew among both amateurs and professionals throughout the nineteenth century. The company was taken over by W. Watson and Sons in 1900.



**John Browning Polarizing Microscope, c1880**



This is a fine polarizing microscope, c1880. It is signed on the body tube "John Browning, 63 Strand London 884." The all brass instrument is supported by a flat tripod base and two uprights. A short square limb is carried on trunnions. The limb has an inner triangular bar with rack and a double milled-head pinion and holds the 3 ¼ inch circular stage. An arm is attached to the top of the rack and holds the body tube and nosepiece. The arm carries the fine adjustment. The stage has a rotating slide plate. The mirror is attached to a sliding case fitting over the tubular tailpiece.



There are two eyepieces and two objectives, a 1 inch and ¼ inch in signed brass canisters. A collar on the underside of the stage holds the substage attachments. There is a Nicol polarizer, a condensing lens, and a revolving disc of diaphragms. An eyepiece with a Nicol prism analyzer fits over the conventional eyepiece. The instrument

stands 17 inches high arranged for use. It can be mounted onto a wooden platform and is held in an original mahogany case with openings for the eyepieces, objectives, and condensers and a drawer containing forceps. The instrument is in very fine condition with only some spotting to the lacquer on the body tube. It is fully functional and produces fine polarizing images.

### English Wenham Binocular Compound Microscope, R & J Beck, 1880

The signature microscope of Victorian England was the large Wenham binocular compound microscope. These microscopes were elegant and impressive, and often accompanied by a large number of lenses, condensers, and accessories. For a while, they were in great demand, mostly by the comfortably leisured class for amusement in parlors. However, they were expensive and difficult to use because of their complexity and were gradually supplanted by the smaller, more practical Continental form of microscope.

Francis Herbert Wenham (1824-1908) was a British marine engineer who studied the problem of manned flight and wrote a perceptive and influential academic paper that he presented to the first meeting of the Royal Aeronautical Society in London in 1866. In 1860, he designed the first truly successful binocular microscope by utilizing an achromatic prism to split the light beam at the rear of a single objective into the two body tubes, one tube straight and the other inclined. The Wenham prism was one of the simplest and most successful of the early solutions to binocular vision with a microscope. It continued as a mainstay of binocular design until the turn of the century. Manufactures of Wenham binocular microscopes in the latter part of the nineteenth century included R & J Beck, Charles Collins, J. B. Dancer, Henry Crouch, M. Pillischer, Powell & Lealand, Ross, and James Swift & Son.

R & J Beck was a renowned British optical company based in London. It had its origins with Joseph Jackson Lister (1786-1869), whose son became Lord Lister the discoverer of antiseptics, and James Smith (d1870). Lister published a paper in 1830 entitled "*On Some Properties in Achromatic Object-Glasses Applicable to the Improvement of the Microscope.*" This was the first scientifically-based design for microscope lenses. He asked James Smith, a mathematical instrument maker and employee of the instrument-making firm of William Tulley, to make a microscope to suit his new lenses. Smith set up on his own in 1837, later taking on Richard Beck (1827-1866), a nephew of Lister, as an apprentice. Beck became a partner in 1847 when the company was renamed "Smith & Beck." In 1851, Joseph Beck (1828-1891) joined his brother in the firm having served an apprenticeship with Troughton & Simms. By 1853, the demand for the firm's products had risen to such a degree that they established a factory in Kentish Town, Holloway and called it "Lister Works." In 1857, Joseph became a partner and the name was changed to "Smith, Beck & Beck." In

## Compound Microscopes

1864, James Smith retired and the name was changed again to "R & J Beck." Joseph Beck's son, Conrad, beginning in 1879 continued to operate the firm into the early years of the twentieth century. The company produced a wide range of optical products: microscopes, telescopes, cameras, camera lenses, optician's equipment, trench periscopes for army officers in the First World War, and other optical equipment.



**R & J Beck Wenham Binocular Microscope**

This R & J Beck "New National" microscope is a fine English example of the grand Wenham binocular microscope manufactured primarily for the American market. It signed Beck London Philadelphia and the serial number of 10,201 dates it to 1880. It closely resembles Zentmayer's U. S. Army Hospital binocular microscope. At that time, R & J Beck, Manufacturing Opticians had a branch at 1016 Chestnut Street in Philadelphia, W. H. Walmsley, Manager.

The lacquered brass microscope has a heavy tripod base. A cylindrical pillar terminates in a compass joint which supports the Jackson limb carrying the binocular body. Coarse focus is rack and pinion and fine focus with an indicator micrometer knob located on the rear of the limb. Eyepiece width is rack and pinion adjustable. The glass stage can be rotated. There is an object holder with an opening and a glass circle. Beneath the stage is a tube movable by rack and pinion and into which a nicol prism polarizer or a shutter diaphragm can be inserted. The swinging substage allows the condenser and mirror to swing for oblique lighting. A graduated circle is provided for registering the degree of obliquity. There is a plano-convex mirror. There are two pairs of binocular eyepieces, an analyzer, and three objectives; an unmarked low power, an R & J Beck  $\frac{1}{6}$  inch, and a HOMOGENOUS IMMERSION  $105^\circ$  ERNST GUNDLACH PAT<sup>D</sup> DEC 2 1879 D  $\frac{1}{16}$ . The case is original and all accessories are present. In closed position, the microscope is 17 inches high.

### Zeiss Continental Microscope, c1892

In Germany, the firms of Leitz and Zeiss eventually became the largest manufacturers of microscopes in the world. In Jena, the remarkable combination of Carl Zeiss, a machinist, Ernst Abbe, an optical theorist, and Otto Schott, an optical glass maker, resulted in the development of microscopes with unsurpassed optics.



Carl Friedrich Zeiss (1816-1888) grew up apprenticed in the machinist shop of Dr. Friedrich Körner, becoming well familiar with the operation of fine tools and machinery to make microscopes and scientific instruments. He completed his practicals at the Physiological Institute in Jena under Professor Schleiden. In 1846, Carl Zeiss opened a mechanical workshop in Jena and began to make improvements in microscopes, offering simple microscopes and in 1857 introducing his first compound microscope, the "Stand I". In 1861, Zeiss compound microscopes were declared to be "among the most excellent instruments made in Germany" and he was awarded a Gold medal at the Thuringian Industrial Exhibition. In 1866, the 1000th microscope was delivered.

Ernst Abbe (1840-1905) went to graduate school at the University of Göttingen where he received a Doctorate in thermodynamics. In 1863, Abbe joined the faculty at the University of Jena where he lectured on physics and mathematics, and later where he would serve his professorship. Up to this time, advances in optical designs and materials relied heavily on inefficient trial and error efforts and Zeiss realized that the improvement of optical instruments demanded advances in optical theory. Introduced to Carl Zeiss in 1866, Abbe became very interested in the optical challenges facing microscopy. Late in 1866, Zeiss and Abbe formed a partnership where Abbe became the director



of research of the Zeiss Optical Works. Abbe devised the mathematical formulas to characterize the physics of optics. Among Abbe's most significant breakthroughs was the formulation in 1872 of a wave theory of microscopic imaging that became known as the "Abbe sine condition." This approach made possible the development of new microscope objectives based on sound optical theory and the laws of physics. Abbe also invented the Abbe condenser, used for microscope illumination.

Otto Schott (1851-1935) grew up in a family that introduced him to making window glass. He became the father of modern glass science and technology. Schott earned his Doctorate at the University of Jena in 1875 for his work about defects in window glass manufacturing. In 1881, Schott met with Dr. Abbe who encouraged Schott to employ a scientific approach to the determination of raw ingredients to be used in glass formulations. In 1882, Schott moved to a new glass-making laboratory set up for him in Jena. In 1884, Schott joined Carl Zeiss and developed many new glass types, a number of which are still in use including Borosilicate Crown. Schott's glass innovations made possible the use of the Abbe sine condition. In 1886, Zeiss introduced the first apochromatic microscope objectives that were totally color corrected. These first true apochromatic objectives were so superior to the competition that Zeiss gained nearly the entire high-end microscope market. Zeiss delivered his 10,000<sup>th</sup> microscope in 1888.

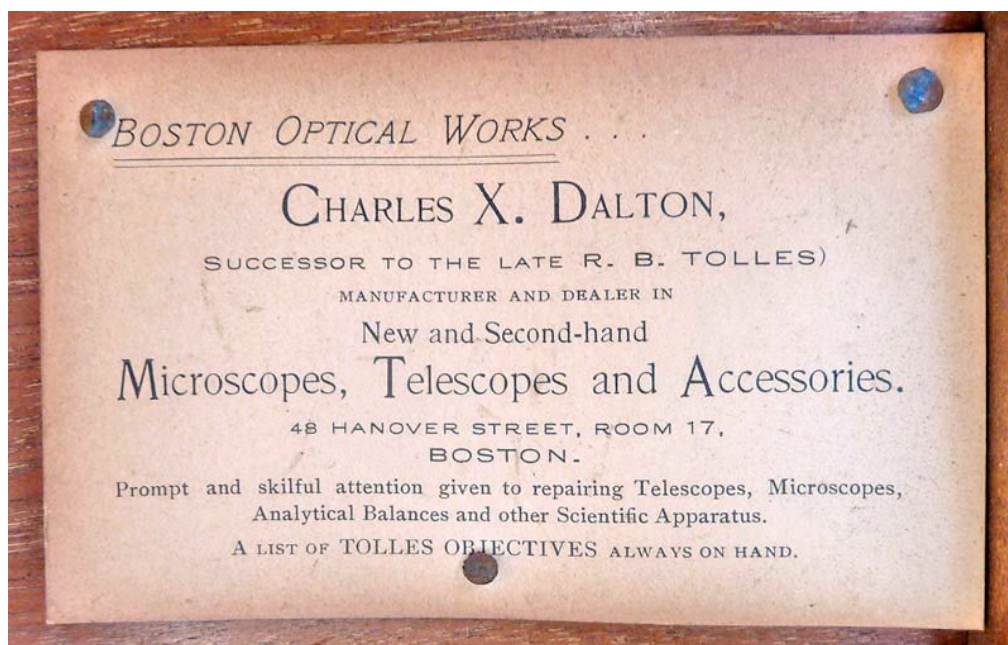


This is a Zeiss IVa Continental model microscope, c1892. The instrument sits on a horseshoe base and a slotted rectangular pillar supports the stage and tubular limb. The body tube moves by rackwork. Below the stage are a rotating double mirror, a swinging platform for the iris diaphragm which moves on the platform by rackwork, and an Abbe condenser. The substage moves vertically by rackwork. The objectives are a C. Zeiss A,  $\frac{1}{4}$  In., and C. Zeiss Homog. Immers.  $\frac{1}{12}$  N. Ap. 1.20. It comes with a non-original wooden carrying case. Signed Carl Zeiss Jena 19146. These simple but elegant and functional Continental microscopes set the pattern for the microscopes of the twentieth century.

**Leitz Continental Microscope, 1888**

In 1849, Karl Kellner founded the Optical Institute in Wetzlar, Germany. Telescopes were the original emphasis, but within a few years microscopes took over as the main product. The company hired a very capable engineer named Ernst Leitz in 1865, who soon became a partner. In 1867, the Optical Institute manufactured its 1000th microscope. Leitz took over the company in 1869 and renamed it Optical Institute of Ernst Leitz. Leitz's organizational talent and extensive experience together with an expanding market for microscopes led to the growing success of the company. One of the major decisions he made as an entrepreneur was to switch from the slow, labor-intensive manufacturing by hand to serial manufacturing, which would soon become the industry standard. In addition to its economical efficiency, the new production techniques improved the quality standards of the microscopes, which in turn made them more reliable for scientific research. In the last decades of the 19th century the use of microscopy increased rapidly with the rising popularity of natural sciences. By 1900 the Leitz company consisted of several facilities, oversaw 400 employees, and produced yearly about 4,000 microscopes of which there were many types. In 1907, the 100,000th Leitz microscope was shipped to German bacteriologist and Nobel Prize Laureate Robert Koch.

This all brass Continental microscope was made in 1888. It has objectives # 3 and # 7, eyepieces #1 and #3, and two condensers. It has a horseshoe base, inclinable pillar with micrometer fine focus on top. The arm has the coarse focus knob and holds the body tube. The mirror and condenser are below the square stage. The microscope is engraved "E Leitz Wetzlar No 12530" and "Educational Supply Co Boston." There is a card in the case that says "Boston Optical Works, Charles X. Dalton, Successor to the late R. B. Tolles." Robert B. Tolles met Charles A. Spencer in Canastota, New York in 1843 and apprenticed with Spencer in making microscopes until 1858. Tolles then left Spencer's employ to establish his own business. In 1867, Charles Stodder and several other Boston businessmen offered Tolles a partnership if he would move his business to Boston. Tolles agreed, and moved to Boston to supervise Boston Optical Works. Tolles produced a number of inventions and patents for improvements to the microscope and was renowned for his high quality objectives. Tolles died in 1883 at the age of 61. Charles X. Dalton continued the business, advertising as late as 1895. Dalton had worked with Tolles since their time with Charles Spencer in Canastota.







**Leitz Continental Microscope, 1888**

**W. Watson and Sons Compound Monocular Microscope**

William Watson set up an opticians firm in London in 1837. The name was W. Watson & Son 1867-1882, W. Watson & Sons 1882-1908, and W. Watson & Sons Ltd 1908-1957. They supplied all types of optical and scientific instruments including microscopes, binoculars, cameras, and telescopes. They began supplying slide preparations in 1884 when they took over the business of



## Compound Microscopes

Edmund Wheeler. They offered very fine slides on a wide variety of subjects and there are many slides in this collection by this firm.



Toward the end of the nineteenth century, Watson and Sons manufactured a distinctive style of microscope. Instead of a horseshoe base, these microscopes have an English tripod base. Models included the Edinburgh, Royal, and Van Heurck microscopes. These instruments were very well received and manufactured well into the twentieth century. The Edinburgh microscope, followed a design first proposed by Dr. A. Edington, professor of Bacteriology at Edinburgh University. The Van Heurck microscope was introduced in 1891 at the suggestion of the renowned Belgian diatomist Henri van Heurck (1838-1909). The model of this microscope is uncertain as the models are very similar with varying size, features, and accessories. It is most likely a large Edinburgh or the Royal.

The microscope is constructed in lacquered and black-painted brass and is about 15 inches tall when set up for use. The main focus and calibrated drawtube for setting tube length are by rack and pinion. The fine focus is by micrometer thumbwheel-lever. The microscope has a double nosepiece changer with a

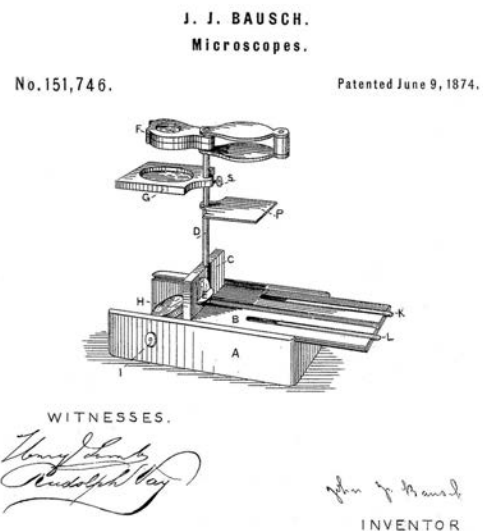
Watson and Sons  $\frac{1}{6}$  inch objective. The microscope has a mechanical stage with thumb-wheel X-Y control. The substage is focused by rack and pinion. There is a substage Abbe condenser with lateral centering adjustments, a filter holder, and variable diaphragm. The plano-convex mirror on a swing-out limb for oblique illumination is not original. It is labeled "W. WATSON & SONS, 313 High Holborn, London" on the base. The serial number of 4208 would date it c1898.

## Bausch & Lomb Microscopes

Excelsior Pocket and Dissecting Microscope, 1874  
 American Agriculturist Microscope, 1877  
 Library Microscope, 1878  
 Family Microscope, 1886  
 Harvard Microscope, 1889  
 Model Microscope, 1892  
 Library Microscope, 1893  
 Universal Microscope, 1895  
 Continental AA Microscope, 1897  
 Continental BB Microscope, 1899  
 Continental CC Microscope, c1895  
 Laboratory Dissecting Microscope, 1895  
 Jug Handle Microscope, 1911  
 Binocular Microscope, 1945  
 Dissecting Microscope, 1946

In 1850, John Jacob Bausch, an immigrant from Germany, began a business of making and selling spectacles in Rochester, New York. He was joined by Henry Lomb, also from Germany, in 1853. In 1866, the partnership became incorporated as the Vulcanite Optical Instrument Company. In 1874, the name was changed to the Bausch & Lomb Optical Company and the first microscope was produced. Ernst Gundlach was hired to head up the microscope department but left in 1878. The earliest microscopes were relatively simple Gundlach type stands but were optically excellent. These were replaced by the more sophisticated American type stands around 1882. Toward the end of the nineteenth century, the Continental type stand was adopted by most manufacturers around the world. By 1900, Bausch & Lomb along with Leitz and Zeiss were the largest producers of microscopes in the world. The history of the Bausch & Lomb Optical Company can be found in Padgitt (1975). The microscopes in this collection represent the basic types of stands made in the nineteenth century. Although Bausch & Lomb made a great many different models, most are variants of these basic types, differing only in the type and number of accessories.

### Bausch & Lomb Excelsior Pocket and Dissecting Microscope 1874



## Compound Microscopes

This microscope was sold from 1874 to 1895 as a portable dissecting microscope for botanical and entomological work. It is a tiny instrument in a walnut case measuring 3 inches wide, 1 ½ inches deep, and 7/8 inch high in folded position and meant to be carried in the pocket. It is 3 ¾ inches high when assembled. The gutta-percha instrument is erected on the underside of the sliding cover which is then slid back into place over the small mirror. There are four lenses and a stage with a glass insert. Two dissecting needles are stored in channels in the cover's underside. This example is signed on the lid "J. J. Bausch Pat. June 9 '74." It is numbered 50 in two places. This means it must have been manufactured shortly after the patent date making it one of the earliest microscopes produced by the Bausch & Lomb Optical Company. The instrument is in excellent original condition.

### American Agriculturist Microscope



In 1877, The American Agriculturist magazine owned by the Orange Judd Company announced that every subscriber could receive a microscope with their 1878 subscription for an additional 40 cents. Non-subscribers could purchase the microscope for \$1.50. The publisher claimed that 125,000 of these hard rubber stand, 3 lens microscopes were manufactured for the 1878 mailing. Unlike the great variety of "household" and small drum microscopes that were being imported from France in the 1870's, the American Agriculturist microscope was made in America and designed by Bausch & Lomb. The microscope was proclaimed to be valuable to farmers to detect disease in plants and animals, the degree of goodness of seeds, adulteration of fertilizer, insect pests, etc. It was used to examine pork for trichina cysts. In addition to

farmers, it was also claimed useful to all classes to detect adulteration of coffee, tea, spices and sugar. It probably introduced thousands of children to microscopy and science. For a time, The American Agriculturist ran a column entitled "The Young Microscopists' Club," in which techniques for using and modifying this microscope were presented. Stands made from wood, or even a window shade fixture, were offered up as ways to provide the American Agriculturist microscope with an inclination joint. A cigar box mount allowed for the use of a mirror under the microscope for transillumination. A cardboard eyepiece collar was devised to remedy an acknowledged defect; the upright holding the lens tended to poke users in the eye.

This example is signed "Bausch & Lomb Optical Co. Rochester, N. Y." and "Pat App'd For" so that it predates the patent date of Jan. 8, 1878. The tiny microscope consists of a gutta-percha stand, a stage, and three lenses on a pillar. The height is 5 cm. The stage is square glass slides held by clips. There is a pair of tweezers. This microscope has its original cardboard box printed on the cover "American Agriculturist Microscope From Orange Judd Company, 245 Broadway, New York." The cover is scuffed and some of the letters are missing, otherwise the instrument is in very good condition.

### Bausch & Lomb Library Microscope, 1878

This is an early Bausch & Lomb production compound microscope. The serial number is 648 indicating it was made in 1878. This model of the Library microscope was made from 1878 to



## Compound Microscopes

1885. It is a small microscope only 7 inches tall closed. The microscope is in excellent condition and seems to have received little use. It is original and complete and includes the camera lucida. This was the least expensive of the Bausch & Lomb microscopes which ranged in price from \$10 to \$200 in 1879. The ability of the Bausch & Lomb Optical Company to mass produce relatively inexpensive but functional microscopes was a major reason for the success of the company.

The microscope is described in the 1879 price list as follows:



The Library Microscope has a finely finished and japanned foot, arm with joint to incline, a nickel plated body or tube, carrying the optical parts of the instrument and adjustable by rack and pinion, with draw tube to increase magnifying power; a concave mirror, swinging so as to give oblique illumination when desired, and capable of being brought above the stage for illumination of opaque objects. The screw at the lower end of the tube is so arranged as to permit the attachment of achromatic triplets, so that if desired a much higher magnifying power than the above can be obtained. The stage is made of hard rubber, which is not injured by water or ordinary fluids, and is provided with spring clamps for holding object slides. The camera lucida, which accompanies this microscope, although exceedingly simple, is a valuable addition for the same, and greatly adds to its usefulness. It is very easily managed and a little practice will enable

anybody to make by the aid of it drawings of the magnified image of microscopic objects. The microscope has one eyepiece and a divisible two-lens objective, giving, in combination with the draw tube, magnifying power of from 50 to 125 diameters.....\$10



### **Bausch & Lomb Family Microscope, 1886**

This is the Family Microscope made from 1877 to 1888. This microscope bears the serial number 3954 and was made in 1886. It is described in the 1879 Price list as follows: "The Family Microscope base and pillars are of cast iron, neatly japanned. They support the axis, which carries the arm in such a way that the instrument may be inclined to any angle. Rack and pinion for adjustment of focus, made with such exactness as to leave no perceptible jar, and neither lost or lateral motion while adjusting. In order to give greater sensitiveness to the adjustment, the milled heads of the pinion have been made of large dimensions, in consequence of which the lower and medium powers can be adjusted and used with great ease. The tube is supplied with standard Society screw. The mirror, which is concave, is so arranged that it can, if desired, be swung above the stage for the illumination of opaque objects. A revolving diaphragm is fixed beneath the stage. This stand is accompanied by one eyepiece, "B", mounted in either hard rubber or brass, and one objective, ½ inch, which divides so as to permit the separate use of the posterior

combination, thus giving the power of an excellent 1 ½ inch. Range of magnifying power from 50 to 100 diameters.....\$20." In this microscope, the eyepiece is not numbered and the objectives are a 1 inch and ¼ inch.

**Bausch & Lomb Harvard Microscope, 1889**

The Harvard microscope was made between 1884 and 1896. It was the first Continental type stand with a horseshoe base. This microscope has the serial number 6550 showing it was made in 1889. It stands 11 inches high. It is a brass basic stand with sliding-tube coarse focusing rather than rack and pinion. There is a screw fine adjustment at the top of the limb. It has two eyepieces and a Student ¾ objective and matching brass canister. The microscope is in very fine condition with complete coverage by the original lacquer. It was named the Harvard microscope because it incorporated suggestions made by the faculty of Harvard Medical School. The microscope is inscribed on the case and on inside of the base "Donated by Charles H Hamlin, M.D. 1980."

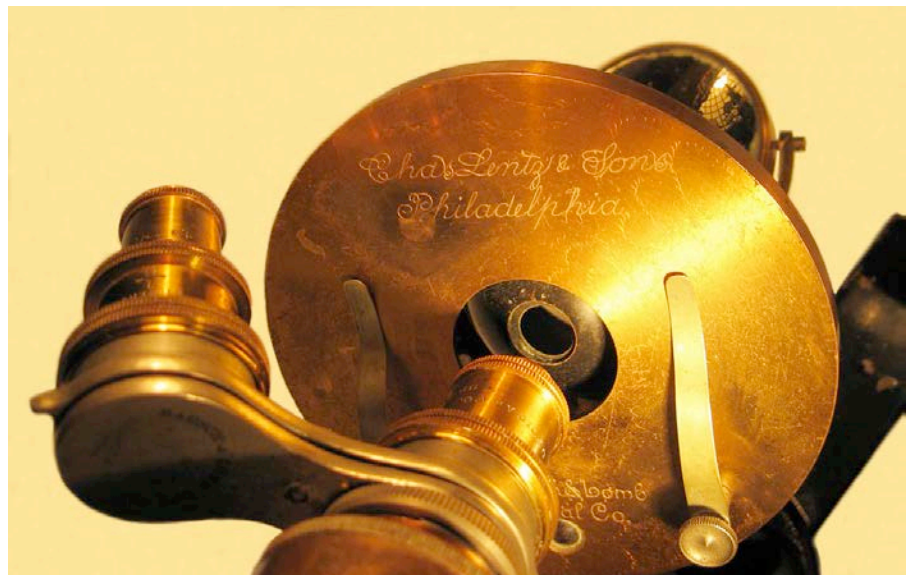




### Bausch & Lomb Model Microscope, 1892

The Model microscope was made from 1883 to 1896. The serial number on this microscope is 11688 indicating it was made in 1892. It is signed, "Chas Lentz & Sons Philadelphia" and "Bausch & Lomb, Optical Co." on the stage. Chas Lentz was a seller of scientific instruments and an agent for Bausch & Lomb. At the top of the limb are "PAT. OCT. 3.1876" and "PAT. OCT 13.1885." The closed height of the microscope is 12 ½ inches. This microscope features a nicely sculpted Japanned Y-shaped foot that supports dual pillars that rise to a trunnion joint with extra strong bearings. This joint supports a very attractive sculpted curved limb of the microscope and the stage. The limb, in turn, supports the remainder of the microscope including the focus mechanisms and the body tube. The trunnion joint allows the microscope to be tilted at any angle from the vertical to allow for the comfortable viewing of specimen slides.

The limb design is attributed to Gundlach when he was with the Bausch & Lomb firm. This design was both practical and popular and lasted into the twentieth century. The microscope has one original eyepiece and two objectives in a double nosepiece. The eyepiece is a 1 inch. The B & L objectives are a ¾ inch and ⅕ inch with signed brass canisters. The objectives are marked as the "student" series for an 8 ½ inch tube length. The lenses produce excellent images of high contrast, sharpness, and bright color. Coarse focus is rack and pinion, and fine focus is achieved with a micrometer knob on top of the limb. The mirror is plano-concave and can rotate on a compass joint so that it can be used above the stage for oblique illumination of opaque subjects. The substage condenser is a hemisphere of stops. The microscope is finished in lacquered brass with a black painted base. There is spotting to the optical tube and stage and small chips in the black paint. A mahogany case with brass carry handle and interior accessory drawer holds the microscope and its accessories. On the inside of the door, there is a cardboard table showing the "Linear Magnifying Powers of Objectives and Eyepieces."





**Bausch & Lomb Library Microscope, 1893**

A new model of the Library microscope came out in 1886 and was made until 1896. This example has the serial number 13826 indicating it was made in 1893. The microscope is considerably larger standing 8  $\frac{3}{4}$  inches closed. This microscope features a Japanned Y-shaped foot that supports dual pillars that rise to a trunnion joint. This joint supports the Gundlach-type limb which holds the brass body tube and circular stage. The stage and tube are lacquered brass. The round stage is signed Bausch & Lomb Optical Co., Rochester N. Y. and New York City. This microscope is in exceptional condition with no spotting of the brass and only one or two small chips in the black paint. It has two objectives, one a large unsigned brass objective marked  $\frac{1}{2}$  Special.



**Bausch & Lomb Library Microscope, 1893**

**Bausch & Lomb Universal Microscope, 1895**

The Universal microscope was the last of the classical American stands. It was called "universal" because the optical tube is adjustable and could use the English "long tube" objectives or the objectives of the shorter Continental tube. The microscope is signed on the base "Bausch & Lomb Optical Co., Rochester, N. Y. and New York City." The serial number is 19052 indicating the microscope was manufactured in 1895. The instrument is 13  $\frac{3}{4}$  inches tall when fully closed. The original finish is lacquered brass with a gold painted base. Coverage is largely complete with typical age wear. The base is a heavy fixed tripod foot on which a single pillar is attached by wing screw under the foot. The limb is held to the pillar by compass joint. Coarse focusing is by rackwork on the body tube and fine focus is by micrometer screw at the top of the limb. The body

## Compound Microscopes

tube has a drawtube graduated from 170mm to 230mm. Both the substage and the plano-concave mirror are on swinging arms with internal dovetails. Both ride vertically by rackwork on separate arms connected by rotating drum plates attached above the compass joint. The arms give individual axial movement to both the substage and mirror. The circular drum plates are graduated separately, and are numbered with the angle of radius for a total of 180 degrees (90 degrees each direction). The dome-shaped substage carries a rotating inner hemisphere of five iris diameters. The circular stage can be rotated. A nickel-plated slide carrier sits on the stage and is attached underneath by metal tabs acting as springs to provide effortless but firm movement. The slide carrier is engraved " Pat. Dec. 25 1877. " The microscope has a triple nosepiece with three Bausch & Lomb brass objectives, a  $\frac{3}{4}$  inch, 4mm, and  $\frac{1}{12}$  inch. There are two original eyepieces, a 1 inch and a 2 inch. The optical system produces very clear, sharp images of good contrast. The original pine case has a paneled door, brass carry handle, and interior accessory drawer. This is an elegant representative of the best American microscopes before 1900.



**Bausch & Lomb Universal Microscope, 1895**

**Bausch & Lomb AA Continental microscope, 1897**

This is a relatively simple microscope first made in 1892. It was probably meant for student use. The serial number on this example is 26361 dating it to 1897. It stands 11 inches high closed. It has a black japanned iron horseshoe base. It has a straight arm attached to the pillar. The pillar and body tube are brass. There is a revolving disc of diaphragms under the black stage. Coarse focus is by rack and pinion with one knob. There is a screw fine adjustment at the top of the limb. It has two objectives.

**Bausch & Lomb BB Continental microscope, 1899**

This is a turn-of-the-century continental model BB microscope. It is signed "Bausch & Lomb Optical Co., New York, Rochester, N.Y., Chicago and Chas. Lentz & Sons, Philadelphia, PA on the base. The instrument measures 12 ½ inches high in closed position. The serial number 31833 on a disk on the base dates it to 1899. It has a brass body, a stage with a hard rubber top, and a brass U-shaped base. The microscope has three objectives, a 16mm, 4mm and 1.9mm Oil Imm. The eyepiece is a 2 inch. There is a detachable mechanical stage marked Patent Aug 24, '97. Beneath the stage is a swing-out Abbe sub-stage condenser with variable iris diaphragm and filter holder. Coarse focus is rack and pinion, fine focus with a micrometer dial and indicator on top of the limb. The mirror is plano-concave. The finish is lacquered brass. The wood case has a metal carry handle and two slide-out drawers for objectives and eyepieces. This is a fine example of the Bausch & Lomb continental style microscope that was popular at the turn of the century.

**Bausch & Lomb Continental AA, 1897****Bausch & Lomb Continental BB, 1899**



**Bausch & Lomb Continental CC Microscope, circa 1895**

This is a very fine Bausch & Lomb Continental CC microscope. The microscope lacks a serial number, indicating it may have been a prototype or presentation microscope. The microscope was restored by James A. Rendina, Kansas City, Missouri.



## Compound Microscopes

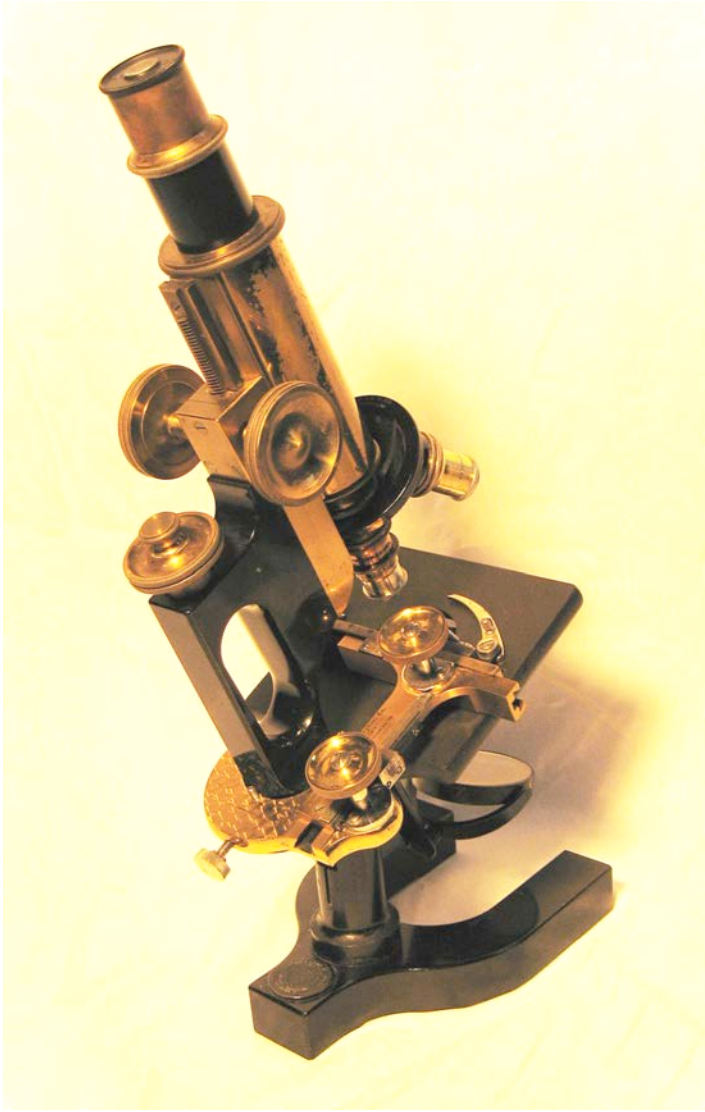
This is a very substantial microscope standing 14 inches tall when closed. It is labeled Bausch & Lomb Optical Co., Rochester N. Y. and New York City on the base. The microscope is constructed largely of highly finished heavy brass. The horseshoe type base allows stability with the microscope at full inclination. The pillar consists of a rectangular brass column to support the body. The optical tube consists of a brass body tube with revolving brass triple nose piece and a nickel-chrome draw tube graduated in millimeters from 160 to 220mm. Coarse focus is rack and pinion; fine focus by a micrometer knob on top of the limb. The revolving slide stage is 3  $\frac{3}{4}$  inches in diameter. The stage is made of brass and fitted with a vulcanite top and is provided with two centering screws. The substage parts are the Abbe condenser lens with rack and pinion for vertical adjustment, iris diaphragm, and mirror. The diaphragm can be moved horizontally or swung out of the way to modify the type of illumination. The microscope has one eyepiece and six Bausch & Lomb brass objective lenses. The objectives are 1 inch,  $\frac{2}{3}$ , 4mm, 48mm,  $\frac{1}{6}$  and  $\frac{1}{12}$  with brass canisters. The optics are excellent.

### **Bausch & Lomb Laboratory Dissecting Microscope, 1895**

This model microscope was made between 1893 and 1896. This example has the serial number 17236 and was made in 1895. It is complete with the original case, mirror, three lenses, and a glass circle with micrometer rulings. It has a round brass base and pillar, rectangular stage, and rack and pinion focusing. The articulated arm at the top of the rack has ring mounts to hold the magnifiers. One lens is marked Bausch & Lomb Optical Co., Rochester, N.Y. U.S.A., 19mm Coddington. The Coddington lens is a double convex lens with a circular incision in the middle which is blackened and thus acts as a diaphragm, shutting out the marginal rays and correcting the spherical aberration.



**Laboratory Dissecting Microscope, 1895**

**B & L Jug Handle Microscope, 1911**

This instrument is signed on the base, "Bausch & Lomb Optical Co." and "Arthur H. Thomas Co., Philadelphia, PA," with a serial number of 83942, the serial number dating the instrument to 1911. The base plaque is the post-1909 Triple Alliance logo reflecting the union between Bausch & Lomb, Zeiss, and Saegmuller. Bausch & Lomb and Arthur H. Thomas had entered into an association in 1900. The microscope stands 11 1/8" tall when fully closed, and opens to typical continental size and has a variable tube length. It has Continental style rack and pinion coarse focus and fine focus by a micrometer knob on top of the limb. The substage Abbe condenser has two variable iris diaphragms – one on top and one below the condenser lens. A circular filter slot is located on the bottom. The plano-concave mirror is excellent on both sides. There are three Bausch & Lomb objectives, a 16mm., 4mm, and 1.9mm fluorite oil immersion, all with original signed brass canisters painted black. Two original eyepieces, a 5x and 10x, are included, along with two filters, a blue glass and a center dark spot. Optics are clear and sharp with good color and contrast. The instrument is finished in lacquered brass and painted black brass. The finish is complete with some wear. The microscope comes in its original wood case with brass carry handle,

lock and key. The profile of this instrument is one the most stylized of the jug handle designs. It features an integrated carry handle cut into a squared off limb, and looks sleek and sophisticated against the black and brass finish. The jug handle style is a variation of the Continental style that began around 1900 and ended around 1920.

**B & L Binocular Microscope, 1945**

This is a fine Bausch & Lomb binocular compound microscope with a stand CTAV in the original carrying case. The serial number BD 5658 dates it to 1945. It is equipped with a large binocular body with a revolving triple nosepiece, a mechanical stage, a blackened U-shaped base, and a curved arm. A condenser with an iris diaphragm on an adjustable support and mirror are located beneath the stage. The coarse adjustment on this instrument is by rack and pinion. The fine adjustment is a knob located on the side of the arm. There is also a monocular body tube. There is a pair of 10X and a pair of 5X eyepieces. The objectives are Bausch & Lomb Achromat 10X 16mm, 43X 4mm, and 97X 1.8mm. The microscope is in excellent condition and a fine representative of mid-twentieth century microscopes.





**B & L binocular compound microscope, 1945**



**B & L Dissecting Microscope, 1946**

### **Bausch & Lomb Dissecting Microscope, 1946**

This is a Bausch & Lomb dissecting microscope made of iron with a pebbled finish. Dissecting microscopes were designed for low power observations and fine dissections. The serial number of TL5996 dates it to 1946. It rests on a horseshoe base and stands 13 inches high and has rack and pinion focusing, a glass stage, and substage mirror. There are two pairs of eyepieces, 10X and 15X. There are three pairs of parfocal objectives, 0.7X, 1.5X, and 2.0X, which are mounted on a drum nosepiece that can be turned to select the desired power. The microscope has its original wood case and is in excellent working condition.

### **Other American Microscopes**

- Charles A. Spencer Horizontal/Vertical Microscope, First American Microscope, c1845
- Grunow Educational Microscope, c1857
- E & J Bausch Microscope, c1860
- Craig Microscope, c1865
- Thomas H. McAllister Household Microscope, c1875
- William Y. McAllister Universal Microscope, c1870
- Geneva Optical Company Microscope, c1888
- Zentmayer U. S. Army Hospital Binocular Microscope, c1880
- Queen & Co. Acme No. 5 Microscope, c1885
- Gundlach-Manhattan Optical Co. Simplex Model, c1905
- Spencer Lens Company Compound Microscope, 1917

## Microscopy in America

Microscopes were almost nonexistent in America until the middle of the nineteenth century. There were makers of scientific instruments in the eighteenth century but they manufactured surveying and navigational instruments needed for the settlement of the country. The few microscopes that existed were imported from England. Cotton Mather used a microscope as early as 1684 and believed "animalcules" were the cause of smallpox. Harvard College obtained a Wilson screw-barrel microscope in 1732. Yale College purchased a Culpeper/Loft tripod microscope in 1734. This was the first known compound microscope in America and is preserved in the Peabody Museum of Natural History at Yale. There are a few references to microscopes made by accomplished amateur opticians in the first part of the nineteenth century, but the first lasting impact was made by Charles A. Spencer. He published an advertisement in 1838 announcing his ability to make reflecting telescopes and reflecting microscopes. He became well-known for the quality of his achromatic objectives. The next significant manufacturer of microscopes was the firm of Julius and William Grunow who began making microscopes around 1852. By 1880, there were over 20 firms dealing in microscopes although some were primarily importers of microscopes from England and Europe. The Bausch & Lomb Optical Company produced its first microscope in 1874. While most makers hand crafted their instruments individually, Bausch & Lomb employed methods for the large scale mass production of microscopes. By 1900, Bausch & Lomb along with Leitz and Zeiss were the largest producers of microscopes in the world. The only American makers to survive after the first part of the twentieth century were the Bausch & Lomb Optical Company and the Spencer Lens Company.

### Charles A. Spencer Horizontal/Vertical Microscope, First American Microscope, c1845

#### History of Spencer Microscopes

Charles Achilles Spencer (1813-1881) is known as America's first microscope maker. Spencer's was the only microscope manufacturing firm in America until 1849. By 1880 it had been joined by 19 others, including Bausch & Lomb, but by 1903, Spencer and Bausch & Lomb were the only two remaining American firms making microscopes. Charles Spencer was born in 1813, in Madison County, New York, in what would later become Canastota on the banks of the Eire Canal. In 1838, he had an ad printed, announcing his ability to make and deliver various reflecting telescopes and reflecting microscopes. By 1840, he published a catalog listing numerous microscopes, reflecting telescopes, and other instruments. Spencer is thought to have made the first American achromatic objective, and, by the late 1840's, had acquired a reputation for his excellent quality objectives of great angle of aperture. His objectives were considered superior to those of European opticians and were not surpassed until those of Carl Zeiss produced with Ernst Abbe and Otto Schott in the 1880s. Spencer apparently had no formal training in optics and learned from reading books and experimenting with glass. Spencer's first microscope



Charles A. Spencer (1813-1881)

was a horizontal type modeled from eminent French instrument maker Charles Chevalier's "Universal" microscope developed in 1834. This was followed by a "Pritchard" type microscope. Microscopes made by Spencer in the 1840's, signed "C. A. & H. Spencer" refer to Charles' cousin, Hamilton, not his son, Herbert. In 1854, Spencer formed a partnership with Professor E. K. Eaton of Troy, New York, under the firm name of Spencer & Eaton. They produced a large "Trunnion" microscope. Herbert R. Spencer (1849-1900) worked in his father's shop and became a partner after Eaton left the business, around 1865. Until 1875, the instruments were marked "C. A. Spencer & Sons, Canastota." In 1873, a fire destroyed the workshop in Canastota and in 1875, the Spencers moved to Geneva, NY, to build microscopes for the Geneva Optical Co. During the next three years, their instruments were marked, "C. A. Spencer & Sons for Geneva Optical Company." In 1877, this association was terminated and their stands were marked, "C. A. Spencer & Sons, Geneva."

After Charles's death in 1881, the business was carried on by his son Herbert under the name H. R. Spencer & Company. In 1889, he moved to Cleveland, Ohio, and then, in 1890, to Buffalo, New York, where the company remained. He formed a partnership with Fred R. Smith and between 1890 and 1895 the firm was known as Spencer & Smith Optical Company. The Spencer Company was incorporated in 1895, using the name Spencer Lens Company. The Spencer Lens Company was successful and over the years produced tens of thousands of microscopes. It was acquired by the American Optical Company in 1935. For several years after the acquisition, the Spencer Lens Company continued operation under its own name before becoming known as the Instrument Division of American Optical Company in 1945.

### Description of Microscope

This is Charles Spencer's first microscope, the large version of the convertible horizontal/vertical microscope modeled after Charles Chevalier's horizontal microscope. It is signed "C. A. & H. Spencer, Canastota, N. Y." and dates to between 1840 and 1850. This extraordinary and massive brass instrument weighs 13 pounds total, and stands 14 inches (36 cm) high overall in the horizontal mode. It is transformable to a vertical instrument, extending by drawtube to a maximum height of  $20 \frac{3}{4}$  inches (53 cm). It stands on a large, stable three-legged base that fills a 12-inch diameter circle. In the horizontal mode, the stage, which dovetails into place and remains horizontal, has rack-and-pinion motion for coarse focusing. The huge double mirror cell,  $3 \frac{5}{8}$  inches in outside diameter, has similar geared motion along the same rack. There is an ingenious fine focus motion to the stage, by knob and long screw (located just below the coarse motion controls) driving a brass wedge against a steel slope. The microscope itself has a two-element eyepiece assembly that bayonets on, a push-on dust cover, a  $90^\circ$  prism box that bayonets on, and an achromatic objective that bayonets in place on the prism box. The objective canister is marked "1 inch" but the unmarked objective is a  $\frac{1}{8}$  inch. The objective has knurled-ring adjustment of the separation of lenses, to compensate for different thicknesses of microscope slide cover slips; it has an index position marked "Uncov'd." The system gives fine images of high magnification. At the base of the pillar is a pin release to allow inclination of the limb, when converting to a vertical instrument. With the prism box removed, an adapter fits into the end of the body tube and holds the objective. Several of the microscope parts are internally numbered "9" and one is numbered "4." The outfit is in good condition noting that the brass is rather browned, with spotting, although it still retains a portion of its lacquer. Purchased from David Coffeen, 2014.

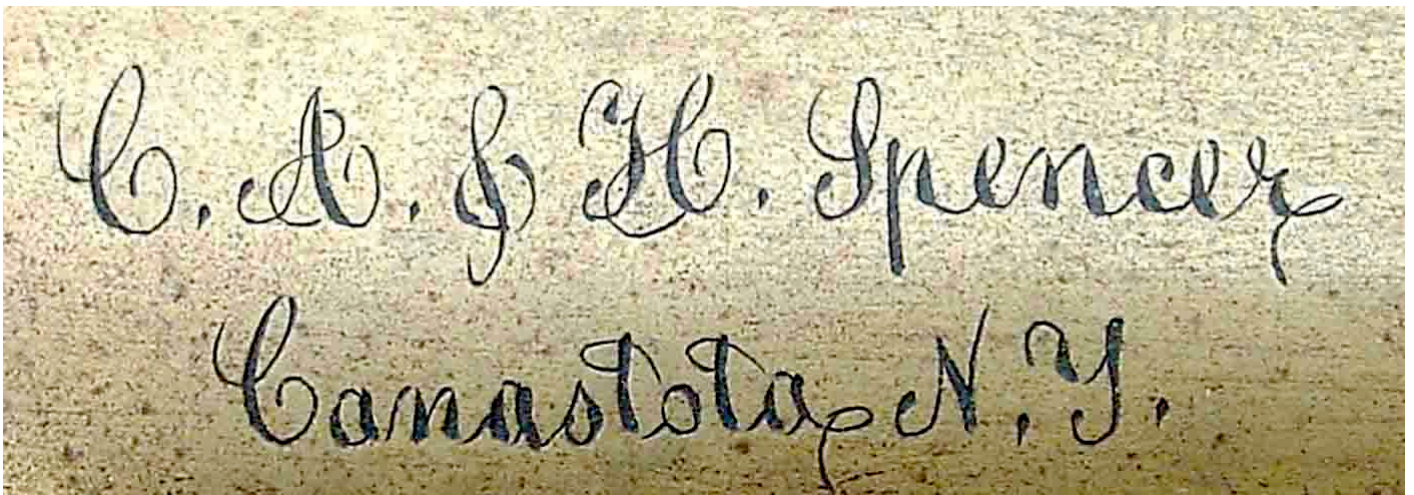


### Information on Microscope

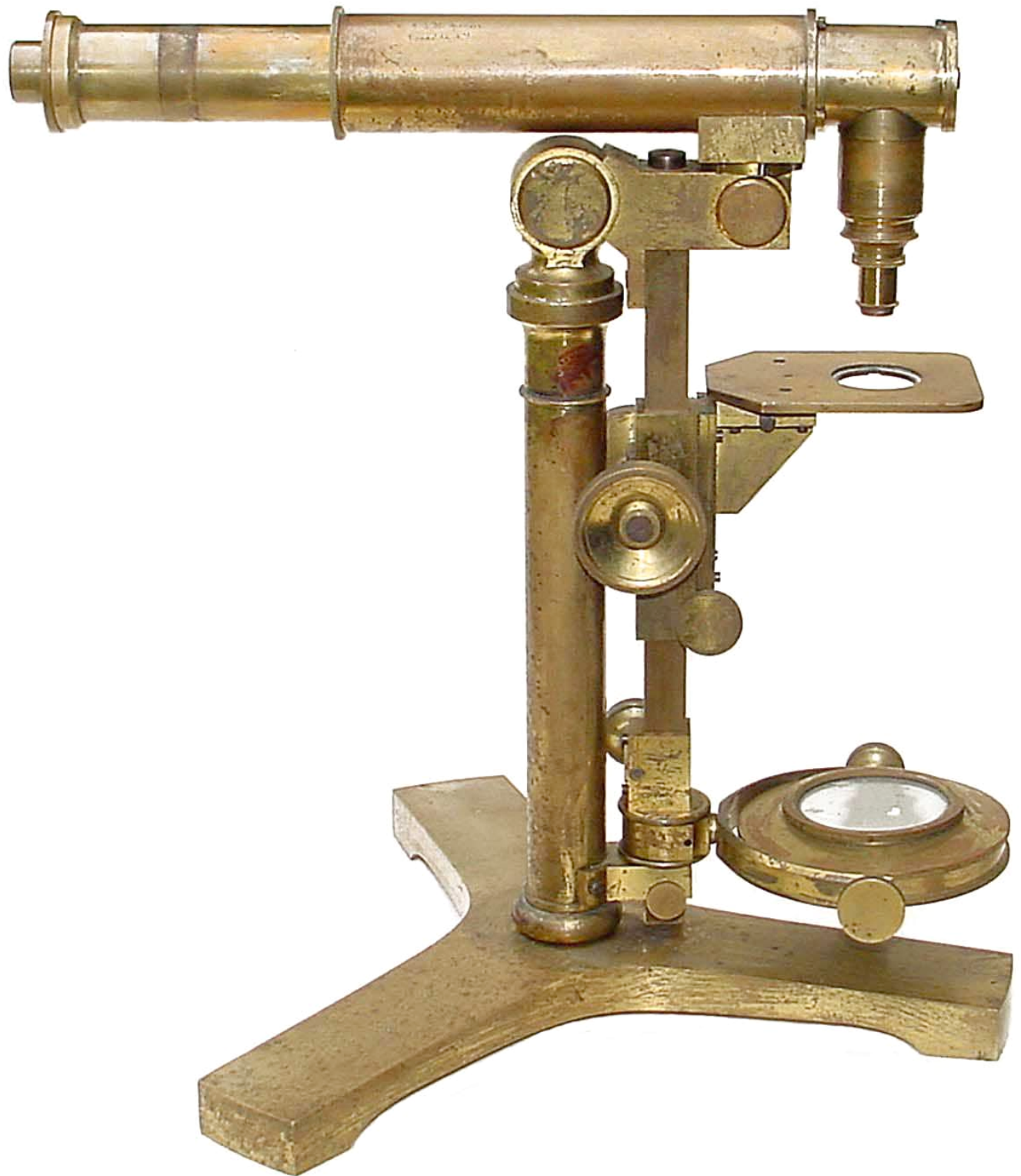
Charles Chevalier made a large and a small version of his universal microscope. In 1848, Spencer wrote to the Smithsonian Institution stating that he was “making microscopes of the model of the Large and Small Chevalier...” This indicates that he was making two sizes of his horizontal microscope, the present example being the large type. The Smithsonian ordered a microscope in 1848 but, typical of Spencer’s perfectionism, it was not delivered until 1854 and was of the later trunnion type. It is believed this microscope was destroyed in a fire in 1865.

Oscar W. Richards, a Yale graduate and an authority on microscopes, spent over 40 years searching and studying the microscopes of Charles Spencer (Rittenhouse, 1988). Only about 15 microscopes of all types by Charles A. Spencer have been identified. On the other hand, microscopes made by the Spencer Lens Company after 1895 are common. It is surprising that in view of the high regard in which Charles Spencer’s microscopes were held, that so few exist today. One explanation is that Charles was a perfectionist and, despite a backlog of orders, made very few microscopes and did not release them until completely satisfied with them.

Spencer did not have serial numbers on his microscopes but he numbered several of the internal parts. He probably made around 20 of the horizontal microscopes. In 1988, six were known; numbers 2, 11, 12, 16, 19, and one unspecified. This example is the seventh microscope known (unless it is the unspecified microscope) and has parts numbered 9 or 6 and one part numbered 4. Some of the surviving microscopes have been modified, and number 2 is missing the base and mirror so that the present example is the earliest surviving intact American microscope.



Signature on Microscope Body Tube



**Spencer Microscope in Horizontal Position**



**Spencer Microscope in Vertical Position**



**Grunow Educational Microscope, c1857**

Julius and William Grunow emigrated to New York from Germany in 1849. The brothers formed a business partnership under the name J. & W. Grunow & Co. and began to make microscopes in 1851 or 1852. Around 1854, the brothers had moved to New Haven, Connecticut. Little information is available about the early career of the Grunows, but according to an 1880 account, Julius was induced by Dr. Henry Van Arsdale and Dr. Chandler R. Gilman to study optics and manufacture microscopes. It was said that Julius taught himself optics and constructed a microscope in 1852 for Dr. Van Arsdale and soon afterward a second one for Dr. Gilman. Dr. Van Arsdale was an authority on microscopical pathology and histology and President of the New York Pathological Society in 1853. Dr. Gilman was Professor of Obstetrics at the Columbia College of Physicians and Surgeons. Charles A. Spencer had completed an achromatic microscope for Dr. Gilman in 1847. At the same time, the Grunow brothers produced two innovative microscopes. The first was the first workable binocular microscope made in 1853 and designed by Professor John Leonard Riddell, Professor of Chemistry at the University of Louisiana (now Tulane University). The second was a chemical or inverted microscope designed by Professor J. Lawrence Smith, a prominent American chemist then also at the University of Louisiana. In the New York Crystal Palace Exhibition in 1855, the Grunows received the second prize for microscopes, the first going to Charles A. Spencer. The Grunows produced several types of stands, high quality objectives, and microscope accessories. In 1864, the brothers moved back to

New York City and later formed their own separate businesses. Given the innovative nature and high quality of the microscopes produced by the Grunows and their association with prominent academicians, it seems unlikely that they learned how to manufacture microscopes entirely on their own. They first worked for the optician Benjamin Pike in New York. It is possible they may have received instruction from a microscope maker such as Charles Spencer or Robert Tolles who apprenticed with Spencer. In 1859, Tolles was fabricating microscopes with Charles E. Grunow, another brother. The Grunows produced microscopes with serial numbers up to 1048.



This is Stand No. 1, the Educational Microscope, the smallest of the stands made by the Grunow brothers. The microscope is signed "J. & W. Grunow Co., New Haven, Ct., N<sup>o</sup> 138." It stands around 13 inches arranged for use. The tripod base and two uprights are japanned cast iron. The japanned cast iron limb is attached to the uprights by a trunnion joint allowing the instrument to be inclined. A brass cylinder is attached to the limb and holds the brass body tube. Coarse focus is achieved by sliding the body tube. The stage is two by three inches with stage clips. A milled-head screw to the right of the stage provides fine focus by raising or lowering a stage plate. There is no substage diaphragm or condenser. A concave mirror is held in a cradle joint. There are two eyepieces with lens caps. There are three objectives; a 1/2 inch in a marked brass canister, a 2 inch, and an

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objective with three screw-on lenses. The latter two objectives are held in a long cylindrical brass canister marked Grunow II<sup>N</sup>. The instrument is held in an original fitted mahogany case with a drawer. The microscope shows signs of extensive use with wear to the lacquer and chips to the paint. It functions well and provides a clear, sharp image. It is a fine example of one of the earliest microscopes manufactured in America.

The 1857 *Illustrated Scientific and Descriptive Catalogue of Achromatic Microscopes, Manufactured by J. & W. Grunow & Co., New Haven, Conn.* describes the microscope as follows: "This microscope is designed, as its name implies, for educational purposes, for schools, private families, and for young people generally. Farmers, mechanics and merchants, who desire to devote some of their leisure hours to intellectual improvement, or to the investigation of those branches of natural science more or less connected with their several avocations, will find this at once a cheap, substantial and efficient microscope." The price of the microscope was \$45.

### E & J Bausch Microscope, c1860

John Jacob Bausch emigrated to America from Germany in 1849. After several unsuccessful business ventures, Bausch opened a retail optical shop in Rochester in 1853 and hung out a sign offering his services as "J. J. Bausch, Optician." Eyeglasses were then a relative luxury, and business was slow. At a local German social club he became friends with Henry Lomb, a fellow immigrant. Trained as a cabinetmaker, Lomb had emigrated to the United States in 1849 and settled in Rochester. In exchange for a loan of sixty dollars to help Bausch's business, Lomb apprenticed himself to Bausch to learn the optician's trade and became a boarder in the Bausch family home. By 1856, Bausch's business, now renamed the J. J. Bausch Optical Institute, had improved. Bausch's wares had expanded, and he now offered other products in addition to spectacles including thermometers, field glasses, telescopes, magnifiers, opera glasses, microscopes, and hour glasses. Most products were imported from Germany. Bausch's brother, E. E. Bausch, emigrated to America in 1854. In 1857, E. E. Bausch joined J. Bausch and Lomb as a clerk where he remained for about five years. E. E. Bausch went on to form the optical firm of Bausch & Dransfield, later E. E. Bausch & Son. J. Bausch and Lomb formed the Vulcanite Optical Instrument Company in 1866 and in 1874 the Bausch & Lomb Optical Company which specialized in microscopes.



## Compound Microscopes

This microscope measures 8  $\frac{1}{8}$  inches tall on a 4  $\frac{5}{8}$  inch diameter base. The circular base is made of cast iron overlaid with a sheet of nickel-plated brass, and bears underneath the cast signature in relief "E. & J. B 5." The microscope itself is made of relatively thin brass with remains of a clear lacquer finish. It features a vertical cylindrical rear pillar with internal racked motion to the stage, compound optics, above-stage condenser on an articulated arm mounted to the main tube, and plane gimbaled substage mirror. Condition is reasonably good noting losses to the finish, a crack in the mirror glass, and a couple of small cracks in the sheathing of the base. It is likely this instrument was made between 1857 and 1862 when E. Bausch was associated with J. Bausch. It appears to be a French microscope mounted on a base made by the Bausch's. As such, it is an important instrument in the history of American instrument manufacture.

### Craig Microscope, c1865

The Craig microscope was the first inexpensive American microscope. In 1861-62, Henry Craig was working as a janitor in the Western Homeopathic College in Cleveland and living at the school. In 1862, he patented his fused glass lens and began manufacturing microscopes. This 4  $\frac{7}{8}$  inch (12.4 cm) tall microscope is made of thin sheet brass, with vertical design and articulated plane mirror. A gutta percha cell holds the special tiny lens, with its domed top and plane base. It is signed around the lens "Craig's Lens, Pat'd Feb'y 18, 1862." A key feature of the patent was the lens, made with a globule of flint glass fused to a plate of crown glass. The focal point was at the bottom of the crown plate itself, which would have been in direct contact with the specimen on a slide, or fluid droplet specimen. No focus adjustment was necessary. The present example is complete with the original green card case, noting a bit of scuffing. The case bears directions and an illustration of the microscope. Included with the microscope are five original small slides (Humming Bird's feathers, Fly's eye, Bee's tongue, Flea, and Sweet William Anther) and a copy of a sheet showing an enlarged microscope in use. The price of the microscope was \$2.00 in brass and 50 cents for the more common hard rubber version. Condition is fine noting minor spotting to the original lacquer finish on the brass. The instrument is in good working order.



Craig Microscope



In the second half of the nineteenth century, American optical and scientific instrument firms began offering small compound microscopes. These were probably meant to compete with the small French drum microscopes that were being imported in large numbers, even though many of the microscopes they offered were also made in France. Shown below are three examples of small microscopes offered by American firms.

The McAllister Family formed a dynasty of opticians and optometrists that continued on into the early years of the twentieth century and lasted some five generations. John McAllister, Sr. (1755-1830), arrived in America from Scotland in 1775 and established a shop in Philadelphia selling whips and canes in 1783. In 1796, he added spectacles to his inventory forming the first optical shop in America. He is now recognized as the Father of optometry and opticians in the United States. John McAllister, Jr. (1786-1877) joined the business in 1807. In addition to spectacles, they sold spyglasses, magic lanterns, camera lucidas and obscuras, lenses, and other photography equipment. The shop was frequented by the earliest practitioners in photography who became John Jr.'s friends and colleagues. Renamed McAllister & Brother when it was taken over by John Jr.'s sons, William Y. McAllister (1812-1896) and Thomas H. McAllister (1824-1898) in 1853, the enterprise became the country's first major dealer in lanterns.

### **Thomas H. McAllister Household Microscope**

In 1865, Thomas H. McAllister moved to New York City and set up his own business. In 1880, he listed eye glasses, spectacles, spy glasses and telescopes, opera glasses, field glasses, compasses, camera lucida, camera obscura, microscopes, magnifiers, magic lanterns, stereopticians, anomorphoscope, and zoetrope. He came to specialize in magic lanterns (see T. H. McAllister lantern in this collection), slides, and related supplies. T. H. McAllister would subsequently deal in motion-picture projectors and films as well. While the early McAllister Brothers' scientific instrument business in Philadelphia did not make microscopes, Thomas began making microscopes as early as 1867 after he moved to New York City. This first effort was the "Household Microscope," a small and very inexpensive compound microscope. The claw foot base of the microscope supports two columns holding the curved limb which supports the stage and the body tube. The body tube is bright brass and the rest of the microscope is gold-painted iron. The tube is signed "T. H. McAllister New York." There are two objectives. Focus is by sliding the eye tube. There are stage clips and a substage mirror. The microscope stands seven inches high and has its original wood box. c1875.

### **William Y. McAllister Universal Microscope**

William Y. McAllister in Philadelphia sold spectacles, opera glasses, telescopes, microscopes, magic lanterns, globes, drawing instruments, surveyor's equipment, barometers, thermometers, chemistry supplies, medical equipment, and a host of other scientific instruments. Many of these instruments were imported from Europe. This microscope is labeled "Universal Microscope, Wm Y McAllister, Phila" on the green-painted, curved Y-shaped cast iron base. It stands seven inches high closed. The body tube is brass and focuses by sliding the eye tube in an outer brass tube. There are two unmarked objectives and a substage mirror. The microscope was imported from France and is stamped "Déposé," French for registered. c1870.

### **Geneva Optical Company**

This microscope is labeled "GENEVA OPT Co. 57 WASHINGTON ST CHICAGO" on the stage. The Geneva Optical Company was founded in 1869 by Andrew L. Smith as the A. L. Smith Optical Company of Geneva, New York. The company primarily made spectacles and tools for

## Compound Microscopes

opticians. A branch known as the Geneva Optical Company of Chicago was opened in 1888. The microscope presumably dates to after 1888 when the Chicago branch opened although it follows an earlier design. The claw-footed base supports two uprights into which are screwed the Lister limb and trunnion. These parts are of black japanned cast iron. The circular stage is fixed to the limb but there is no tailpiece or mirror. The body tube has a short cone nose, a rack at the back, and a drawtube with a field lens. The single eye lens screws into the tube. There are three objective lenses that screw into one another so different magnifications can be obtained.



T. H. McAllister Household



Wm. Y. McAllister Universal



Geneva Optical Company

### Zentmayer U. S. Army Hospital Binocular Microscope, c1880

Born in Germany, in 1826, Joseph Zentmayer (1826-1888) emigrated to the United States in 1848 as a young man, already trained in optics and instrument making. After working for several American instrument makers, including Young & Sons, he opened his own business in 1853 in Philadelphia, making his first large stand, the Grand American, sometime before 1858. As many as ten different types of stands were made over the next 30 years. The U. S. Army Hospital microscope was first made in 1862. The government was in urgent need of microscopes for use in military hospitals during the Civil War. Zentmayer was one of only four American microscope makers at the time and was called upon to supply quality instruments. The American Centennial Stand, introduced in 1876, is a large and elaborate instrument that cost \$765. His large stands were comparable in quality to the finest English microscopes. They were also very expensive so the simpler and less expensive American Histological Model and Student Microscope were also introduced in 1876. Zentmayer was an innovator in the design of instruments and optics. His shop on Walnut Street was a gathering place for scientists, physicians, and professors of the day. After Joseph's death in 1888, his sons carried on the business until at least 1895.



**Zentmayer U. S. Army Hospital Binocular Microscope**

This is a binocular U. S. Army Hospital microscope made after 1876. This model cost \$173 in 1879. It is labeled J. Zentmayer, Phila., Pat. 1876, and numbered 3774. It is made of polished brass and stands 16 inches high when arranged for use. It is in excellent condition with almost all of the lacquer intact. It has a Y-shaped base, round column, and Jackson limb. There is a Wenham binocular body, rack and pinion coarse adjustment, long-lever fine adjustment, graduated revolving stage, and swinging substage assembly. The swinging substage, patented in 1876,



allows the condenser to swing and the mirror to be positioned at any point under or over the stage. This provides for oblique lighting or directing light from above onto an opaque object. A graduated circle is provided for registering the degree of obliquity. The substage consists of a centerable condenser with rack and pinion adjustment and mirror. The microscope has an early E. Leitz Wetzlar brass mechanical stage attached to the circular stage. There are four unnumbered eyepieces. There are two objectives, a Zentmayer 1 ½ inch and one numbered 2. The microscope is housed in its original walnut case but the drawer is missing. Large, early American binocular microscopes are rare and seldom seen on the market today. Except for Zentmayer's more elaborate Centennial microscope, this is probably the finest American microscope of the nineteenth century.

### Queen & Co. Acme No. 5 Microscope, c1885

One of the largest American sellers of scientific instruments in the nineteenth century was Queen & Co. James W. Queen (1813-1890) began working for the McAllister Brothers in Philadelphia, as a boy, around 1825. From 1836 to 1852 he was a partner in the McAllister business, leaving in 1853 to start his own company selling optical and philosophical apparatus. In 1859, he became associated with Samuel L. Fox and the firm became James W. Queen & Co. James Queen retired in 1870 and the business was continued by Fox until 1893, when it was incorporated as Queen & Co. Queen & Co. imported and sold a great variety of microscopes by many other makers. By the end of the third quarter of the nineteenth century, much of the American demand for microscopes was being met by imports from Nacet in France, Hartnack in Potsdam, and R. & J. Beck and Henry Crouch in London, among others. Later, Queen & Co. manufactured their own microscopes. By the 1880s, the firm sold mathematical instruments, optical instruments including spectacles, microscopes, and telescopes, magic lanterns and slides, physical and chemical apparatus, and meteorological instruments. The headquarters of the company was at 924 Chestnut Street, Philadelphia, and there also was a branch office in New York City. Queen & Co., Inc. existed until 1912 at which time it was reorganized as the Queen-Gray Co. by John G. Gray and continued as such until Mr. Gray's death in 1925.

The Acme line of microscopes was first introduced in 1879 by the firm Sidle and Poalk of Philadelphia. The first microscope made by the firm was called "The Acme." By 1880, the firm was located in Lancaster Pennsylvania under the name John W. Sidle & Co. or the "Acme Optical Works." Subsequently, the entire output of the Acme factory was consigned to the James W. Queen & Co. Five models of the Acme microscopes were produced numbered 2-6. This is the Acme No. 5 microscope. It is 9 ½ inches high closed. It has a cast iron Y-shaped foot and twin pillars painted with black enamel. The curved limb supports the lacquered brass body tube that



moves by rackwork. The body is fitted with a nickel-plated draw tube. There is a single objective with three button lenses that screw into one another so different magnifications can be obtained. A swinging mirror is attached to the tailpiece. It is signed on the circular brass stage "Jas. W. Queen & Co. Philadelphia." It has its original dovetailed cherry case. The case bears the numbers "76" and "82" and the microscope "VIII" on the bottom. The microscope is in used but good condition. c1885.



Queen & Co. Acme No. 5, c1885

**Gundlach-Manhattan Optical Co. Simplex Model, c1905**

Ernst Gundlach (1834-1908) was one of the more inventive, skilled, and restless opticians of the nineteenth century. He was an apprentice to C. F. Belthe who took over the Optical Institute in Wetzlar Germany from Carl Kellner's estate and before the Institute was purchased by Ernst Leitz. Gundlach established his own Berlin workshop in partnership with the Siebert brothers and gained a reputation as a maker of highest quality objectives and microscopes. In 1871, he sold his Berlin shop and came to America where he set up as a sole proprietor making microscope objectives in Hackensack, New Jersey. In 1876, Henry Lomb induced Gundlach to head up the newly formed microscope department for Bausch & Lomb. Gundlach designed a full product line of microscopes and patented a variety of stands and accessories. Apparently, Gundlach's desire for perfection instead of economical production led to losses for Bausch & Lomb and he was let go from the firm in 1878. In 1879, Gundlach and Lewis R. Sexton set up and operated an optical

goods establishment in Rochester. He was in Hartford where he was listed as an optician from 1880 to 1884. In 1884, Gundlach returned to Rochester and reorganized the business as the Gundlach Optical Company which produced microscopes and cameras. Gundlach had no connection to the company after 1895 and, instead, produced photographic lenses including the celebrated Rapid Rectigraphic and Perigraphic lenses under the name Gundlach Photo-Optical Co. In 1902, Gundlach Optical Company acquired Manhattan Optical Co. They manufactured microscopes and cameras under their new name, Gundlach-Manhattan Optical Co. In 1904, Gundlach returned to Berlin and founded another company.



This is a small case-mounted portable microscope manufactured by Gundlach-Manhattan Optical Co. and called the "Simplex" model. The main focusing is by push-tube and the fine focus mechanism utilizes a micrometer screw that tilts a thin plate slide support on the stage. The six inch draw tube slips inside a nickel-plated split tube mounted on a six inch nickel-plated pillar. The minimum microscope height above the box is  $9 \frac{3}{4}$  inches. The eyepiece is signed GMO Co. There are three Bausch & Lomb objectives, a 1 inch, 16 mm, and 4 mm in a cannister. The nosepiece holds two objectives. There is a substage mirror and stage clips. The black fabric covered carrying case is  $10 \frac{1}{4} \times 3 \frac{3}{4} \times 4 \frac{1}{4}$  inches with a handle, and a purple felt-lined interior. Both the microscope and case are in very fine condition. The microscope cost \$12 in 1910.

### Spencer Lens Company Compound Microscope, 1917

Charles A. Spencer (1813-1881) is known as America's first microscope maker. Spencer's was the only microscope manufacturing firm in America until 1849. By 1880 it had been joined by 19 others, including Bausch & Lomb, but by 1903, Spencer and Bausch & Lomb were the only two remaining American firms making microscopes. Charles Spencer was born in 1813, in Madison County, New York, in what would later become Canastota. In 1838, he had an ad printed, announcing his ability to make and deliver various reflecting telescopes and reflecting microscopes. By 1840, he published a catalog listing numerous microscopes, reflecting telescopes, and other instruments. Spencer is thought to have made the first American achromatic objective, and, by the late 1840's, had acquired a reputation for his excellent quality objectives of great angle of aperture. In 1854, Spencer formed a partnership with Professor E. K. Eaton of Troy, New York, under the firm name of Spencer & Eaton. Microscopes made by Spencer in the 1840's, signed "C.A. & H. Spencer" refer to Charles' cousin, Hamilton, not his son, Herbert. Herbert R. Spencer (1849-1900) worked in his father's shop and became a partner after Eaton left the business, around 1865. Until 1875, the instruments were marked "C. A. Spencer & Sons, Canastota." In 1873, a fire destroyed the workshop in Canastota and in 1875, the Spencers moved to Geneva, NY, to build microscopes for the Geneva Optical Co. During the next three years, their instruments were marked, "C. A. Spencer & Sons for Geneva Optical Company." In 1877, this association was terminated and their stands were marked, "C. A. Spencer & Sons, Geneva."



## Compound Microscopes

After Charles's death in 1881, the business was carried on by his son Herbert under the name H. R. Spencer & Company. In 1889, he moved to Cleveland, Ohio, and then, in 1890, to Buffalo, New York, where the company remained. He formed a partnership with Fred R. Smith and between 1890 and 1895 the firm was known as Spencer & Smith Optical Company. The Spencer Company was incorporated in 1895, using the name Spencer Lens Company. The Spencer Lens Company was acquired by the American Optical Company in 1935. For several years after the acquisition, the Spencer Lens Company continued operation under its own name before becoming known as the Instrument Division of American Optical Company in 1945. Microscopes made by the Spencer Lens Company are relatively common whereas Spencer microscopes made before 1895 are extremely rare.



This microscope by the Spencer Lens Company has an iron horseshoe base, a tubular pillar, square fixed stage, screw substage condenser, and a double mirror. It has a continental limb, arm, fine adjustment at the top of the limb, and a rack and pinion coarse adjustment. The body tube has a graduated drawtube and triple nosepiece. There are three eyepieces, 6X, 10X, and 20X; and three objectives marked Spencer Lens Co., 10X, 44X, and 95X. The limb, arm, and body tube are brass. It stands 12 inches high closed. It is signed Spencer Microscope, ALOE CO Sales Agents, 38775. The A. S. Aloe & Company in St. Louis supplied surveying, optical, mathematical, and surgical instruments from 1860 to 1959. The company resold the instruments of other makers, a common practice of the period, and engraved

them with the Aloe name and the true maker's name. This is model 40H and was made from about 1900 to 1920. The serial number dates this instrument to 1917. The microscope is in exceptionally fine condition.

## Twentieth Century Microscopes

Leitz Compound Microscope, 1907 (Yale University)

Waechter Trichinoscope, c1910

Ernst Leitz Wetzlar, Binocular Microscope and Accessories, 1923

Leitz III M Petrographic Microscope, 1928

Zeiss Binocular/Monocular Microscope, 1932

Ernst Leitz Wetzlar Binocular Microscope, 1947

AO Spencer Binocular Microscope, 1947

Nikon S-Cb Binocular Microscope, c1970

Leitz SM Phase Contrast Microscope, c1965

Reichert CSM Binocular Microscope, 1952

Wild M11 Microscope, c1965  
 Olympus EH Binocular Microscope, c1970  
 Olympus CK Inverted Microscope, c1970  
 Nikon Alphaphot-2 Binocular Microscope, 1988  
 Olympus BH-2 Binocular Research Microscope, 1982  
 Children's Microscopes  
     Gilbert S-15 Monocular Microscope, 1954  
     Adams Student Microscope  
     Gilbert Junior Microscope & Lab Set

Twentieth century microscopes should not be overlooked in a microscope collection as they will become antiques in the future. At the present time, complete, high quality instruments in good condition are readily available at a reasonable cost. In addition, most of these microscopes are easy to use and produce excellent images. The twentieth century experienced many advances in microscope technology with the introduction of new contrast enhancing techniques such as phase contrast, Hoffman modulation contrast, differential interference contrast, and fluorescence and confocal microscopy. Photographic technology achieved a high level of sophistication, but this progress has been largely eclipsed by rapid advances in digital imaging technology.

#### **Leitz Compound Microscope, 1907 (Yale University)**

This is an all brass Leitz compound laboratory microscope with stand IIa. It has a horseshoe base and cylindrical post that terminates in a hinge. The post above the hinge carries the stage and the arm that holds the body tube. The ocular tube is a drawtube that is nickel-plated and divided into millimeters. The triple nosepiece is also nickel-plated. The coarse adjustment is by rack and pinion. The fine focus is by a non-graduated knob on top of the post. The square brass stage is topped with vulcanite. There is an E. Leitz Wetzlar brass mechanical stage. Beneath the stage is a swing out Abbe condenser raised and lowered by a knob and an iris diaphragm and filter holder. The substage mirror is plano-concave and mounted on a swing arm that slides on its own track. The objectives are E. Leitz Wetzlar 3, 6, and 1/12 Oel Immersion with matching brass canisters. The oculars are Leitz 2, 4, and 10X. One foot of the base is marked "E. Leitz Wetzlar New York" and with the serial number 103497 that dates the instrument to 1907. The other foot is marked "Yale University." The number 5 is stamped on the heel of the foot. The microscope has its original mahogany dovetailed case without the key. There is a magnification table on the inside of the door. There is a brass label on the top that reads "E. Leitz-Wetzlar, New-York= Chicago." The microscope is in good condition and functional but was polished at some time in the past. It is not known where this microscope was used at Yale. It could have been used at the Zoological Laboratory or at the medical school. The number on the heel suggests it may have been part of a set. It possibly was a student microscope and preceded the 1923 Leitz microscopes that were used in the histology laboratories.



**Leitz Compound Microscope, 1907**

**Waechter Trichinoscope, c1910**

This microscope is a Paul Waechter Stand Va (Stativ Va) Trichinoscope ("Trichinoskop"). It is especially designed for the examination of raw or cooked pork for the presence of Trichinae. *Trichinella spiralis* is a tiny nematode worm that is responsible for the serious parasitic disease, trichinosis. Humans as well as dogs, cats, rats, and hogs can be infected and the cysts of *Trichinella* are found in raw or poorly cooked pork. Trichinosis is a very serious public health problem that has plagued mankind for centuries. The cause was finally discovered in the 1870s and specialty



## Compound Microscopes

microscopes were developed mainly in Germany for the microscopic examination of pork and pork products (Germans love sausages made with pork) for the presence of the parasite.

The microscope is a monocular compound microscope equipped with an extra large stage plate. The horseshoe base, pillar, and curved arm are finished in black enamel. The body tube is brass. The stage plate is designed to accommodate a large (2.5 inch by 8 inch) dual plate glass

compressorium. This compressorium is used to squeeze meat samples between the two glass plates thereby making the meat samples transparent in thin section. Brass thumbscrews are provided at each end of the compressorium to facilitate the compression of the meat sample. A low power objective is the prime objective. For greater magnification of a sample, a supplementary objective lens can be rotated into position with a hand knob making for a high power objective combination. Beneath the stage is a circle of apertures and a mirror. In the closed position, the microscope stands 11 $\frac{1}{4}$  inches tall.

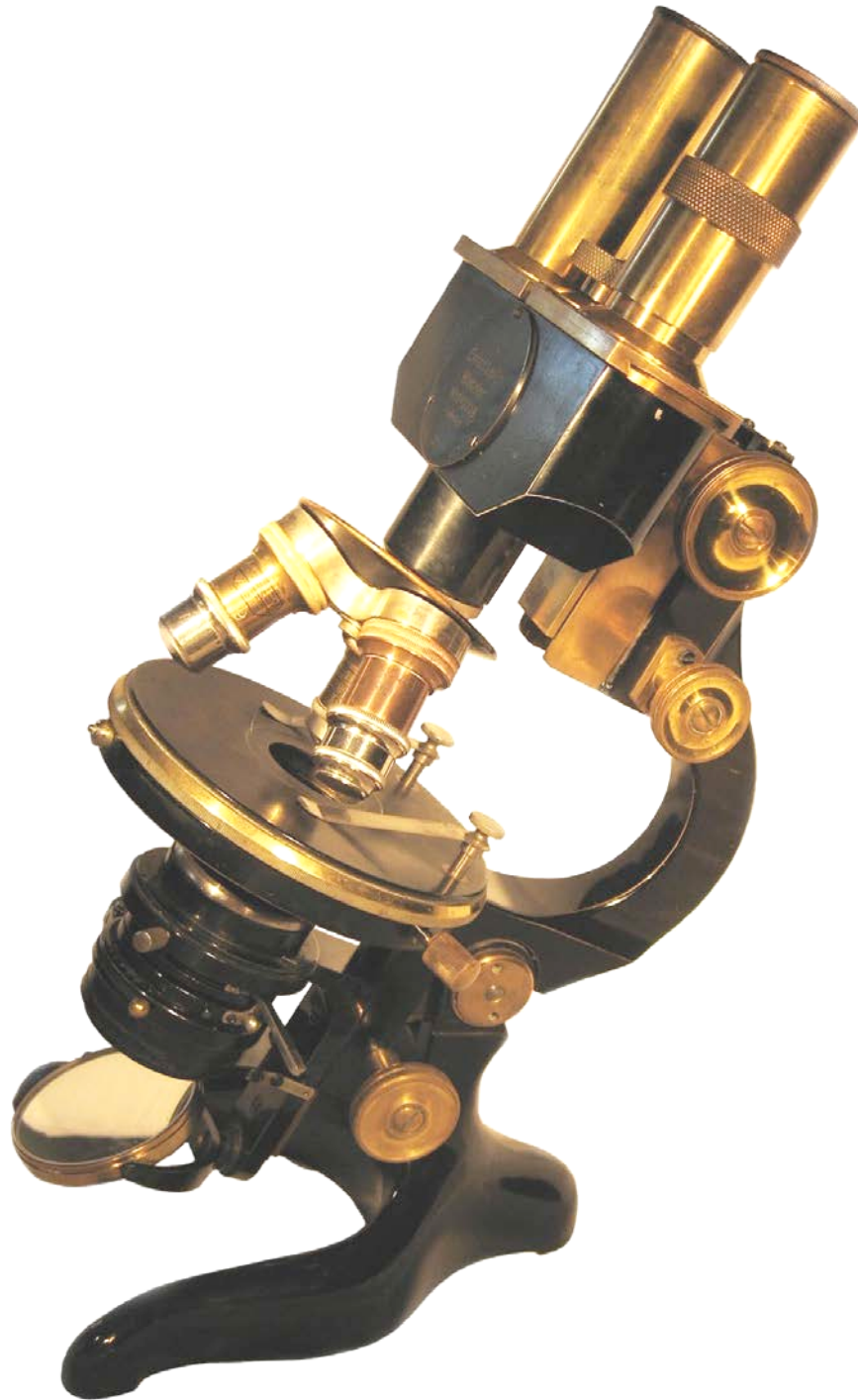


Paul Waechter (1846-1893) was trained to be an optician and mechanic at the Zeiss Optical Works in Jena. In 1872, Waechter founded his own optical workshop in Berlin. Between the years 1872 and 1892, Waechter produced over 20,000 microscopes, mostly for the examination of trichinae in meat. Rudolph Virchow, in circa 1870, succeeded in inducing various German states to make compulsory the testing of pork for trichinosis in abattoirs (slaughter houses). Waechter and several other German microscope manufacturers designed and produced microscopes especially to meet this need. Many of these instruments were exported outside of Europe including to the United

States. The Henry Heil Chemical Company of Saint Louis, Missouri, USA imported Waechter's instruments.

### **Ernst Leitz Wetzlar, Binocular Microscope and Accessories, 1923**

This binocular microscope dates from 1923 based on the serial number #212339. It represents the finest microscopes available at that time. This microscope was used by the instructors of the histology course at the Yale Medical School from 1923 until about 1950. The eyetubes, focus rack, and focusing knobs are polished brass. The modified curved horseshoe base, curved limb, and binocular body are painted black. The circular stage with stage clips can be rotated. It has 4X and 10X oculars and 3 10X, 6LG, and 1/12 Oel 1.30 objectives. There is an achromatic substage condenser and a plano-convex mirror. The microscope has its original wooden case.



**Ernst Leitz Wetzlar binocular microscope**

**Leitz III M Petrographic Microscope, 1928**

The polarizing microscope proved to be useful in petrology and optical mineralogy to identify rocks and minerals in thin sections. Microscopes were developed specifically for study of minerals in rock sections and are called petrographic microscopes. Petrographic microscopes are constructed with optical parts that do not add unwanted polarizing effects due to strained glass, or polarization by reflection in prisms and mirrors. In addition to modifications of the

## Compound Microscopes

microscope's optical system, petrographic microscopes allow for the insertion of specially-cut oriented filters of biaxial minerals (named the Quartz Wedge, quarter-wave mica plate, and half-wave mica plate), into the optical train between the polarizers to identify positive and negative birefringence, and in extreme cases, the mineral order when needed. These special parts add to the cost and complexity of the microscope.

This is a Leitz III M petrographic microscope, one of the classical microscopes of the twentieth century. Serial number is 268328, (1928), with three eyepieces (two listed on the original label in the case), four objectives (three listed on the original label in the case),  $\frac{1}{4}$  wave plate, quartz wedge, and two centering wrenches. The objectives have their own wooden case. The horseshoe base and curved pillar are finished in black enamel. The body tube is brass and holds the analyzer. The substage condenser holds the polarizer. This is a beautiful and functional microscope, with all original lacquer and the original wooden case.



**Leitz III M Petrographic Microscope**



Compound Microscopes



**Zeiss Binocular Microscope, 1932**



**Leitz Binocular Microscope, 1947**



**AO Spencer Binocular Microscope, 1947**



**Nikon S-Cb Binocular Microscope, c1970**

**Carl Zeiss Jena Binocular/Monocular Microscope, 1932**

This is a Carl Zeiss Jena compound laboratory microscope with stand DSG 2 and serial number 253028. The microscope stand is constructed with a heavy cast iron frame that is polished and coated with a hard coat of black enamel. It has a blackened U-shaped base, a rectangular mechanical stage, and a curved arm. It has interchangeable binocular and monocular heads. The eye tubes on the binocular head can be turned to adjust the interpupillary distance. A nickel-plated quadruple nosepiece is located above the stage. Beneath the stage is a condenser, NA 1.2, with iris diaphragm and filter holder. There is a substage mirror, three stops for the illuminating apparatus (r, 1, and one with two apertures), an Elmer & Amend substage lamp, and two card slide boxes with slides and various accessories. The objectives are Zeiss 3; 8, 0.20; D 40, 0.65, 0.17; and 1/12, HI 90, 1.25. Coarse focus is by rack and pinion. Fine focus is by the Meyer geared slow-motion device operated by two knobs, one having a divided drum. One interval on the drum corresponds to 0.002 mm of vertical motion of the optical assembly. The eyepieces are Zeiss single 2X 90mm, paired 5.5X, paired 7X Mobimi, paired 10X Mobimi, and paired K15X Mobimi. The microscope is carried in a wood case with a leather handle covered with embossed black paper. The case is stamped Elmer and Amend Third Ave. 18th to 19th St New York City. The microscope is in excellent condition.

**Ernst Leitz Wetzlar Binocular Microscope, 1947**

This is a Leitz binocular compound microscope of the BS design, serial number 385582. It has an inclinable stand with a V-shaped cast-iron base. The arm is a curved handle attached to an upright rectangular support that carries the rack and pinion and focusing knobs. The end of the arm carries an inclined binocular tube marked 1.25x. The interpupillary distance is adjustable by means of a calibrated knob. The microscope has a mechanical stage, substage condenser with a small swing-out lens in addition to the large central lens, removable iris diaphragm and a swing out glass filter, and a plano-concave mirror. There is a chrome-plated quadruple, revolving nosepiece. The objectives are 1h, 3.5:1; 3, A=0.25, 10:1; 3R, A=0.25, 10:1; 4, A=0.45, 20:1 (two); 6L, A=0.65, 45:1 (two); and 1/12 Oel, A=1.30, 100:1. Eyepieces are two 6XB and two 10XB. The microscope is in excellent condition and complete with Scopelite lamp by Clay-Adams Co. N.Y. and original case. The microscope is in excellent condition.

**AO Spencer Binocular Microscope, 1947**

A similar microscope is an AO Spencer binocular microscope #253484, Model 13MLHW, 1947. It has a blackened horseshoe-shaped base of cast iron, a curved arm, square Bakelite stage, and an inclined binocular body with converging eyepieces. The coarse adjustment is by rack and pinion. The fine focus is by a micrometer screw. The focus knobs and objectives are chrome plated. A revolving triple nosepiece is attached to the body. The objectives are AO 3.5X; Spencer Lens Co., Buffalo, N. Y. 16mm-N. A. 0.25-10X; 4mm-N.A. 0.66-44X; Hom. Imm-1.8mm-N. A. 1.25-95X; and AO 3.5X. Eyepieces are two 6X 834 K and two 10X W. F. 587. The substage is fork-type rack and pinion with Abbe NA 1.25 condenser in mount with iris diaphragm. The microscope is in excellent condition and complete with a mechanical stage, mirror, American Optical Co. substage lamp, and original case.

**Nikon S-Cb Binocular Microscope, c1970**

In the second half of the twentieth century, the traditional microscope manufacturers began to experience competition from microscopes made in Japan, particularly by Nikon and Olympus. The Japanese microscopes were of high quality and considerably less expensive than those by the

## Compound Microscopes

American and German manufacturers. The Nikon Optical Company, a Japanese firm, was established in the United States in 1953. This is a Nikon S-Cb clinical/laboratory microscope. The S models microscopes were made from 1967 to 1978. There is a rectangular base with built in illuminator with dimmer knob. The arm extends up from the base and curves forward to hold the binocular body. There is a quadruple nosepiece. There are 4X, 10X, 40X, and 100X objectives and HKW 10x eyepieces. This model has a preset lever that locks the coarse focus. The microscope is in excellent condition with a mechanical stage, substage condenser, original booklet, and original case. These microscopes were the student microscopes in the histology laboratory at Yale beginning around 1970. In 1985, they were replaced by Nikon Alphaphot microscopes that are still present in the laboratories.



**Reichert CSM Binocular Microscope, 1952**



**Leitz SM Phase Contrast Microscope, c1965**

**Leitz SM Phase Contrast Microscope, c1965**

Phase contrast microscopy, first described in 1934 by Dutch physicist Frits Zernike, is a contrast-enhancing optical technique that can be utilized to produce high-contrast images of transparent specimens such as living cells, microorganisms, thin tissue slices, lithographic patterns, and sub-cellular particles (such as nuclei and other organelles). In effect, the phase contrast technique employs an optical mechanism to translate minute variations in phase into corresponding changes in amplitude, which can be visualized as differences in image contrast. The phase shifts themselves are invisible to the human eye, but become visible when they are shown as brightness changes. One of the major advantages of phase contrast microscopy is that



living cells can be examined in their natural state without being killed, fixed, and stained. As a result, the dynamics of ongoing biological processes in live cells such as the cell cycle can be observed and recorded in sharp clarity and high contrast. The phase contrast technique proved to be such an advancement in microscopy that Zernike was awarded the Nobel prize in physics in 1953.

This is a Leitz binocular phase contrast microscope, model SM, serial number 680185. The microscope dates around 1965. The microscope is made of black enameled metal. A curved arm rests on a triangular base and supports the binocular head. The base is 7 ½ inches long and the microscope 13 inches high. There is a square stage with a mechanical stage. It has single-knob focusing control in which coarse and fine focusing motions are combined in a single operating control. A lamp is attached to the base. The most important feature of this type of microscope is the condenser. This has a Leitz phase contrast condenser system according to Zernike in a configuration known as 402a. It consists of a brightfield condenser with a condenser lens for low powers, an aperture diaphragm, and a top Achr 0.90 swing out condenser. Below is an annular six position turret with stops for phase 1, phase 2, phase 3, open, darkfield, and brightfield. The eyepieces are Leitz 10X periplan. The four objectives are 3.5 0.10, Phaco 10 0.25, Phaco 40 0.65, and Phaco Oel 100 1.30. The objectives are designed for a 170 mm mechanical tube length. A 1.25X magnification is built into the head. Trinity College Biology is marked on the base. The microscope is in excellent cosmetic and functional condition.

### **Reichert CSM Binocular Microscope, 1952**

Carl Reichert (1851-1922) founded "Optische Werke C. Reichert" in 1876 in Vienna. The Reichert firm was one of the principal microscope manufacturing firms in Europe in the late 19th century and, by 1900, the company had produced 30,000 microscopes. Reichert employed some Leitz technicians which may explain why his microscopes were so similar to those of Ernst Leitz. The company was later led by his two sons Karl (1883-1953) and Otto (1888-1972). The firm was partially sold to American Optical in 1962 and fully taken over in 1972.

This is a fine deco style microscope signed on the inclined binocular body, "REICHERT, AUSTRIA, Tubusvergröß. 1:5 x." It is model CSM and the serial number of 236 587 dates it to 1952. It stands 13 inches tall in closed position. Coarse focus is rack and pinion, with fine focus via dual micrometer knobs. It comes with an original mechanical stage and Abbe substage condenser with variable iris diaphragm and swing out filter holder. The plano-concave mirror is in excellent condition on both sides. There is a substage illuminator "LUX TB" that can be substituted for the mirror. Four original Reichert achromatic objectives are a 4x, 10x, 45x, and a 100x oil immersion. Two pairs of Reichert eyepieces, 5x and 10x, complete the optical system which is of excellent quality, producing sharp images of good contrast. The microscope is finished in black and silver. The microscope was retailed by and bears the label of William J. Hacker & Co., Inc. 82 Beaver Street New York. A packing list and "Instruction Manual for Reichert Microscopes" is included. Condition of the microscope is good with minor wear to the finish. The microscope comes with its original wooden case which is lined inside and outside with cloth and has brass corners. The case shows signs of wear. Inside is a rack and compartment to hold the four plastic lens canisters, extra eyepieces, and original stage clips.



**Wild M11 Microscope, c1965**



**Olympus EH Microscope, c1970**

**Wild M11 Microscope, c1965**

The firm of Wild Heerbrugg was established in 1921 in Switzerland. It began primarily as a maker of theodolites and other surveying instruments. Their first microscope was made in 1939. Their microscopes and stereomicroscopes are of the highest quality. In 1987, Ernst Leitz Wetzlar GmbH and Wild Heerbrugg AG merged to form the Wild Leitz group. In 1990, Wild Leitz merged with the Cambridge Instrument Company to form the Leica Holding B. V. group.

This is a Wild model M11 microscope that was first made in 1954 and produced until 1976. The serial number is 24014. This instrument features a binocular head and also an inclining monocular tube with a 45 degree prism inside a rotating housing. It also features a revolving nosepiece that holds four objectives. Present are three Wild objectives having magnifications of 10X, 40X and 100X. There are three Wild eyepieces with magnification of 10X. The coarse focus adjustment is by rack and pinion acting on the body tube. Fine focus movement acts on the stage with micrometer screw adjustment. The circular stage measures five inches in diameter, and holds a mechanical stage. Below the stage is an adjustable Abbe condenser having a NA of 1.30. The circular base measures 6 <sup>7</sup>/<sub>8</sub> inches in diameter. A lamp fits onto the center of the base and has an external transformer. The microscope is 1 <sup>1</sup>/<sub>2</sub> inches high with the binocular head and bears Wild's

distinctive cream color. It is missing the dome-shaped case. The microscope is functional and in excellent condition.

### **Olympus EH Binocular Microscope, c1970**

The forerunner of Olympus was founded in Japan by Takeshi Yamashita in 1919 and produced its first microscope in 1920. In 1956, Elgeet Optical in Rochester, New York, became the exclusive U.S. distributor for the microscope product division of Olympus Optical of Japan. The microscopes were all branded Elgeet-Olympus. Olympus began marketing scientific products in the United States in 1968 and is known as The Olympus Corporation of the Americas. Olympus microscopes became increasingly popular because of their high quality and lower cost relative to comparable American and German microscopes. Olympus now offers a complete range of microscopes from student microscopes to state of the art research imaging systems in both the life and materials sciences.

This is an Olympus Tokyo model EH binocular microscope serial number 253318, c1970. It is a heavy and substantial microscope standing 15 inches high. It has an oval base supporting the curved arm with binocular head. There are two 10X WF eyepieces. The nosepiece holds five objectives; Olympus 4X, 10X 0.10, 40X .65, and 100X 1.30. Coarse and fine focus operate on the stage. The rectangular stage holds an Olympus mechanical stage. There is a substage Abbe condenser, NA 1.25. The illumination system is built into the base and there is an external transformer. There is no case. The microscope is in excellent original condition with only a few nicks to the finish.

### **Olympus CK Inverted Microscope, c1970**





As the name suggests, an inverted microscope is upside down compared to a conventional microscope. The light source and condenser lens are on the top above the stage pointing down and the objectives are below the stage pointing up. As a result, one is looking up through the bottom of the specimen sitting on the stage rather than looking at the specimen from the top as on a conventional microscope. The large accessible stage allows for manipulation of specimens or viewing large objects that would not fit on a conventional stage. An inverted microscope is commonly used in chemistry, metallurgy, tissue cell culture, and for viewing aquatic specimens. In 1853, Julius and William Grunow produced a chemical or inverted microscope designed by Professor J. Lawrence Smith, a prominent American chemist then at the University of Louisiana. The Grunows had shown the design of the microscope to Camille Sebastien Nacet in France who proceeded to manufacture inverted microscopes without acknowledging the Grunows.

This microscope is an Olympus CK inverted microscope which was introduced in 1966. The serial numbers are 215560 (body) and 301094 (binocular). Overall the microscope is about 15 inches long and 18 inches high. The base is 8 x 5 ½ inches and supports the stage and binocular body tube. The lamp housing pillar fits into the stage and holds an arm for the lamp and condenser with an iris diaphragm. A ring allows for focusing the condenser. The transformer for the lamp is built into the base. Controls for illumination are located on the front of the base. The stage is 6 x 7 inches, large enough to hold a tissue culture dish or Petri dish. A 2 ¾ x 5 ½ extension can be attached to the stage. The eyepieces are Olympus CK 10X and the Olympus objectives are 4X, 10X, and C20X in a triple nosepiece. The focus knob is on the base beneath the stage. This was a very popular and successful microscope. This example is in exceptional condition without any blemishes and is fully functional.

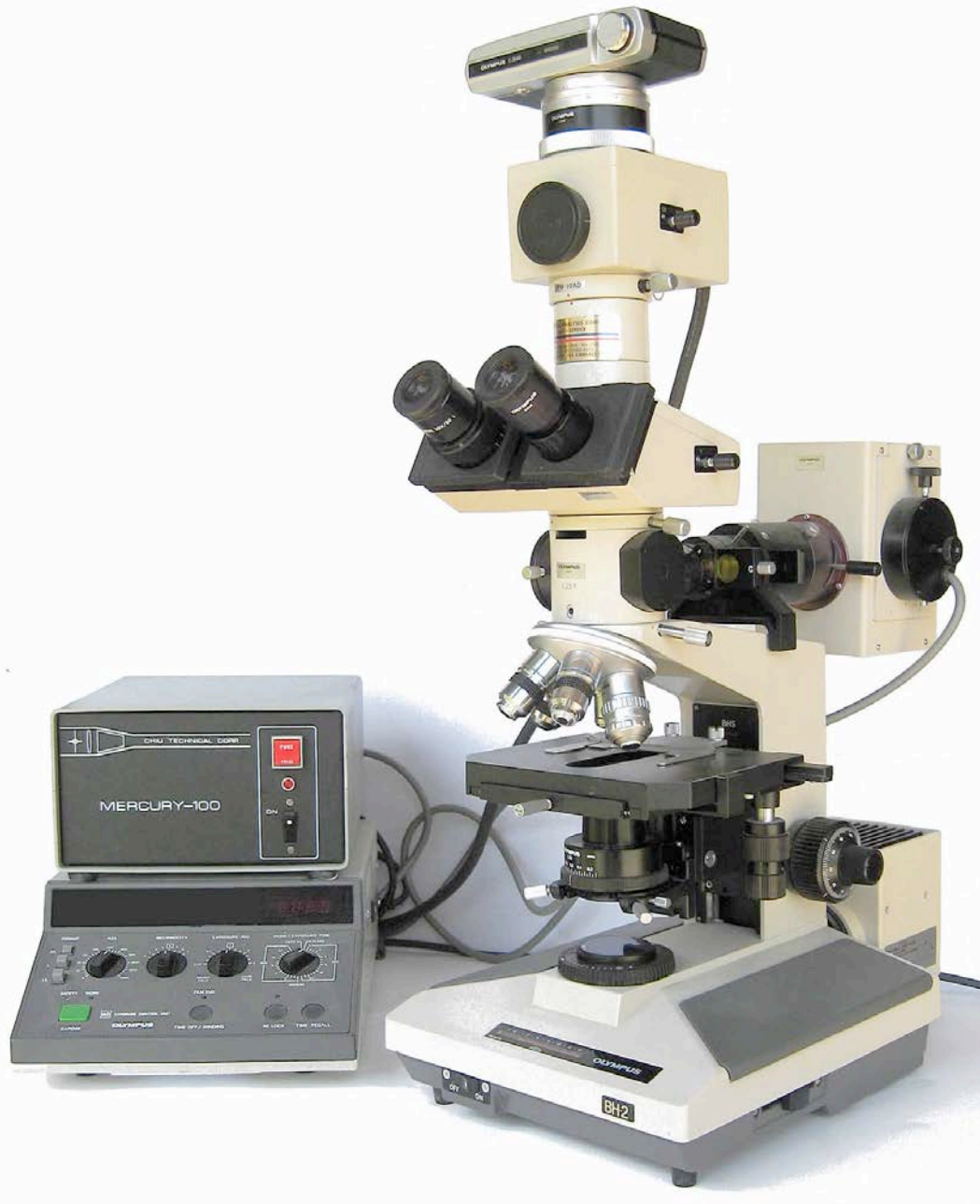
### **Nikon Alphaphot-2 Binocular Microscope, 1988**

The last microscope used in the histology laboratories at the Yale Medical School was the Nikon Alphaphot. Most were Alphaphot Y5 microscopes and there were a few Alphaphot-2 YS2 microscopes. The Alphaphot-2 is shown here. The stand consists of a rectangular base and an arm with upright and inclined sections. The base is 7 x 8 ½ inches in size. The inclined arm holds the binocular eyepiece tube and revolving nosepiece. The microscope stands 15 inches high. There is a stage, mechanical stage, and substage condenser with aperture diaphragm and focus knob. The lamp with a field lens and field diaphragm and the brightness control dial with on/off switch are built into the base. Coarse focus is on the sides with the fine focus built through the center of it. The eyepieces are CFWE 10X/18 and there are four objectives; 4X 0.1, 10X 0.25, 40X 0.65, and 100X 1.25. The objectives are for a 160 mm tube length. One side of the base is inscribed "Property of Yale University Student Teaching Lab." The Alphaphot microscopes were excellent teaching microscopes giving clear images and being reliable, durable, and requiring little maintenance.



### Olympus BH-2 Binocular Research Microscope, 1982

Olympus introduced the successful and popular BH-2 binocular research microscope in 1980. This is the BHS model purchased in 1982. The microscope is equipped for brightfield and fluorescence microscopy and photography. It consists of a BHS-F stand, 100 watt halogen lamp, binocular tube, and graduated mechanical stage. It has a quintuple nose piece with Olympus objectives SPlan 10 (0.30, 160/0.17), SPlan 20 (0.46, 160/0.17), SPlan 40 (0.70, 160/0.17), and DPlan Apo 60 (0.90, 160/0.11-0.23), and an AO Plan Achrom 4/.12 ∞ objective. The eyepieces are widefield WHK 10X/20 L and the condenser an Abbe 1.25 NA brightfield. It has an automatic exposure control photomicrographic and cinemicrographic camera system. It has a reflected light fluorescence illuminator with a high pressure 100 watt mercury vapor arc lamp and a blue/green dichroic mirror set. An Olympus catalog and instruction manuals are included with the microscope. The microscope is in excellent condition and fully functional.



Olympus BH-2 Microscope

### Gilbert S-15 Monocular Microscope, 1954

A. C. Gilbert graduated from Yale's School of Medicine in 1909. He did not practice medicine, but instead founded a company first making magic supplies. This company would later become the A. C. Gilbert Company that was one of the largest manufacturers of toys in the world. Gilbert added microscope kits to his popular lines of Erector and Chemistry sets in 1934. Gilbert was not the first or only manufacturer of microscopes for young scientists. But he was unique in his training and in the authority he could borrow from experts like Yale's Oscar W. Richards, a leader in microscope science at that time. This is a 1954 Gilbert monocular microscope model S-15. The base and limb are aluminum. It has a 10x ocular and 12X, 20X, and 45X objectives. It comes with its original green alligator case with handle. The case measures 4.5 x 5 x 10 inches. The instruction manual is present. The microscope and case are in excellent condition with only minor scuffing at the corners of the case.

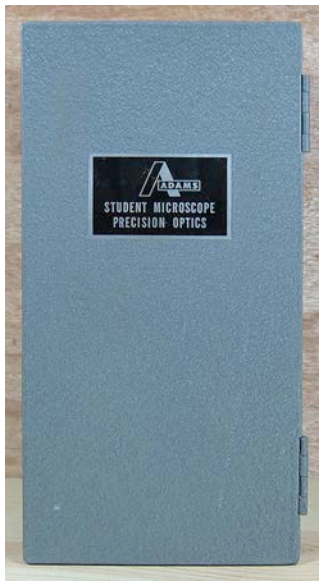


Gilbert S-15 Microscope

### Adams Student Microscope

This is another microscope for children and students. It is an Adams Student Microscope sold by Montgomery Ward in the mid twentieth century. The microscope is eight inches high and has an eyepiece and four objectives. The magnifications are 100X, 200X, 300X, and 500X. It has coarse focus, fine focus at the rear of the limb, stage with clips, and single-sided substage mirror. There is an instruction manual and a folding case for instruments. The microscope fits into a metal case and both are in mint condition. This is a well-built and functional instrument that is more than a toy.





Adams Student Microscope

### Gilbert Junior Microscope & Lab Set

This is a Gilbert Junior Microscope & Lab Set. The box is 18 x 10 inches. The set contains a 60 power microscope and various accessories, all of which are present. There is an informative booklet *Exploring the World with the Microscope* explaining microscopes and their uses and describing experiments to be performed with a microscope. The booklet is edited by Oscar W. Richards, Ph. D., University of Oregon B.A. 1923, M. A. 1925, Yale University, Ph. D. 1931 in collaboration with Alfred C. Gilbert, M. D., Yale University, 1909, Copyright 1938 by The A. C. Gilbert Company, New Haven, Conn., USA. The box and set are in excellent unused condition.



Gilbert Junior Microscope

## Microscope Objective Lenses

The most important imaging component in the optical microscope is the objective, a complex multi-lens assembly that focuses light waves originating from the specimen and forms a primary image that is subsequently magnified by the eyepiece. The quality of the image, magnification of the specimen, and the resolution under which fine specimen detail can be observed heavily depends on the objective. Objectives received their name from the fact that they are, by proximity, the closest component to the object, or specimen, being imaged. They are the most difficult component of an optical microscope to design and assemble. The development of the microscope as a usable scientific instrument depended on improvements to the optical properties of objectives over a period of two hundred years.

### History

For two hundred years after the invention of the microscope around 1595, the objective was a single lens, usually biconvex. The objectives of the period suffered from chromatic and spherical aberration and low resolution (see definitions below) making them of limited value for scientific investigation. Resolution of early microscopes was 2 to 3 microns. In 1758, John Dollond (1706-1761) patented an achromatic lens for telescopes corrected for two colors, although he did not discover it. An achromatic lens is a compound lens composed of a concave lens made of flint glass and a convex lens made of crown glass. The dispersions of the two lenses partially compensate for each other producing reduced chromatic aberration. This discovery was not immediately applied to the microscope because of the difficulty in manufacturing the tiny lenses necessary for microscope objectives.

The first chromatically corrected microscope lenses were made in the first part of the nineteenth century by Vincent Chevalier (1770-1841) and others. These microscopes resolved 0.5 to 1 micron. The first scientifically-based optical system was developed by optics theoretician Joseph Jackson Lister (1786-1869). He was the first to describe in 1830 a both achromatically and spherically corrected optical system for the compound microscope. Lister was not an instrument maker, so he worked with craftsmen such as Andrew Ross (1798-1859) to produce the lenses and microscopes. The joint efforts of Lister and Ross helped transform the microscope from a parlor oddity into an important scientific tool in medical diagnosis and biological research and elevating histology into an independent science.

In 1886, the physicist Ernst Abbe (1840-1905) working with Carl Zeiss (1816-1888) and Otto Schott (1851-1935) in Germany produced apochromatic objectives based on scientific optical principles and lens composition. These advanced objectives provided images with reduced spherical aberration and totally free of chromatic aberration at high numerical apertures. Achromatic objectives are corrected for two colors while apochromatic lenses are corrected for three. These first true apochromatic objectives were so superior to the competition that Zeiss gained nearly the entire high-end microscope market. By the end of the nineteenth century, the microscope had been perfected to the point where it achieved its theoretical limit of resolution of 0.2  $\mu\text{m}$ . The best modern objectives combine multiple functions such as various combinations of bright field, dark field, flat field (plan), achromatic, apochromatic, polarized light, ultraviolet light, phase contrast, and differential interference contrast microscopy. Some of these objectives can cost a few thousand dollars. In 2014, Stefan W. Hell, Eric Betzig, and William E. Moerner, were awarded the Nobel Prize in Chemistry for the development of super-resolved fluorescence microscopy with which a resolution as low as 30 nm can be achieved.

### Definitions

- Focal length – a measure of how strongly a lens converges (focuses) or diverges (diffuses) light. A system with a shorter focal length has greater optical power than one with a long focal length. Currently measured in mm, inches in earlier objectives.
- Magnification – the power of the objective lens times the power of the ocular lens. For example, an objective with a magnification of 45X and a 10X eyepiece produces a magnification of 450 times.
- Numerical aperture – the light gathering power of an objective at a fixed object distance. Derived by a mathematical formula defined by Abbe based on the angular aperture of the lens in degrees and the index of refraction of the medium found between the lens and the specimen. Previously, the angle of aperture of the light cone captured by the objective was used, which did not account for the nature of medium.
- The numerical aperture (NA) of an objective lens is defined by  $NA = n \sin \theta$  where  $n$  is the index of refraction of the medium in which the lens is working (1.00 for air, 1.33 for water, and typically 1.52 for immersion oil) and  $\theta$  is the half-angle of the maximum cone of light that can enter or exit the lens. In practice, however, most oil immersion objectives have a maximum numerical aperture of 1.4, with the most common numerical apertures ranging from 1.0 to 1.35. The higher the numerical aperture of a lens, the higher the resolution of a specimen will be.
- Resolution – the smallest distance that can be detected between two points. Resolution =  $0.61 \lambda / NA$  where  $\lambda$  is the wavelength of light and NA is numerical aperture. Thus, for blue light and an objective with a NA of 1.35,  $0.61 \times 450 \text{ nm} \div 1.35$  equals 203 nm or  $0.2 \mu\text{m}$ , the limit of resolution for a compound light microscope.
- Chromatic aberration - different wavelengths of light passing through a lens have differing focal lengths. When the image is in focus for one color, other colors will be out of focus and produce a halo.
- Spherical aberration – different parts of a lens, e. g., center and edge, do not have the same focal point. When image is in focus at one point, other areas will be out of focus.
- Achromatic objective – corrected for chromatic aberration of two colors, red and blue, and corrected for spherical aberration in the color green
- Fluorite objective – corrected chromatically for red and blue light and corrected spherically for two or three colors. High resolution and allows the passage of ultraviolet light for use in fluorescent microscopy.
- Apochromatic objective – objective corrected spherically and chromatically for three colors, red, blue, and green. Highest level of correction. First introduced by Carl Zeiss (1816-1888) working with Ernst Abbe (1840-1905) and Otto Schott (1851-1935) in 1886.
- Plan objective – objective corrected for image field curvature producing a flat field so that images are in common focus throughout the view field.
- Immersion objective – a medium such as oil, glycerin, or water with a refractive index close to that of glass is placed between the coverslip and objective lens. This reduces the refraction of light occurring at the interface of glass and air.
- Correction collar – invented by Andrew Ross (1798-1859) in 1837, corrects for variations in coverslip thickness. Adjustment by a rotating collar causes two of the lens element groups in the objective to move closer together or farther apart.
- RMS thread standard – in 1858, the Royal Microscopical Society adopted a screw thread standard that was adopted by virtually all microscope makers thereafter. Previously, each maker had their own thread so that objectives of different microscope makers were not interchangeable.
- Tube length - the distance from the nosepiece where the objective is attached to the point where the ocular sits in the eyetube. The Royal Microscopical Society standardized microscope tube length at 160mm during the nineteenth century and this standard was accepted for over 100 years. Objectives designed for a 160mm finite tube length microscope bear the inscription "160" (mm) on the barrel.



- Polarizing microscopy - a polarizing microscope utilizes a polarizer and an analyzer to test whether a specimen is birefringent and can rotate a plane of polarized light. Objectives designed for polarized light microscopy utilize special glass that has been cooled more carefully to avoid strains within the glass that will affect the image quality. The polarizing microscope was invented in 1828 by William Nicol (1768-1851).
- Dark field microscopy – an illumination technique that enhances the contrast in unstained specimens. It works by detecting only scattered light and excluding directly transmitted, unscattered light. As a result, the field around the specimen (i.e., where there is no specimen to scatter the light) is dark.
- Phase contrast microscopy – with a phase condenser, converts phase shifts in light passing through a transparent specimen to brightness changes in the image enhancing contrast. It reveals many cellular structures that are not visible with a conventional bright field microscope. Phase contrast microscopy was first described in 1934 by Dutch physicist Frits Zernike (1888-1966) for which he was awarded a Nobel Prize.
- Differential interference contrast (DIC) microscopy (also Nomarski microscopy) – through a mechanism different from phase contrast, differential interference contrast detects specimen optical path gradients in material with different refraction values (e.g. a cell) in a particular medium (e.g. water) and converts them into amplitude (intensity) differences that can be visualized as improved contrast in the resulting image. It is useful for visualizing unstained, transparent samples.
- Hoffman modulation contrast (HMC) microscopy - designed to increase visibility and contrast in unstained and living material. This technique was invented by Dr. Robert Hoffman in 1975. It accentuates phase gradients within the sample and displays them in the image plane as levels of gray modulated lighter and darker than an average background gray. When viewed under modulation contrast optics, transparent objects that are essentially invisible in ordinary brightfield microscopy take on an apparent three-dimensional appearance dictated by the phase gradients. The technique is particularly suitable for applications like *in vitro* fertilization, where DIC is not possible due to the use of plastic dishes.
- Infinity optical system - microscope manufacturers today utilize infinity-corrected optical systems instead of the older fixed tube lengths, e.g., 160mm. A tube lens is placed within the body tube between the objective and the eyepieces to produce the intermediate image. Infinity optical systems allow introduction of auxiliary components, such as differential interference contrast (DIC) prisms, polarizers, and epi-fluorescence illuminators, into the parallel optical path between the objective and the tube lens with only a minimal effect on focus and aberration corrections.
- Reflecting microscope - utilizes reflecting rather than refracting objectives. They are used to carry out microscopy over a wide range of visible light and especially in the ultraviolet or infrared regions, where conventional optical glasses do not transmit. The reflecting microscope objective usually consists of two components: a relatively large, concave primary mirror and a smaller, convex secondary mirror, which is located between the primary mirror and the object and serves to relay the image from the primary mirror to the focal plane of the eyepiece. Although reflecting objectives do not have chromatic aberration, they need to be corrected for spherical aberrations. Reflecting microscopes were first made in the eighteenth century.

## List of Objectives

AO Spencer, 10X, c1940	Leitz, 160X, c1995
AO Spencer, 43X, c1940	LOMO, 40X, c1990
AO Spencer, 50X reflecting, c1958	Mason, variable 6 to 4 in, c1890
Baker, 1 in, c1875	Meopta, 20X, c1980
Bausch & Lomb, 2/3 in, c1885	Nikon, 10X, c2010
Bausch & Lomb, 1/5 in, c1895	Nikon, 100X, c1980
Bausch & Lomb, 1/6 in, c1890	Nikon, 100X, c1985
Bausch & Lomb, 1/6 in 140°, c1890	Nikon, 40X DIC, c1995
Bausch & Lomb, 1/12 in, c1890	Nikon, 100X, DIC, c1995
Bausch & Lomb, 16 mm, c1900	Officine Galileo, 97X, c1960
Bausch & Lomb, 43X, 1925	Olympus, 100X Fluorite, c1990
Bausch & Lomb-Zeiss, 48 mm, 1903	Olympus, 100X UV, c1990
R & J Beck, ¼ in, c1880	PZO, 10X, c1980
Button objectives, 3 element, c1840 (4)	Reichert, IX, c1900
Button objective, 5 element, c1820	Ross, ¼ in, 1852
Crouch, 3 in, c1880	Ross, ½ in, c1865
Cuff-type, 1760-1790	Screw barrel objective, 1+, c1710
Dallmeyer, 4/10 in, c1860	Sidle & Poalk, 1 ½ in, 1879/80
Davon, 3 in, c1910	Spencer Lens Co, 62X, c1910
Edscorp, 20X, c2005	Spencer Lens Co, 44X, c1915
Engelbert & Hensoldt, 1/50 in, c1870	Spencer & Smith, 1/10 in, c1890
Fisher, 4X, c2010	Spencer & Sons, 1/8 in, c1870
Flatters & Garnett Ltd, 2 in, c1900	Steward, 1 in, c1880
Glycerine, 1/16 in, c1870	Swift & Son, 1/8 in, c1890
Grunow, 1/6 in, c1880	Tolles, variable 3 to 4 in, c1875
Gundlach, 1/12 in, c1870	Vickers, 40X, c1990
Gundlach Berlin, 1/5 in, c1865	Watson & Sons, ½ in, 1897
Gundlach Optical, 1/5 in, c1890	Watson & Sons Ltd, Versalic, 1/12 in, c1910
Hawksley & Sons Ltd, 1/12 in, c1925	Watson & Sons Ltd, Utility, 1/12 in, c1940
Highley, ¼ in, c1855	Watson & Sons Ltd, Holos, 10X, c1950
Hoffman Modulation Optics, 40X, c2000	Wild, 10X, c1970
Horne & Thornthwaite, 1 in, c1860	Winkel, 2.2 mm, c1910
How, ¼ in, c1870	Zeiss CC, c1890
Husbands, 1/6 in, c1875	Zeiss, 2.5 mm, c1900
Koristka, 7Fl, c1930	Zeiss, 70 mm, c1910
Koristka, 9Fl, c1920	Zeiss, 40X phase, c1980
Leica, 100X, c2010	Zeiss, 40X Pol, c1995
Leitz, 1/12 in, c1910	Zeiss, 5X, c2000
Leitz, 1/12 in, c1925	Zeiss, 3.2X, c1970
Leitz, 10X, c1995	
Leitz, 10X DF, c1995	

## Objectives

The objectives shown below illustrate the development of objectives from the eighteenth century to the present time. They also provide a history of microscope manufacturers and the development of microscopes over this time. All are in excellent original optical and cosmetic condition. Most have their original canisters. The descriptions begin with the labels on the objective followed by an explanatory note and length of the objective.



1/12, Oel Immersion, E. Leitz Wetzlar, Apert. 1.30. "Tubus 170<sup>mm</sup>" on lid. c1910. In 1849, Karl Kellner founded the Optical Institute in Wetzlar, Germany. Ernst Leitz took over the company in 1869 and renamed it Optical Institute of Ernst Leitz. 41mm.



E. Leitz Wetzlar, Germany, 1/12, 256972, 170/0.17, Oel 100:1, A 1.30. c1925. 41mm.



Zeiss, West Germany, Planapo 40/1.0 Oel m.l., Ph 3, 160/-, 46 17 47-9903. Iris diaphragm. c1980. This phase contrast, 40X oil immersion, plan apochromatic objective is one of the finest and most complex objectives ever made. 48mm.



1 In. "1 in Baker London" on canister lid. c1875. The objective is fitted with a sleeve with a Lieberkuhn that serves to reflect light onto the object. Charles Baker (c1814-1893) was in business in London by 1851. 41mm.



Bausch & Lomb Optical Co. Rochester, N. Y., 1/6 0.75 N. A., Tube Length 160.0 MM. c1890. 42mm.



1/4 R & J. Beck, Uncovered. c1880. R & J Beck, previously Smith & Beck then Smith, Beck & Beck, was a renowned British optical company based in London and run by Richard Beck (1827-1866) and Joseph Beck (1828-1891). 41mm.



F. Koristka Milano Italy, 7 F1. Correction collar. c1930. The firm of F. Koristka Milano was an Italian optical company established in Milan around 1880 By Fratelli Koristka. 42mm.



R. Winkel, Göttingen, Achrom-Immers: 2,2mm, Ap. 1,0, 25212. c1910. In 1857, Rudolf Winkel (1827-1905) established a mechanic's workshop in Göttingen, Germany where he produced microscopes. 42mm.





Bausch & Lomb Optical Co. Rochester, N. Y., Oil Imm. 1/12 1.32 N. A., Tube Length 160.0 MM. c1890. 41mm.



C. Zeiss, Jena, 2.5 Mm, Apert 1.25, Tubusl 160 Mm. Correction collar. Wasser Immers. and 118 on lid. c1900. 46mm.



Spencer Lens Co. 50236, 62X, 4 MM.N.AP. 0.75. c1910. The Spencer Lens Company was incorporated in 1895 and was one of two American microscope makers to survive into the 20<sup>th</sup> century. 40mm.



J. Swift & Son, London. W., 1/8 in. Correction collar. c1890. James Swift founded his firm in 1857 in London and was joined by his son in 1884. 44mm.



Watson & Sons, London, 1/2 Inch, N.A. 0.34. "Parachromatic" on lid of canister. A high quality achromatic objective brought out by Watson in 1897. This large and successful London firm operated under the name W. Watson & Sons from 1882 to 1908. 33mm.



Engelbert & Hensoldt, XIV Immersion. "1/50 Inch Immersion" on canister lid. Correction collar. Louis Engelbert (1814-1887) and Moritz Hensoldt (1821-1903) worked together in Germany from 1852 to 1887. 38mm.



Olympus Tokyo, HI, FLPL 100 / 1.30, Japan, 400243. Internal iris diaphragm. C1990. A 100X, phase contrast, fluorite objective with an iris diaphragm to increase contrast and change numerical aperture. Olympus, a Japanese company, began marketing scientific products in the United States in 1968 and is known as The Olympus Corporation of the Americas. 42mm.



Horne & Thornthwaite, 1 In, 121, 122 & 123 Newgate Street, London. Fallon Horne (1814-1858) and William Thornthwaite (1819-1894) were opticians who operated at this address from 1857 to 1866 and were best known for their cameras. 27mm.





Bausch & Lomb Optical Co, Rochester N.Y., 16 mm, 0.25 N.A. c1900. 35mm.



AO Spencer, 16 mm, N. A. 0.30, Apoch, 10 X, Made in U. S. A., A35998. c1940. 35mm.



Bausch & Lomb Optical Co. Rochester, N. Y. and New York City, Series I, 2/3 0.25 N. A., Tube Length 160.0 M. M. c1885. 34mm.



"1 in, J. H. Steward, 406 Strand, London" on canister lid. c1880. The J. H. Steward company was established in London in 1852. 34mm.



J. Grunow. N. Y., 1/6. Correction collar. c1880. The J. & W. Grunow Co, begun by Julius and William Grunow, was the second microscope manufacturing firm in the U. S. They operated in New Haven around 1854 and moved to New York in 1864 and in 1874 the firm became J. Grunow. 48mm.



Nikon Japan, E 100, 1.25 oil, 160/0.17. c1985. The Nikon Optical Company, a Japanese firm, was established in the United States in 1953. 51mm.



C. Zeiss CC. Correction collar. c1890. Carl Zeiss (1816-1888) opened a mechanical workshop in Jena Germany in 1846 and offered his first compound microscope in 1857. With Ernst Abbe (1840-1905) and Otto Schott (1851-1935), he produced the first apochromatic objectives in 1886. 53mm.



Bausch & Lomb Optical Co., 1/6, 140°. Correction collar. c1890. The Bausch & Lomb Optical Company founded by John Jacob Bausch (1830-1926) and Henry Lomb (1828-1908) began producing microscopes in 1874 in Rochester, New York. 52mm.





"Utility", 1/12 IN, 1.25 N.A, oil imm, 1.25 .75 .25 N.A. "W. Watson & Sons, Ltd." on lid. c1940. Iris diaphragm for darkfield work. 39 mm.



Triplet button objective with 2 screw-on lenses. Marked "7" on objective and canister lid. c1840. Objective has internal female thread i.d. 0.485 in. 29mm.



Zeiss, CP-Achromat, 5X/0,12, ∞/-, 440920. c2000. 38mm.



Holo, W Watson & Sons, Ltd, London, 9729, 16 mm, 45 n.a, X 10, Tube Length, 160 mm. c1950. 34 mm.



Ex<sup>d</sup> by Hawksley & Sons Ltd., 1/12, N° 1298, N.A. 1.25 Oil Immersion. c1925. Hawksley and Sons Limited, established in 1869 by Charles Hawksley, is a manufacturer of medical and laboratory equipment. 38mm.



Unmarked five button objective with a 1/4 in female thread. c1820. This type of objective was used on some Cary-Gould and drum microscopes. 13 mm.



6 TO 4 in, 4 5 6. "R.G. Mason, Clapham, S.W., 6 TO 4 in" on lid. c1890. Continuously variable 6 to 4 inches. Robert George Mason (1849-1912) was a microscope manufacturer and preparer of microscope slides during the last decades of the 19<sup>th</sup> century and the early years of the 20<sup>th</sup>. 48 to 56 mm.



Sidle & Poak, Phila., 1 1/2. John W. Sidle was in partnership with Poak in Philadelphia in 1879-80 and introduced the Acme line of microscopes. 42 mm.





A. Rofs, 1852. Uncovered, Covered. On lid, "1/4 In. A. Rofs, London." Correction collar. One of the foremost microscope makers in London, Andrew Ross (1798-1859) began business in 1830 and collaborated with Joseph J. Lister (1786-1869) who perfected achromatic lenses. 51mm.



J. H. Dallmeyer, London. "4/10 in." on canister lid. c1860. John Henry Dallmeyer (1830 - 1883) first worked with Andrew Ross before turning mainly to the making and improvement of photographic lenses. 50mm.



Ross, London., Patent 1/2 In., Uncovered, Covered. c1865. There is a small symbol of an arrow piercing a circle or lens. Correction collar. 55mm.



Tolles. "4 In." on canister. c1875. 4 inch continuously variable to 3 inch by internal draw-tube. Robert B. Tolles (1822-1883) apprenticed with Charles A. Spencer and supervised the Boston Optical Works from 1867 to 1883. He was renowned for his high quality objectives. 80mm extended.



Fisher, 4, 0.10. c2010. Fisher Scientific was a major laboratory supply company founded in 1902 in Pittsburgh by Chester G. Fisher (1880-1965). In 2006, it merged with Thermo Electron to form Thermo Fisher Scientific. 26 mm.



Leitz, Wetzlar, Germany, 170/-, 10/0.25. c1995, 36mm.

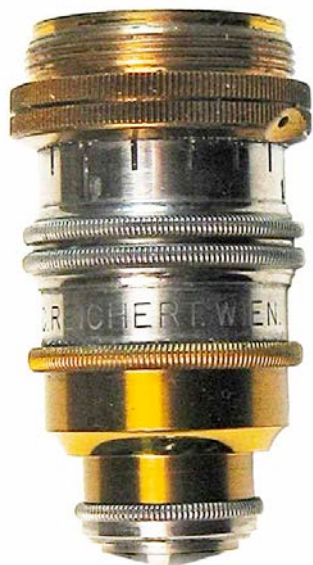


AO Spencer, Made in USA, B31841, 50X, Reflecting, N. A. .56. c1958. A reflecting objective by the American Optical Company. 35mm.



C. Zeiss 70.0 mm. c1910. "397" on lid of canister. 21mm.





C. Reichert., Wien., IX, No11 220. Correction collar. c1900. Carl Reichert (1851-1922) founded "Optische Werke C. Reichert" in 1876 in Vienna. 41mm.



Spencer & Smith Opt. Co., Educational, Water Im., 1018, 160M.M.Tube. "1/10" on lid. Herbert R. Spencer (1849-1900) formed a partnership with Fred R. Smith and between 1890 and 1895 the firm was known as Spencer & Smith Optical Company. 37mm.



Unmarked objective. c1865. "Gundlach, Berlin, 1/5 In, C. Baker, Agent, London" on canister lid. Objective by Baker? 50mm.



Triplet button objective with 3 screw-on lenses. Marked "1" on canister lid. c1840. Shown with adapter from objective internal female thread (0.44 in.) to male RMS thread. 27mm.



C. A. Spencer & Sons., 1/8. c1870. Charles A. Spencer (1813-1881) is known as America's first microscope maker. Herbert R. Spencer (1849-1900) worked in his father's shop and became a partner around 1865. Until 1875, the instruments were marked "C. A. Spencer & Sons, Canastota." 37mm.



Nikon, 80779, Lens Made In Japan, s HI 100 1.25. c1980. For homogeneous immersion. 39mm.



Olympus Japan, DApO 100 UV PL, 1.30oil, 160/0.17, 100, 102311. c1990. An apochromatic (Apo), 100X, ultraviolet light transmitting (UV), phase contrast positive low (PL), spring-loaded objective with iris diaphragm. A complex and versatile objective. 50mm.



Meopta, 240904, 20, 0.45. c1980. Meopta, founded in 1933, is the largest producer of optical equipment in the Czech Republic. 39mm.





AO Spencer, A92046, Made in U.S.A., 43X APO, N.A. 95. Correction collar. c1940. The Spencer Lens Company was acquired by the American Optical Company in 1935. 41mm.



Microplan, Vickers England, P 12 90, 40/0.65, Met. c1990. Spring loaded. This plan objective was designed for a metallurgical microscope using incident light. In 1963, following the acquisition of the C. Baker Ltd. microscope factory, the company of Vickers Instruments was formed in York. England. 47mm.



Nikon 332890, Japan, BD Plan 100 DIC, 0.90 Dry, 210/0. c1995. Spring loaded, M26 thread. This is a metallurgical objective using reflected light and designed for brightfield, darkfield, polarizing, and Nomarski differential interference contrast (DIC) microscopy. It requires a 210mm tube length, has a 26mm thread size, and is used dry without oil. 49mm.



N° VI, E. Gundlach. "1/12 in" on lid. c1870. Correction collar. Ernst Gundlach worked in Berlin from 1865 to 1871 before coming to America. 49mm.



W. Watson & Sons Ltd., London, 2311, "Versalio," 1/12 IN., oil. imm. c1910. Watson & Sons Ltd. was active from 1908 to 1969. 39mm.



Spencer Lens Co. 73348, 4M.M.N.AP.0.85 Y.U.15 44X. c1915. 37 mm.



Leitz Wetzlar Germany, 569232, NPL Fluotar 10X/0.22 DF, ∞/0. c1995. This is a normal field of view plan (NPL), fluorite, infinity-corrected objective for dark field (DF) microscopy. 42mm.



F. Koristka Milano, 9 Fl. c1920. A 1/12 fluorite objective. 40mm.





3 in. N.A. 0.11, DAVON, R.G. TR. MK. c1910. The F. Davidson & Co. in London patented the "Davon micro-telescope" in the early 1900s. 45 mm.



"3 in, H. Crouch, London" on canister lid. c1880. Henry Crouch began manufacturing microscopes in 1865. 43mm.



Objective for a screw barrel microscope. Ivory with cap and button lens. c1710. Closely resembles objectives made by James Wilson (1665-1730) (Clay and Court, Figs. 21, 22). Other possible makers are Edmund Culpeper (1670-1738) and Edward Scarlett (c1677-1743). 30mm wide.



PZO, Poland, 10/0.24, 160/-, 97016. c1980. The precursor of the Polish Optical Industries (PZO) produced its first microscopes in 1926. 46mm.



Leitz Wetzlar, C 11256, Germany, ∞/0, Pl Oel, 160X/1.40. c1995. Spring loaded. This oil immersion, infinity-corrected, plan objective represents the maximum practical magnification (160X) and numerical aperture (1.40) achievable for an objective. 50mm.



Leica, 160/0.17, E<sub>1</sub> Achro, 100X/1.25, 13394015. c2010. Leica Microsystems emerged in 1997 through mergers and acquisitions from five brand names: Wild, Leitz, Reichert, Jung, and Cambridge Instruments. 50mm.



Nikon, Japan, 240774, Plan 40/0.70 DIC, 160/0.17. c1995. Objective for differential interference contrast (DIC) microscopy. 49mm.

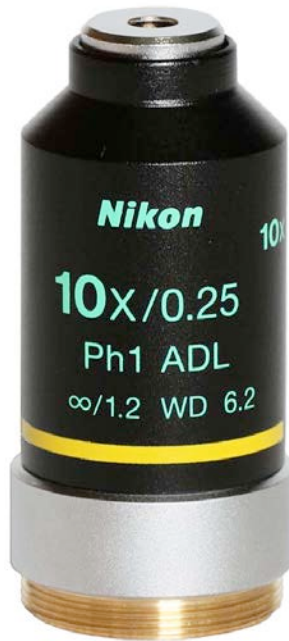


ЛОМО, Ви, 40, 0.75, 890063. c1990. A 40X water immersion objective. ЛОМО (Russian: ЛОМО) or Leningrad Optical Mechanical Enterprise was founded in 1914 and manufactured its first microscope in 1934. 35mm.





Bausch & Lomb Optical Co., Rochester N. Y. & New York City., Series II. 1/5 0.82 N. A. , Tube Length 8.5 Inch. c1895. 41mm.



Nikon, 10X/0.25, Ph1 ADL,  $\infty/1.2$  WD 6.2. c2010. An apodized dark low (ADL) phase contrast, infinity-corrected objective with M25 thread and 6.2mm working distance (WD). 57mm.



J. How., London., Uncovered., Covered. "1/4 In" on lid. Correction collar. c1870. James How operated at 2 Foster Lane from about 1860 to 1880. 46mm.



2 IN, N. A. .17, Tube 170<sup>MM</sup>, Flatters & Garnett Ltd., Manchester 13. c1910. Flatters & Garnett Ltd operated in Manchester, England from 1901 to 1967 and was best known for its microscope slides and lantern slides. 38mm.



Officine Galileo, 97X, 1.8mm Imm.Omog. AP. N. 1.30, 249520 Made In Italy. c1960. Officine Galileo traces its origin to Giovanni Battista Amici (1786-1863) in 1862 in Florence, Italy. 38mm.



Bausch & Lomb - Zeiss Tessar Series 1c Pat Feb. 24 1903 1305855 48 mm., f-16 11 8 5.6 4.5. Iris diaphragm, RMS threads. This low power, wide field micro-Tessar lens was used as an objective lens for projection setups and microphotographic work with bellows cameras. Used today in digital macrophotography. 22mm.



Carl Zeiss, 4403027, Germany, Pol, 40/0.85, 160/0.17. c1995. Spring loaded. An objective for a polarizing microscope. 48mm.



Wild Fluotar, 10, 0.45, Wild Heerbrugg Switzerland 104629. c1970. A fluorite objective. The firm of Wild Heerbrugg was established in 1921 in Switzerland and made its first microscope in 1939. 36mm.





Unmarked. 1760-1790. An objective for a Culpeper-type or Cuff-type microscope. 17 mm w x 15 mm h.



1/4 In, Highley, London. c1855. 5/32 inch internal thread. Samuel Highley manufactured microscopes in the 1850s and 60s. 41mm.



Modulation Optics Inc. HMS 40 LWD 0.5NA 160/0-2. c1990. Correction collar. 40X long working distance, Hoffman modulation contrast objective. 48mm.



Unmarked three-element button objective with a 1/2 inch diameter thread. c1840. Objectives of this type have stackable button lenses that can be screwed on in different combinations to produce a variety of focal lengths. Frequently used on microscopes in the mid 19<sup>th</sup> century. 25mm.



Gundlach Optical Co, Rochester N. Y., 1/5, N. A. 0.92, D, 23. Correction collar. c1890. Ernst Gundlach operated the Gundlach Optical Company in Rochester from 1884 to 1895. 44mm.



Bausch & Lomb Opt. Co., Rochester N.Y. U.S.A., 43X 4mm 0.65, Pat. Oct. 13 1925. 40mm.



Glycerine Immersion, 1/16. c1870. Unsigned, button lenses. A glycerine immersion objective was first shown by Ernst Gundlach in Paris in 1867. 45 mm.



7. "Husbands Bristol 1/6" on canister lid. c1875. Henry Husbands (c1824-1900) operated in Bristol under his name from 1870 to 1900. 42mm.





EDSCORP, 20, 0.40. c2005. Edmund Scientific Corporation was a company based in Barrington, New Jersey that specialized in supplying surplus optics and scientific equipment for schools and hobbyists. 38 mm.



Unsigned objective with three button lenses. c1860. 31 mm.



Zeiss, West Germany, 3,2/0,07, 160/-, 46 01 00 - 9903. c1970. 28 mm.

## Other Optical Instruments

The discovery that convex glass or crystal had magnifying effects had a profound effect on how the world was viewed and led to the advancement of science and technology over the next several centuries. Microscopes allowed a previous unknown world of previously unseen objects to be observed and telescopes revealed the depths of the universe. The use of magnifying lenses expanded to almost every area of technology including microscopy, astronomy, photography, navigation, surveying, and medicine. Opticians and manufacturers usually made a wide range of optical instruments. In this section, examples of instruments that besides microscopes evolved from the simple magnifying glass are shown.

### Spectacles

- Pince Nez, late 18<sup>th</sup> century
- Nuremberg Spectacles, 17<sup>th</sup> century
- Scarlett Spectacles, c1730
- Temple Spectacles, c1755
- Steel-framed Spectacles, late 18<sup>th</sup> century
- Child-sized Wire Rim Spectacles, early 19<sup>th</sup> century
- Chinese Temple Spectacles, c1800
- Magnifying Spectacles, c1920

### Telescopes

- Galilean Bone Telescope (Perspective Glass), c1690-1730
- English Single Draw Telescope, mid 18<sup>th</sup> century
- Venetian Three Draw Telescope, early 18<sup>th</sup> century
- Italian Three-Draw Telescope, c1720
- James Short Reflecting Telescope, c1758
- Dollond Table Telescope, c1790
- Ramsden "Day or Night" Telescope, c1795
- Dollond Military Telescope, c1800

### Binoculars

- Twin Telescope Binoculars, 1881
- Negretti & Zambra British Navy Field Glasses, 1864
- Lemaire/McAllister Opera Glasses

### Navigational Instruments

- Sextant by John Omer, c1860
- Whitbread Box Sextant, c1840
- Azimuth Circle, first half twentieth century

### Surveying Instruments

- Gurley Telescopic Alidade, 1919
- Bianchi Level, c1840
- Berger & Sons Transit Theodolite, c1904

### Cameras

- Camera Obscura replica
- Scioptic Ball, c1730
- Sliding Box Camera Obscura replica
- Giroux Camera 1839 replica
- Sliding Box Daguerreotype Camera
- Watson & Sons Side-Wing Tailboard Camera, c1885
- Eastman Kodak No. 1 and No. 3 Brownie Box Cameras
- Gundlach-Manhattan Optical Company Korona Petit Camera, c1905

## Other Instruments

Charles Bush Kaleidoscope, 1873

Henri J. Noè Stereoscope, c1890

Morton's Ophthalmoscope, c1890

Geneva Optical Company Ophthalmoscope-Retinoscope, 1902

Spencer Spectroscope, c1940

Spencer Abbe Refractometer, c1940

Bausch & Lomb Dust Counter, c1938

## Spectacles

The first spectacles at the end of the thirteenth century were two magnifying glasses connected together. Each lens was surrounded by a frame with a short handle. These were then connected together through the ends of their handles by a rivet. They secured to the face by clamping the nose between the two riveted lens rims. Even then the wearer could only keep them in place by remaining relatively still. The early spectacles contained convex lenses for the correction of presbyopic long-sightedness. They were not really an invention per se but instead a bright idea or adaptation of the earlier simple glass magnifier. Only five or six of the early rivet spectacles have survived. However, these later folding nose spectacles (pince nez) exemplify the early eyeglasses. The round lenses are set in frames joined at the bridge so they can be folded. The frame is silver with hallmarks. The frame has a loop for attaching a chain. This pair dates from the end of the eighteenth century.



Rivet spectacles were followed by bow spectacles with the lenses joined by a bow-shaped bridge, made in wood, horn, bone or leather and clamped or held to the nose. The middle of the fifteenth century saw Florence emerge as the world leader in the production and sale of spectacles. Following the invention of the printing press around 1450, the demand for spectacles increased as books became more readily available. By the end of the fifteenth century, spectacle peddlers became common on the streets of Western Europe. People would try on various pairs of spectacles until a pair was found which gave them the best vision. The following years saw big improvements in the manufacture of spectacles and the creation of regulations to govern how glasses were made. In Germany, the Nuremberg Spectacle Makers Guild was formed in 1535 and later in London, the Worshipful Company of Spectacle Makers became incorporated by a charter from King Charles I in 1629.

### Nuremberg Spectacles, Seventeenth Century

Around 1600, Nuremberg spectacle makers began making frames from a single length of stiff grooved wire, usually copper, which forms both the rims and the bridge. At each end, where the wire meets the bridge, it is bent sharply back to form a hook and the lens is held firmly in place by a binding between the hook and the adjacent part of the bridge. A sprung steel bridge, gripping the nose, was introduced later in the seventeenth century. The Nuremberg-type, one-piece nose spectacles were very common and persisted into the eighteenth century. Dating individual examples is almost impossible without additional contextual evidence.



This is a rare pair of Nuremberg nose spectacles made from steel wire that is rusted and pitted but still strong. The lenses have air bubbles and other imperfections. Overall width is 3 inches extending to 3 ½ inches. The lenses measure 32 by 26 mm. No attempt has been made to clean these early spectacles. Seventeenth century.



**Nuremberg Spectacles**

**Temple Spectacles**

The first spectacles were simply perched precariously upon the bridge of the nose. They could not be used while walking or doing anything that involved motion as they would fall off. It was not until the first part of the eighteenth century that Edward Scarlett put arms on eyeglasses, to hold them on the ears. This (left) is a pair of steel Scarlett-type spectacles, c1730. The round loop at the end of each temple arm is called a wig loop. One coil of a wig could be wound through these loops so that the wig and the spectacles could be put on at the same time. Also, wig loops helped to hold the spectacles in place. The loops were also used for a cord tied behind the head. The spectacles are marked on the frame "09 CAM." These spectacles come with their original steel flip-top case. 4 ¾ inches wide, 4 ¼ inch temples.



**Scarlett-Type Temple Spectacles**

**Folding Temple Spectacles**

The double folding temple spectacles (right) were the first improvement over the short temple style used by Edward Scarlett. This type of spectacle was introduced by James Ayscough

(d1759) in 1752. Ayscough was an English optician and designer and maker of scientific instruments including microscopes. This is a fine example of a pair of spectacles with double folding frames and wig loops, c1755. The frame of these spectacles are marked "08 CAM." This piece measures 4 5/8" across the front from frame to frame and 6 1/2" long frame length. Other spectacles in the collection are steel-framed spectacles, late 18<sup>th</sup> century, and child-size wire rim spectacles, early 19<sup>th</sup> century.

Edward Scarlett (1677-1743) was apprenticed in 1691 to Christopher Cock of Long Acre, a member of the Worshipful Company of Spectacle Makers. Scarlett was made free of the Spectacle Makers Company in 1705 when he first opened his shop called the Archimedes & the Globe on Dean Street, near St. Anne's Church, Soho, London. He then became Master of the Spectacle Makers Company in 1720. John Marshall had been optician to the reigning monarch so when he died Scarlett was then appointed in 1727 to become "Optician to his Majesty King George the Second". Around 1730, Scarlett advertised that he "Grindeth all manner of Optick Glasses, makes spectacles after a new method, marking the Focus of the Glass upon the Frame, it being approv'd of by all the Learned in Opticks as ye Exactest way of fitting different Eyes." The marks on these spectacles may be the focal length. He was a distinguished and highly respected optician and he remained at his shop until his death in 1743. "Opticians" made and sold all types of optical instruments including microscopes and telescopes. The "Yale microscope," a Culpeper/Loft tripod, was purchased from Edward Scarlett in 1734.

### Chinese Temple Spectacles, c1800

The origin of spectacles in the Far East is uncertain. Chinese historians claim that eyeglasses came to China from Arabia in the eleventh century. Two centuries later in 1271, on his first voyage to the Orient, Marco Polo reported that eyeglasses were being used. Other sources indicate that spectacles were invented in China or brought into China from the West in the fourteenth century. Development of spectacles in the Orient paralleled that of those in the Western world. Lenses were round and usually had no magnification power. To the Chinese, wearing spectacles was generally thought to establish the wearer as intelligent, affluent, and influential. Spectacles, therefore, became a status symbol.



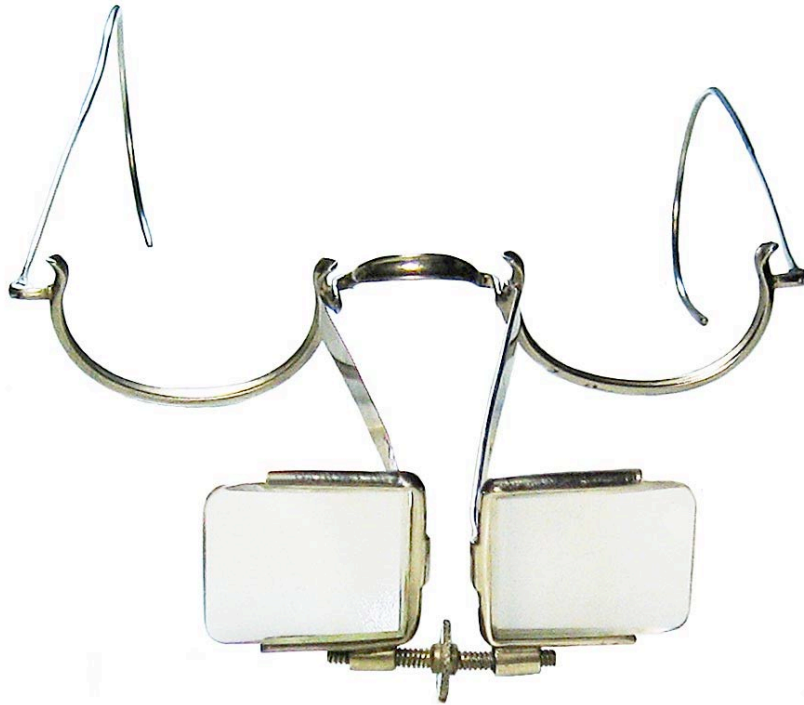
This is a pair of Chinese temple spectacles, c1800. The spectacles are 5 inches wide and the arms 5 inches long. The lenses are round, 1 1/4 inches in diameter. The lenses are dark and produce no magnification. The lenses are enclosed in wide (3/8 inch) tortoise shell rims. The tortoise, a sacred animal to the Chinese, is believed to be endowed with the ability to bring good luck and long life. The metal frame is crafted from paktong, a metal somewhat similar to German silver. Paktong is an alloy of zinc, copper, and nickel that has the lustrous sheen and color tone of silver, is appreciably harder than silver, and does not tarnish. The paktong rivets attaching the nose

bridge and earpieces have an ornate design resembling ruyi clouds, symbolizing power and good fortune. The arms are doubly hinged, next to the lens and then again in the area just in front of the ears. The arms end with a circle enclosing a symbol. The glasses are stored in a wooden case

covered with yellow and brown tortoise shell veneer. The case is  $6\frac{3}{4}$  inches long and  $2\frac{3}{4}$  inches wide.

### Magnifying Spectacles, c1920

This is a pair of magnifying spectacles as would be used by a jeweler, watchmaker, or surgeon for hands free close work. A pair of lenses is extended out 3 inches from the user's face. The frame is made of silver and is  $7\frac{1}{2}$  inches long and  $4\frac{1}{2}$  inches wide. The distance between lenses can be adjusted by a thumbscrew. The frame is marked HCK.



### Telescopes

The microscope and telescope were developed around the same time by lenscrafters in Middelburg, Holland. Hans Lippershey (1570-1619), a master lens grinder and spectacle maker, is generally credited with the earliest recorded design for an optical telescope (a refracting telescope) in 1608, although it is unclear if he invented it. Lippershey applied to the States-General of the Netherlands on October 2, 1608, for a patent for his instrument "for seeing things far away as if they were nearby." Others who claimed to have made the discovery were Zacharias Janssen, also a spectacle maker in Middelburg and credited with inventing the microscope, and Jacob Metius of Alkmaar. The design of these early refracting telescopes consisted of a convex objective lens and a concave eyepiece. Galileo used this design the following year.

### Galilean Bone Telescope (Perspective Glass), c1690-1730

This is an early bone and brass Galilean monocular telescope or perspective glass. It is 9.5 cm long and 2.8 cm in diameter at its widest. The Galilean system of this telescope has a plano-convex objective (16 mm diameter) and a plano-concave ocular (12 mm diameter) and produces an upright image. The tube is made from a bovine metatarsal bone, the long cylindrical bones above a cow's hoof. The ends of the tube are carved on the inside to form a platform for the lenses. The object lens is held in by a brass circlip and lens cap. It has a brass screw-on dust slide. The eye lens is missing its lens cap. Besides the missing lens cap, the tube has hairline fractures and chipping at



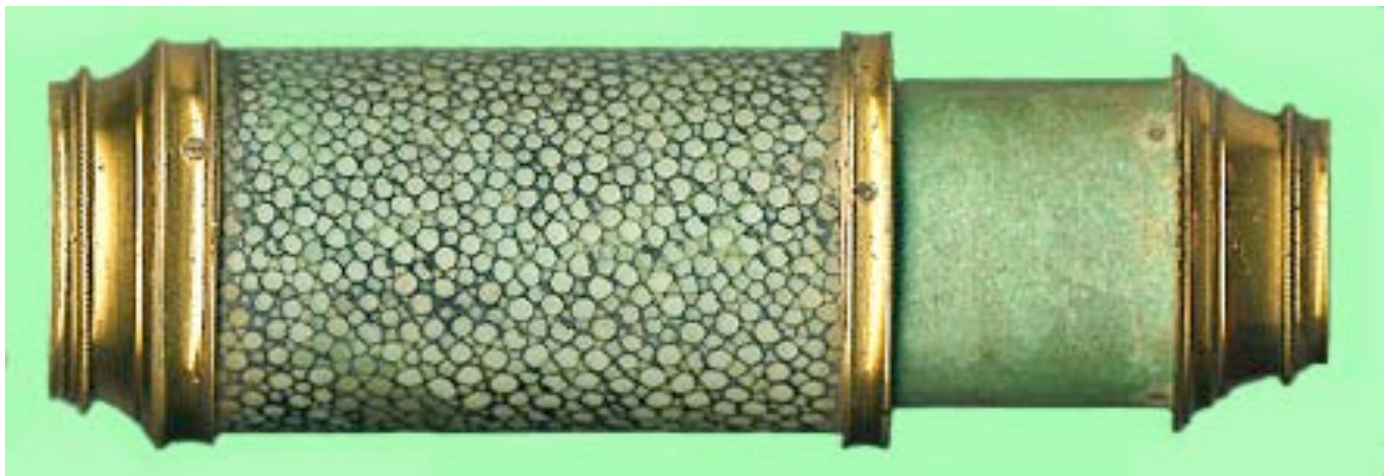
the ocular end. The lenses show a few chips at the edges and numerous tiny bubbles not impairing vision. The instrument is optically in good order offering a magnification of about three times. The origin is unknown, most likely England based on the style of the bone turning and brass object glass shutter.

These small telescopes were probably pocket telescopes for personal terrestrial use and amusement. The craftsmanship required to make them, both the bone carving and the lens grinding, suggests that they were luxury items. Very few of these bone instruments are known. In 2012, five such telescopes and fragments discovered in Amsterdam, two in cesspits, were described. Only one of these contained both lenses. They were dated to the mid eighteenth century although their rarity and construction suggests an earlier date. John Yarwell's trade card of 1683 shows "Little Perspectives," so-called because they show objects in the upright position.



**Galilean Bone Telescope**

**English Single Draw Telescope**



This is an unsigned English eighteenth century, single draw telescope. It is made of green shagreen (rayskin)-covered pasteboard with lacquered brass lens holders and dust sliders. It is 1 ¼

inches in diameter x 3 ¼ inches long (closed) and extending to 4 ¾ inches. The eyepiece is 3/8 inches in diameter and the objective lens 5/8" in diameter. It has a pasteboard slipcase.

### Venetian Three-Draw Telescope

This is a Venetian three-draw telescope, early eighteenth century and restored in the nineteenth century. The telescope extends from 12 ¼" to 32 ½" (31 - 83 cm), and has the main tube bound in mottled brown vellum with fine floral stamped decoration, three drawtubes bound in white vellum, horn binding rings and lens mounts, one (of two) lens covers, singlet objective lens with 7/8" diameter clear aperture, and three-element eyepiece system giving erect images. There are various inked focal positions on the drawtubes. Condition is fine throughout. The telescope is unsigned but is of the style made in Venice by Semitecolo, Olivo, and Selva. It bears a manuscript annotation on one drawtube "Restaure par Perchereau Louis, 25 aout 1847," and with the remains of perhaps similar inscriptions on the other two drawtubes.



Venetian Telescope

### Italian Three-Draw Telescope, c1720

This is an eighteenth century, painted, Italian three-draw telescope. It has a round parallel cardboard barrel covered in red leather hand-painted with floral and vine designs. It has three cardboard draws covered in vellum. The draws have protective rings of horn on their ocular ends. There are various inked focal positions on the drawtubes. None of the draws have retention. The lens mounts are made of turned horn. The single plano-convex objective lens has a clear aperture of ¾ inch. The erector lens is inserted at one end of the smallest tube, while the other end contains the eyepiece lens. The telescope is 12 inches closed and 36 inches extended. It is unsigned but is of the style made in Venice. The optics are good but the body is in somewhat rough condition. It is lacking the screw-on caps and there is wear to the paint. A similar telescope is at The University of Arizona, College of Optical Sciences.





**Italian Three-Draw Telescope**

**James Short Reflecting Telescope, c1758**

Chromatic aberration is the inability of a glass lens to bring all of the wavelengths comprising white light into focus at a single focal point. It manifests itself as fringes or halos of color along boundaries that separate dark and bright parts of the image, because each color in the optical spectrum cannot be focused at a single common point. In a refracting telescope, a bright star or planet viewed through a refractor with a single objective lens would have a bright red and violet halo around it. This sort of extreme color aberration in an objective lens reduces the contrast of the images, blurs the focus, and obscures detail in the image. In the eighteenth century, it was found that chromatic aberration could be reduced by combining two lenses made of different types of glass, one in front of the other, for the objective lens (see Dollond telescope).

The reflecting telescope was invented in the 17th century as an alternative to the refracting telescope because the curved mirrors used in reflecting telescopes focus white light to a single point and do not produce chromatic aberration. The Gregorian telescope is a type of reflecting telescope designed by Scottish mathematician and astronomer James Gregory (1638-1675) in the 17th century, and first built in 1673 by Robert Hooke. The design pre-dates the first practical reflecting telescope, the Newtonian telescope, built by Sir Isaac Newton in 1668, but was not successfully built until five years after Newton's first reflecting telescope. The Gregorian telescope consists of two concave mirrors, the primary mirror (a concave paraboloid) collects the light and brings it to a focus before the secondary mirror (a concave ellipsoid) where it is reflected back through a hole in the centre of the primary mirror and thence out the bottom end of the instrument where it can be viewed with the aid of the eyepiece. The Gregorian design solved the problem of viewing the image in a reflector by allowing the observer to stand behind the primary mirror. This design of this telescope renders an upright image, making it useful for terrestrial observations.

This brass telescope is 12  $\frac{3}{4}$  inches (32 cm) long overall and 2 inches (5 cm) in diameter, fitted with speculum metal mirrors, long side screw focusing to the secondary mirror, two element eyepiece, dust cap, and pillar mounting by iron screw to tree or





fence post, or to the brass fitting on the wood base. Condition is fine, the brass cleaned, and the wood base a replacement. There is no box. The optics give very good images, even in daylight. The telescope is signed "James Short London 149/1032=7." James Short (1710-1768) was a renowned optical instrument maker who worked in his hometown of Edinburgh from 1734 to 1738, when he transferred to London, producing a wide range of reflecting telescopes over the next 30 years. He used an informative numbering system throughout. Thus, the present telescope is the 1032<sup>nd</sup> which he produced, and is the 149<sup>th</sup> to have a focal length of seven inches. The Museum of the History of Science at Oxford holds Short #1077, the 154<sup>th</sup> of this focal length, also c1758.



**James Short Reflecting Telescope, c1758**

### **Dollond Table Telescope, c1790**

The Dollond family made scientific instruments for five generations. On April 21, 1750, Peter Dollond (1731-1821) opened a small optical business in Vine Street, Street, near Hatton Garden in London. He was joined by his father John Dollond (1706-1761) in 1752. John Dollond patented the achromatic lens in 1758, although he did not discover it and the invention was hotly disputed for years. Chromatic aberration occurs because light of different wavelengths, e.g., red, blue, is refracted at different angles by lenses and have different focal points. An achromatic lens is a compound lens composed of a concave lens made of flint glass and a convex made of crown glass. The dispersions of the two lenses partially compensate for each other producing reduced chromatic aberration. In 1761 shortly before his death, John Dollond was appointed optician to King George



III.  
John Dollond (1706-1761)

The discovery of achromatic lenses heralded a new era for telescope makers, but the same did not apply to the microscope. This was primarily due to technical difficulties in manufacturing the tiny achromatic compound lenses necessary for microscope objectives. The only successful

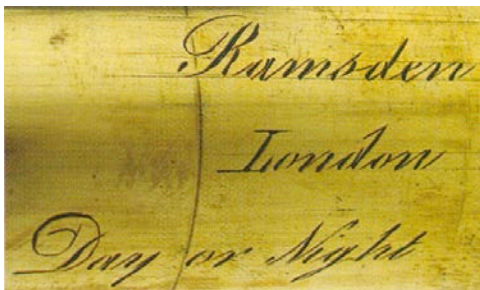


objectives had very low magnifications and long working distances. In 1768, John Dollond, Jr. (1730-1821), now a partner in the business, was appointed optician to King George III and the Duke of York. The Dollonds produced telescopes, microscopes, and other optical instruments of the highest quality. In 1781, Peter Dollond made bifocal spectacles. Dollond & Co merged with Aitchison & Co in 1927 to form Dollond & Aitchison which continued until 2009.

This is a small brass Dollond single draw telescope on a stand. The telescope is 4  $\frac{3}{4}$  inches long closed and extending to 6  $\frac{3}{4}$  inches. The barrel is 1  $\frac{9}{16}$  inches in diameter. The objective lens is 1  $\frac{1}{4}$  inches in diameter. A dust cover screws on over the objective lens. The eyepiece has four lenses on a rotating disk that clicks into place. The tripod base consists of three scroll-shaped legs and a round pillar. It folds up and is stored in the inside barrel. The telescope is signed in script "Dollond London" on the drawtube. The finish on the tubes is worn. The optics are functional and in good condition. c1790.

### Ramsden "Day or Night" Telescope, c1795

English telescope, late eighteenth century, made of glass with three drawtubes, the main tube partially bound in mahogany and mounted with a sliding sun shade/dew cap of reduced aperture. The telescope opens from 11  $\frac{3}{4}$  to 37  $\frac{3}{4}$  inches (30-96 cm) fully extended. It has dust slides at each end, and is equipped with a 1  $\frac{1}{2}$  inch diameter air-spaced achromatic doublet objective, and erecting eyepiece system of four biconvex elements. Condition is fine, with a few small dents, the brass is cleaned. It is complete with the beautiful original card case (lacking end pieces) with its fine gilt-stamped decoration. An inked inscription survives on the back of the objective dust slide. Several aspects suggest this is a late Ramsden product, from the very late in the eighteenth century, in particular the general construction, the tapered eye cup design, and the unusual form of signature. As a "day or night" glass it was certainly appropriate for terrestrial use, with its sunshade and erect image of modest power. And for use at night it offered a relatively large objective with improved light gathering ability. It was a successful form of naval telescope that continued well into the nineteenth century. Jesse Ramsden (1735-1800) was London's leading maker of instruments of astronomy, navigation, and surveying.



Ramsden Day or Night Telescope

### Dollond Military Telescope, c1800

In 1780, Peter Dollond introduced the Military or "Improved Achromatic Telescope," also called the Army telescope. This is a standard type with a mahogany body and brass draw-tubes and was manufactured well into the nineteenth century. They were between 14 and 52 inches long with a lens aperture of between 1 and 2.75 inches. They cost from 2.5 to 12 guineas. This c1800 example has a round parallel mahogany barrel. It measures 11 inches closed and 41 inches extended. The objective lens is an achromatic doublet 2 ¼ inches in diameter. It has four brass draws, a four-lens eyepiece, and a flared eyecup with a swivel cover. It is signed in script "Dollond London" on the eyepiece tube. The telescope is in excellent condition with bright lacquered brass and good optics. The telescope has a shagreen case.



Dollond Military Telescope

### Binoculars

Binoculars, field glasses or binocular telescopes are a pair of identical or mirror-symmetrical telescopes mounted side-by-side and aligned to point accurately in the same direction, allowing the viewer to use both eyes when viewing distant objects. They give viewers a three-dimensional view. When Hans Lippershey applied for a patent on his instrument in 1608, the bureaucracy in charge, who had never before seen a telescope, asked him to build a binocular version of it, with quartz optics, which he is reported to have completed in December 1608. The first type of binoculars created by putting telescopes together were known as Galilean binoculars and used a convex lens and a concave eyepiece lens together. This design provided an erect image of the subject, but a main disadvantage was that it had a narrow field of view. The alternate solution for obtaining an erect image in a pair of binoculars was to use two Keplerian telescopes with Schyrle erecting lenses (terrestrial telescopes). The Keplerian telescope uses a convex lens as the eyepiece instead of Galileo's concave one. Both binocular types had the difficulties of alignment, focusing, and magnification. Nonetheless, they were made from Lippershey's time to the present.

The Galilean binoculars were simply two telescopes side by side and were never satisfactory until they were improved in 1823 by Johann Voigtlander in Vienna. He added eye tubes to the binoculars that were used for focusing each telescope independently. Two years later in Paris, Pierre Lemiére improved on this design and created a center focus wheel allowing the two lenses to be focused together. After this development, opera glasses and theater binoculars grew in popularity because of the superior view they facilitated in opera and theater houses. They were also beautifully designed and used coverings such as pearls, enamel, silver, gold, bone, mother of



pearl, and colored leather. By the 1850's, opera glasses and theater glasses had become a must-have fashion accessory for all opera- and theater-goers.

Binoculars were greatly improved with the development of prism binoculars. Convex lenses are used for both objectives and eyepieces. A wider field of view and higher magnification can be attained than is the case with Galilean binoculars. An erecting prism system is incorporated in the optical path to rectify the image. Also, employing prisms has the effect of making the length of such binoculars shorter. The Italian optician Ignazio Porro patented his technology in the year 1854; this was the technology that was further refined by makers like Carl Zeiss in the 1890s. Another type of prism is the roof (dach) prism system. With the improvements in binoculars, their use extended from theater-goers to the military.

### **Twin Telescope Binoculars, 1881**



This is a very fine pair of nickel silver, taper-barreled telescope binoculars. They measure 10 ½ inches drawn in, 14 inches when out, and 17 inches when the sun visors are extended. Focus is pull/push with final focusing via the central thumb wheel. The barrels and sun visors are covered with diamond patterned black leather that is very much still intact. The binoculars give a very good, clean, sharp image. They are contained in an original leather case showing wear. They are signed around the eyepieces "Adie & Wedderburn." The Adies were a notable family of instrument makers in the eighteenth and nineteenth century. The renowned partnership of Adie & Son (Alexander and John) was succeeded by Richard Adie in 1857 but continued under the same name Adie & Son in Edinburgh. Thomas Wedderburn was employed as foreman at Richard Adie's workshop and became a partner in Adie & Wedderburn in 1881.

### **Negretti & Zambra Binoculars, 1864**

This is a very fine pair of brass Negretti & Zambra British Navy field glasses. They measure 4 ½ inches in length extended and 4 ¼ inches in width. There are engravings in script on each of lens shafts. One reads "Negretti & Zambra, Opticians, London." The other lists the addresses of the firm's shops; "1 Hatton Garden, 59 Cornhill, 122 Regent St, 153 Fleet St." Negretti and Zambra was located at these addresses in 1864 indicating the binoculars were made around this time. The condition of the binoculars is exceptional. The lenses work and adjust beautifully. There is very little wear to the brass and no nicks or scratches.



The firm of Negretti & Zambra (active 1850–c1999) was a producer of scientific and optical instruments and also operated a photographic studio based in London. Henry Negretti (1818–1879) and Joseph Zambra (1822–1897) formed a partnership in 1850, thereby founding the firm that would eventually be appointed opticians and scientific instrument makers to Her Majesty Queen Victoria, Prince Albert and Edward VII of the United Kingdom, the Royal Observatory and the British Admiralty.

### Lemaire/McAllister Opera Glasses

This a pair of mother of pearl opera glasses, a type of Galilean binoculars, with an American connection. One eyepiece bears the signature “Lemaire Paris” and the other “McAllister Philad.” The LeMaire trademark bee with outstretched wings and the number 63 are etched on the underside of the middle bridge. The firm of LeMaire has a long history of making optical instruments and were probably the largest manufacturers of opera glasses in the nineteenth century. John McAllister opened the first optical shop in America in 1796 and the business was carried on by subsequent generations. It is likely these opera glasses were imported by William Y. McAllister who placed his name on them. The glasses measure  $3 \frac{7}{8}$ " wide and  $2 \frac{1}{16}$ " high closed and  $2 \frac{3}{4}$ " extended. The glasses are in excellent condition. The lenses and iridescent mother of pearl are in excellent condition with no cracks or chips. The opera glasses come with their original leather case that also bears the bee logo on the brass push button release of the lid. c1885.





## Navigational Instruments

From the time men sailed beyond the sight of land, the ability to determine one's position became of paramount importance. Many instruments were devised over the centuries culminating in the sextant, an optical instrument, as the main instrument of navigation. Celestial navigation is the use of angular measurements between celestial bodies and the visible horizon to locate one's position on the globe. The nautical sextant is used to perform this function. The nautical sextant consists of a 60 degree arc, the periphery of which is calibrated. An alidade or index arm carries a small mirror (index mirror) at its top while the bottom is moved across the calibration scale. A sighting telescope is mounted on one arm of the sextant while the other arm holds a fixed mirror (horizon mirror). Light from the celestial body strikes the index mirror and is reflected to the silvered portion of the horizon glass, then back to the observer's eye through the telescope. The observer manipulates the index arm so the reflected image of the body in the horizon glass is just resting on the visual horizon, seen through the clear side of the horizon glass. The angle, read on the scale, can be used on a chart to determine the navigator's position.

### Sextant by John Omer, c1860

This is a fine mid-nineteenth century brass sextant signed "J Omer 99 Minories London." It is 10 ½ inches wide with a nine inch radius. The ladder frame has four index and three horizon shades, index and horizon mirrors, a mahogany handle on the reverse, and is supported on three feet. The index arm holds a swinging magnifier. The angle is 0 to 150 degrees with a five degree extension on either side. There is one telescope, a sighting tube, and an adjusting pin. It has a fitted mahogany box. The sextant is in excellent condition with some loss of silvering on the mirrors. John Omer succeeded his uncle George Bradford on Minories Street in 1851. They were "Real Makers of Mathematical Instruments" and manufactured optical instruments, including sextants, quadrants, and telescopes. They also supplied charts, navigational books and flags.

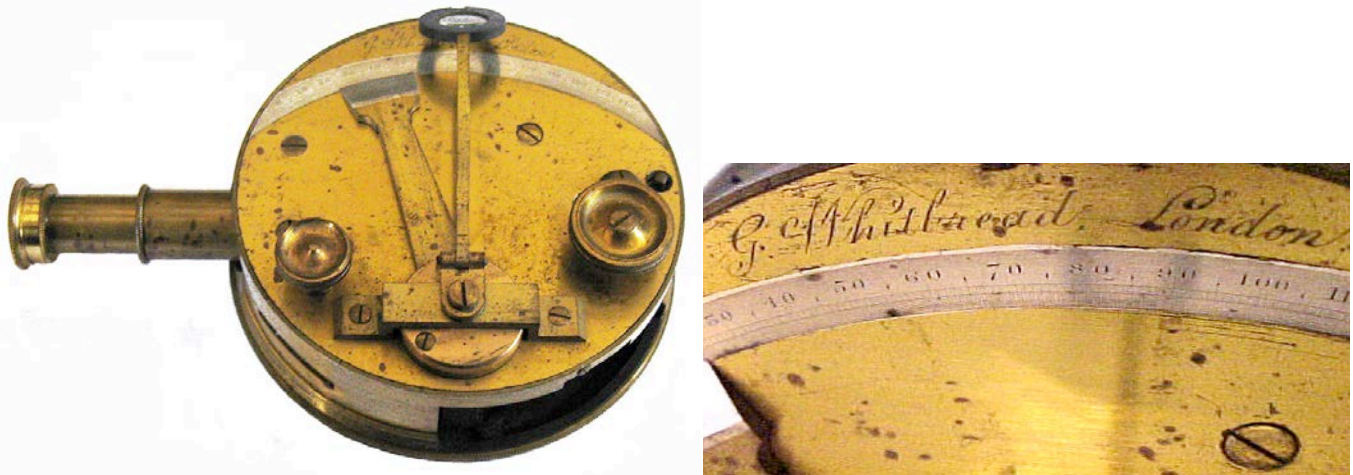


Omer Sextant, c1860



### Whitbread Box Sextant, c1840

A box, pocket, or lifeboat sextant works in the same way as a traditional sextant but is small and compact so that it could be carried easily while traveling, on horseback, or in a lifeboat. William Jones, a leading instrument maker in London, introduced the form in 1797. The German explorer, Alexander von Humboldt, had an early example that he described as being "very useful for travelers when forced in a boat to lay down the sinuosities of a river, or take angles on horseback without dismounting." By the mid-nineteenth century, box sextants were said to be particularly useful for military reconnaissance. They were still available in the early twentieth century.



This is a fine all brass box sextant by G. Whitbread, London. It is three inches in diameter with silver 120 degree scale and vernier adjusted by a knurled knob, hinged arm with magnifying glass, the maker's name and city engraved above the scale, a removable knob for adjustment of the horizon mirror, extendable telescope with sun filter and peep option, slot cover to two sun filters, and a screw fit cover. The brass finish is very good with a few small spots. The mirrors and optics are excellent. George Whitbread was in London from 1828-1877 and the construction of this instrument is quite early.

### Azimuth Circle, first half twentieth century

This is an azimuth circle used to measure the bearings of bodies on the earth's surface and the azimuth of a celestial body. The azimuth circle was made by Jones & Woodland Co., Newark, N. J. The ring and original wooden box are numbered 2049. It is complete and in fine condition noting a crack in the box lid. This type of azimuth circle was used by the US Navy in World War II.

The azimuth is the angle between the north vector and the perpendicular projection of the star down onto the horizon. Azimuth is usually measured in degrees and the concept is used in navigation, astronomy, engineering, mapping, mining and artillery. The azimuth circle is a nonmagnetic metal ring 10 inches in diameter. The inner lip is marked in degrees from 0° to 360° counterclockwise. A compass card is placed inside the ring. The azimuth circle is fitted with two sighting vanes. The forward or far vane has a vertical wire and the after or near vane has a peep sight. A finger lug is used to position the instrument while aligning the vanes. A hinged reflector vane mounted at the base and beyond the forward vane is used for reflecting stars and planets when observing azimuths. Beneath the forward vane are mounted a reflecting mirror and the extended vertical wire. The bearing or azimuth is read from the reflected portion of the compass card. For taking azimuths of the sun, an additional reflecting mirror and housing are mounted on

the ring, each midway between the forward and after vanes. The sun's rays are reflected by the mirror to the housing, where a vertical slit admits a line of light. This admitted light passes through a 45° reflecting prism and is projected on the compass card from which the azimuth is directly read. In observing both bearings and azimuths, an attached spirit level is used to level the instrument.



**Azimuth Circle**

## **Surveying Instruments**

Surveying is another area in which optical instruments play a major role. The need for land surveying dates back to at least 3000 BC when the civilizations of Egypt and Babylon required the setting down of distances, the division of land into plots, and the construction of road systems. A wide variety of tools were devised over the centuries to perform measurements, with the theodolite, an instrument for measuring horizontal and vertical angles, and the level for



measuring the height of distant points eventually becoming the most important. In the early eighteenth century, a telescope was added to these instruments and, with the introduction of achromatic lenses for telescopes by John Dolland (1706-1761) in 1758, the practicality and accuracy of the instruments was greatly increased.

### Gurley Telescopic Alidade, 1919

This is a telescopic plane table alidade that can be placed on a solid and level surface to make field drawings, charts and maps in the horizontal plane. The instrument is labeled "W. & L. E. Gurley, Troy, N. Y., 19372." It is model 592C ("Explorers Alidade," so named because it is relatively small and light so it can be carried into the field. The firm of W. & L. E. Gurley was established in 1852 by the brothers William Gurley (1821-1887) and Lewis Ephraim Gurley (1826-1897). It soon became the largest manufacturer of engineering and surveying instruments in the United States and remained in the family until 1968. The serial number indicates this was the three hundred seventy second instrument manufactured in 1919.



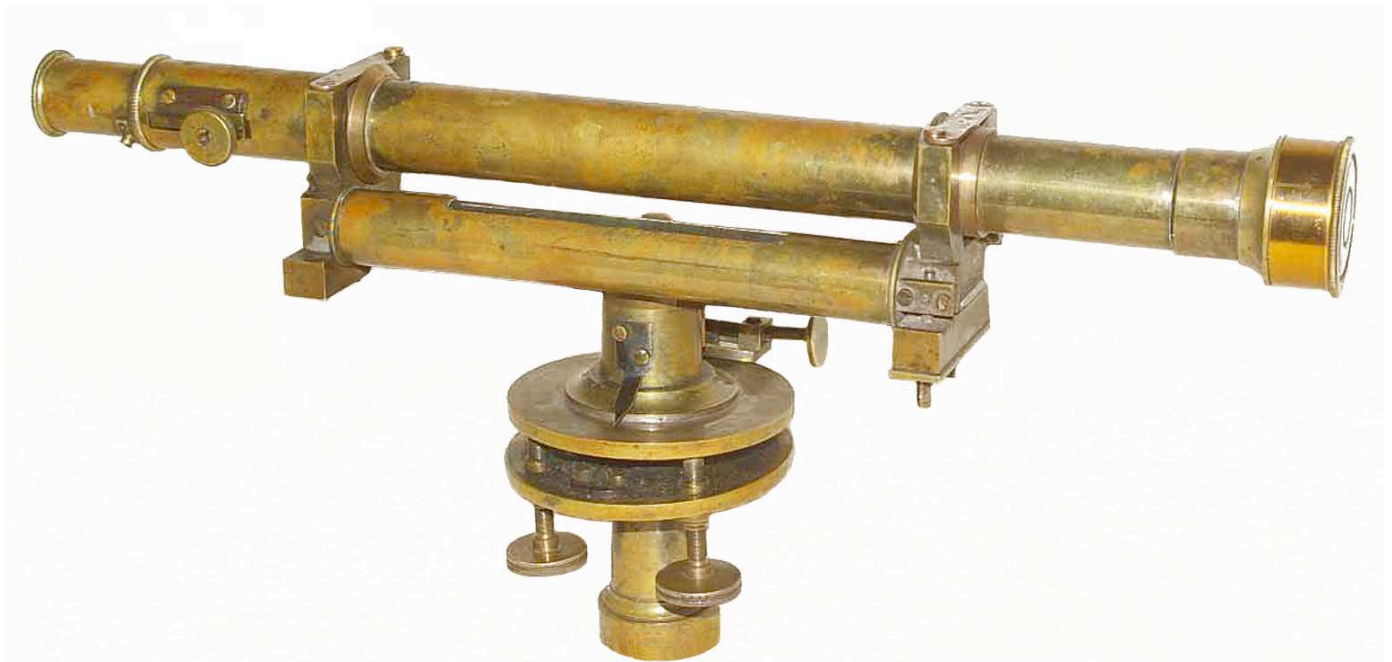
The alidade is made of brass with some parts blackened. It has a brass ruler 10 inches long and 2  $\frac{3}{4}$  inches wide, with the edge beveled and ruled. A circular spirit level and a trough compass having a four inch needle are mounted on the blade. The telescope which is mounted on the blade is eight inches long and equipped with an objective, platinum cross wires and stadia wires, and a detachable striding level with revolving shield. The telescope is furnished with an inverting eyepiece and is fitted with an erecting eyepiece and diagonal prism. The telescope can



be revolved on its longitudinal axis. The telescope is equipped with a Beaman stadia arc and a gradienter attachment. It is carried in a wooden leather covered box with brass reinforcements and a carrying strap. The leather of the case is separated from the wood at the edges and the finish of the alidade is worn in places. The instrument is complete and produces a clear image and is a fine representative of this important surveying instrument.

### Bianchi Level, c1840

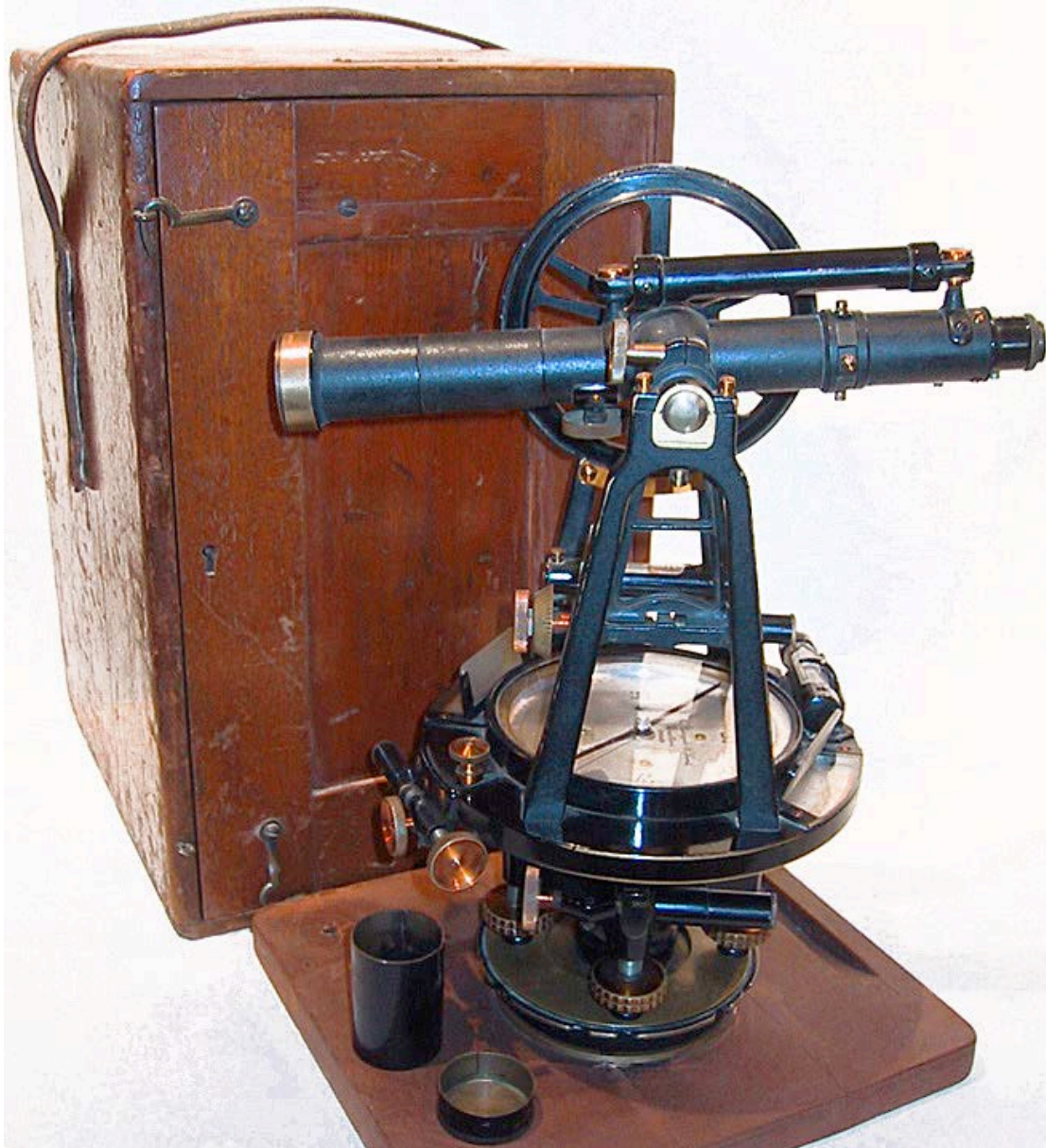
This is an example of a brass surveyor's level. It is engraved on the level in script "Bianchi Opticien Rue du Coq St Honoré 11 à Paris." The instrument is approximately 15 ½ inches long. It consists of a telescope fitted with a spirit level and leveling base. Eyepiece focus is by rack and pinion. There are alignment and locking screws. The bubble level is filled with a clear light green liquid. The level has seen use and little lacquer remains. However, it functions well and the optics are clear. It comes with a lens hood, lens cap and its own original fitted worn wooden case that measures 16 x 8 x 5 inches.



There are several instrument makers named Bianchi in the eighteenth and nineteenth centuries. The maker of this instrument was an optician whose shop was on the same street as that of Alphonse Giroux who produced Daguerre's original camera in 1839 (Bianchi at 11 and Giroux

at 7 Rue du Coq). Bianchi produced a similar sliding box camera at the same time, probably with his own lenses. There is an 1839 catalogue of mathematical, physical, chemical, mineralogical and other instruments made by Bianchi & Son, opticians, in Paris. His son, Barthélemy-Urbain Bianchi, was a maker of instruments until 1898.

### Berger & Sons Transit Theodolite, c1904



This is a very fine example of a transit theodolite which has a telescope that can describe a complete revolution (transit) on a horizontal axis. It is American, early 1st quarter twentieth century, signed in script on the compass face "C.L. Berger & Sons, Boston," serial numbered 3845, and listed in their 1904 catalog. Made of black painted brass, with lacquered brass fittings, and standing  $13 \frac{3}{4}$  inches high on its 4-screw leveling base. The telescope is  $11 \frac{3}{8}$  inches long, with erecting eyepiece,  $1 \frac{3}{16}$  inch diameter objective, internal rack and pinion focusing, and a  $4 \frac{1}{4}$  inch long bubble level mounted underneath. The vertical circle is 5 inches in diameter, graduated on silver and mounted on a  $6 \frac{1}{4}$  inch tall support attached to the top plate. The horizontal circle is  $6 \frac{1}{4}$  inches in diameter under the top plate, with silvered scale, a single vernier, and tangent screw



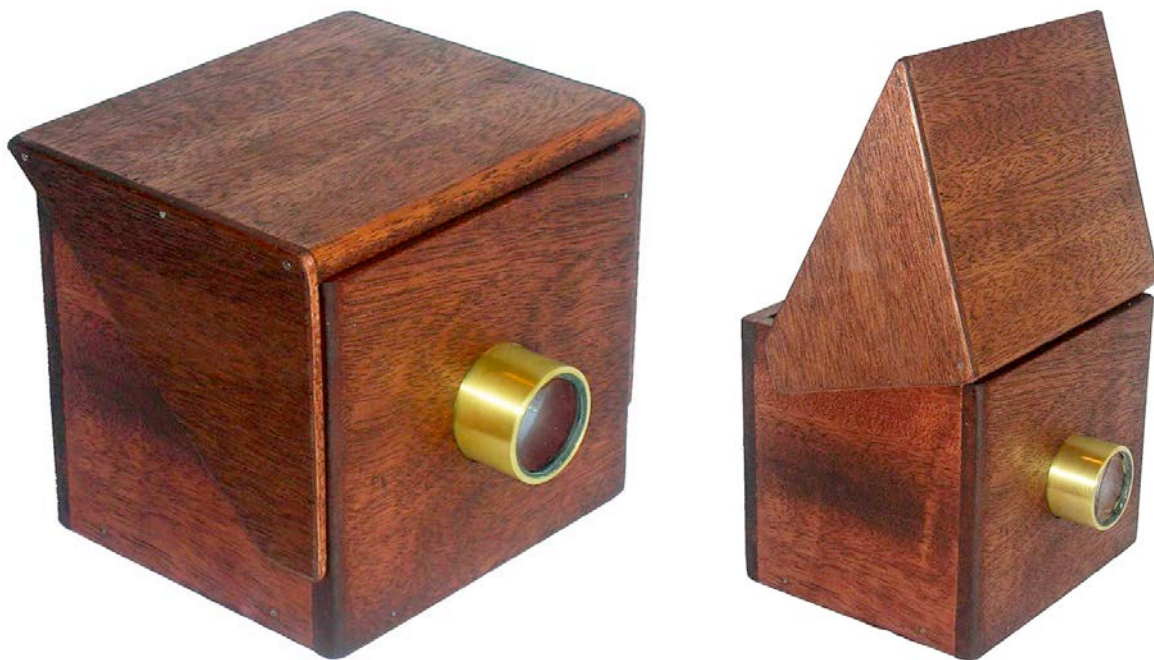
control; the compass housing is 5 inches in diameter, with a 4 ¼ inch needle. The transit is in very good overall condition. The original 10 x 11 ¾ x 15 ¾ inches fitted mahogany case is worn, but is still fully serviceable. Christian Louis Berger (1842-1922), born in Stuttgart, Germany, formed a partnership with George L. Buff in 1871 which became the firm of Buff & Berger. The firm manufactured "all kinds of surveying, astronomical, mathematical and philosophical instruments." It was dissolved on October 18, 1898 and Berger founded a new firm, C. L. Berger & Sons, taking into partnership his two sons, William A. and Louis H. Berger.

## Cameras

A camera is an optical instrument that records images. With a camera, light enters an enclosed box through a converging lens and an image is recorded on a light-sensitive medium. A shutter mechanism controls the length of time that light can enter the camera. The modern camera is derived from the camera obscura (Latin for "dark chamber").

### Camera Obscura Replica

The term "camera obscura" was first used by the German astronomer Johannes Kepler in 1604, although its origins date back to Roman times. The camera obscura in its simplest form consisted of a darkened room with a small hole in a window shutter through which light passed to fall on the opposite wall giving a diminished and reversed image of the scene outside. In the thirteenth century, Roger Bacon described the use of a camera obscura for the safe observation of solar eclipses. Later a lens was placed in the hole to make the picture brighter and clearer. If a convex lens and a concave mirror were used, the picture could be seen enlarged and erect. The dark room of the camera obscura was reduced to a large box and then a small box with a lens. These were used extensively by professional and amateur artists. The scioptic ball, magic lantern, solar projection microscope, and camera are all derived from the camera obscura.



This is a replica of a late eighteenth century box camera obscura. It is made of mahogany. A brass lens tube moves in and out to focus on objects from about one foot away to infinity. It has a front-surface mirror, ground glass screen, a clear acrylic glass screen, and a tripod mount. It is



about 7 inches wide x 6 ½ inches high x 6 inches long. High quality camera obscuras and camera lucidas are manufactured by master craftsman and expert Les Cookson.

### Scioptic Ball, c1730

The scioptic (sciopttric) ball or “sky optick”, a type of camera obscura, is a universal joint that allows an optical instrument attached to the ball to be swiveled into any position. Daniel Schwenter (1585-1636), professor of mathematics and oriental languages at the University of Altdorf, developed the scioptic ball in 1636. Its invention was inspired by his studies of the human eye. The scioptic ball, mounted on the south wall of a darkened room, provided an anchor for a microscope or telescope while allowing the telescope to be swiveled in all directions in order to follow the course of an eclipse or for drawing panoramic views. Scioptic balls have been used as camera obscuras, projecting images from the outside on walls in darkened rooms or used simply as a light source.



This is a rare and fine scioptic ball of the early Georgian period. Usually these are part of a microscope compendium and set in a window frame, but this example shows no signs of being in a cradle or mount of any sort. Being hand-held, it could have been used to condense light from an external source but has little magnifying capability, i.e., the one end glass is plane, the other slightly concave. It may have been used as a camera obscura for projecting and drawing outside scenes. It is constructed from a solid block of Honduran flame mahogany with beautiful graining. The screw-on end caps are free of damage. There is a fine shrinkage crack (no more than a hair in thickness) that runs the full length of the body, but it is very stable. 70 x 70mm. (55mm at ends).

The camera obscura was the forerunner of the photographic camera. Before the invention of photographic processes there was no way to preserve the images produced by the camera obscura apart from manually tracing them. The first photograph was taken around 1817 by Nicéphore Niépce (1765-1833) using camera obscuras of his own making; the photographs though were not permanent, and faded away. Later, in 1827, he made permanent images, called heliographs or sun prints, using a sliding wooden box camera obscura made by Charles and Vincent Chevalier in Paris, France. The images were made by coating a pewter plate with bitumen and exposing the plate to light. The bitumen hardened where light struck. The unhardened areas were then dissolved away.

### Sliding Box Camera Obscura Replica

The sliding box camera obscura consists of two boxes. The outer box contains the lens and the inner box fits into the outer box. The inner box contains the mirror and ground glass. In the simpler camera obscura, focusing is achieved by moving the lens piece in or out. In the sliding box camera, the inner rear box is moved in or out. This is another replica by Les Cookson.

Starting in 1829, Niépce began collaborating on improved photographic processes with Louis Daguerre (1787-1851). The partnership lasted until Niépce's death in 1833. Daguerre continued

with experimentation, eventually developing the first practical photographic process that he named the "Daguerréotype." In 1836, Daguerre coated a copper plate with silver, then treated it with iodine vapor to make it sensitive to light. The image was developed by mercury vapor and fixed with a strong solution of sodium chloride.

### Giroux Camera 1839 Replica

The Daguerreotype camera is essentially a sliding box camera obscura in which a light-sensitive plate is substituted for the ground glass screen. In 1839, Daguerre signed a contract with his brother-in-law Alphonse Giroux and the Susse Brothers. In the contracts, the two companies were given the exclusive rights to produce and sell the Daguerreotype camera and the other necessary equipment. Charles Chevalier who had hoped to receive the contract for the camera was given the commission of producing the lenses for the cameras made by both companies. The first production camera was made by Giroux in 1839. The selling price of 400 Francs was very high, representing approximately the annual income of a normal working man. There are only a few of these cameras known to be in existence and all are stored in public museums except for one recent find that was auctioned for \$899,000 in 2010.



Sliding Box Camera Obscura



Giroux Daguerreotype Camera

The sliding camera obscura consists of two boxes which slide into each other. The larger of the two, which has the lens attached to it, is fixed to the base plate. The smaller box the back of which is the ground glass plate slides into the outer box. The interior of the boxes is black. In order to bring the image into focus, the rear box is moved back or forwards along the wooden camera base. A fold-out mirror behind the ground-glass screen allows the image to be seen upright.

This is a 1/3 scale replica of a Giroux daguerreotype camera. It was made by Jerry Smith of Missouri in the 1970's for museum display and fewer than 20 were made. It is a functional camera except it does not have plate holders. It is wood-cased with a brass barrel lens. It has a golden oval label on the side bearing the maker's mark and Daguerre's signature. The size is a 4 ¼ x 4 x 5 inch box on a 5 x 7 inch base.

### Sliding Box Daguerreotype Camera

This is a box in box daguerreotype camera of early design. It is essentially a sliding box camera obscura with a holder for a photographic plate. It is 25  $\frac{3}{4}$  inches long, 10 inches high, and 8 inches wide. There is an inner box that can be moved in and out by a hand crank on the side. There is a trap door in the middle of the top. A spring-loaded frame to hold a plate is located on the back of the inner box. There is a mirror at the rear. The brass lens is unsigned and has two washer stops. The lens produces an image at the level of the plate holder. The image is viewed upright in the mirror.



Nothing is known about the origin of this instrument. When purchased, it had numerous devices of unknown function attached to it including hinged flaps, a front extension, two levers, metal pieces, and two electric light bulbs in front. These obviously later additions were removed. The silvering on the mirror is crazed and the wood has an alligator finish. There are numerous small holes from the attachments. The wood is unknown.

### Watson & Sons Side-Wing Tailboard Camera, c1885

In subsequent years, cameras underwent improvements and additions including photographic plates, bellows replacing the sliding box, shutter mechanism, iris aperture, and lens construction. However, as illustrated by this c1885 camera, the camera retained its basic similarity to the camera obscura. This is a beautiful Watson side-wing tailboard camera for 4  $\frac{3}{4}$  x 6  $\frac{1}{2}$  inch plates. It is characterized by large front and rear standards fitting onto a baseboard and joined by parallel bellows. The camera is made rigid by folding side wings attached to the front standard and baseboard. It is of mahogany construction with brass fittings. The serial number 10722 is stamped on the base. The brass lens piece is marked "W. Watson & Sons 313 High Holborn London."





**Watson & Sons Side-Wing Tailboard Camera**

### **Eastman Kodak No. 1 and No. 3 Brownie Box Cameras**

The Eastman Kodak Company, commonly known as Kodak, was founded by George Eastman (1854-1932) in 1888. During most of the 20th century Kodak held a dominant position in photographic film, and in 1976, had a 90% market share of photographic film sales in the United States. Among the innovations introduced by Eastman Kodak were roll film cameras of the box form and of fixed focus. The simple cameras did not require burdensome apparatus and processes, were inexpensive, and made photography available to the amateur. In 1900, Kodak introduced a low-priced, point-and-shoot, hand-held camera, called the Brownie. The Brownie was named for the impish little characters illustrated by Palmer Cox, a popular children's author and artist. It was a very basic cardboard box camera with a simple meniscus lens that took pictures on roll film. The Brownie camera, simple enough for even children to use, was designed, priced, and marketed to have wide appeal. It made photography accessible to the masses and millions of these cameras were sold into the 1980s.

This is a Brownie No. 1 model B, box rollfilm camera. It was introduced in 1904 and produced through 1916. The No. 1 Brownie is a leatherette covered card box with a wooden film carrier. The camera is 5 x 3 x 3 ¼ inches in size. It has a meniscus lens. It uses film type 117 roll film and produces a 2 ¼ x 2 ¼ image size. The original price was \$1.00. The camera is fully functional and the body coverings and finishes are in excellent condition.



**Brownie No. 1B Camera**

This is a Brownie No. 3 box rollfilm camera that was introduced in 1908 and discontinued in 1934. This model produced a larger image than the earlier models. The leatherette card case with handle is 6 x 4  $\frac{3}{8}$  x 5 inches in size. It has a meniscus achromat lens and rotary shutter. The camera has two finders (one for vertical and the other for horizontal exposures), three aperture stops, and a slide for timed exposures. It uses film type 124 size roll film and produces a 3  $\frac{1}{4}$  x 4  $\frac{1}{4}$  image size. The camera has an exposed roll of film in it. The original price was \$4.00. The camera comes with a 1909 instruction manual ("Picture Taking with the Brownie Camera No. 3") and original carrying case. The camera is fully functional and the body coverings and finishes are in excellent condition. The case is missing the shoulder strap.



**Brownie No. 3 Camera**



**Gundlach-Manhattan Optical Company Korona Petit Camera, c1905**

Ernst Gundlach (1834-1908) was one of the more inventive, skilled, and restless opticians of the nineteenth century. His history is described in the section on Other American Microscopes. The Gundlach Optical Company was founded by Gundlach in 1885 in Rochester, New York. The company acquired the Milburn Korona Company in 1896 and the Manhattan Optical Company in 1902. The company manufactured microscopes and cameras under their new name, Gundlach-Manhattan Optical Co.

This is a Korona Petit Model folding-bed plate camera manufactured by the Gundlach-Manhattan Optical Company around 1905. It was described as an excellent compact and complete camera for making negatives for prints, lantern slides, and enlargements. It is constructed of a cherry wood body, maroon bellows, and a leather covered case. Metal parts are nickel-plated. There is a spring-actuated ground glass focusing screen to accept Korona petit plate holders, a reversible finder, and two tripod sockets. The brass shutter mechanism is by the Wollensak Optical Company with T, B, and I settings. Aperture settings are marked F8 to 128. With the camera is a new pneumatic shutter release bulb and tubing. The outside dimensions of the folded camera are 2 ¼ x 4 ¼ x 5 inches. The camera is in very good condition noting only some slight scuffing to the edges of the case.

**Korona Petit Camera**



## Other Instruments

### Charles Bush Kaleidoscope, 1873

A kaleidoscope is a cylindrical optical instrument that when rotated the viewer sees a succession of radial designs. The designs are produced by a set of mirrors reflecting constantly

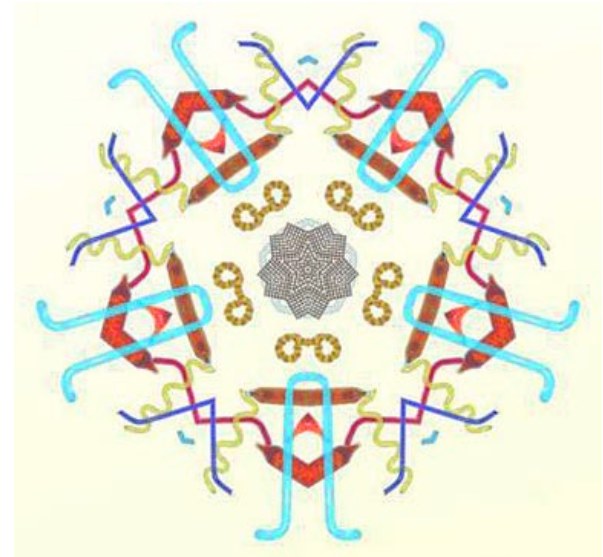


changing patterns made by small translucent objects, often bits of colored glass, in a chamber at one end of the cylinder. The kaleidoscope was invented by Sir David Brewster (1781-1868) in 1816. Brewster was studying polarization optics and the properties of light. While looking at some objects at the end of two mirrors, he noticed patterns and colors were recreated and reformed into beautiful new arrangements. He named this new invention after the Greek words kalos - beautiful, beauty; eidos - shape, form; and skopos - to examine, to look at; thus "observer of beautiful forms." His initial design was a tube with pairs of mirrors at one end, pairs of translucent disks at the other, and beads between the two. Brewster chose Philip Carpenter, maker of optical instruments and achromatic lenses, as the manufacturer of the kaleidoscope in 1817. It proved to be a massive success with thousands of kaleidoscopes sold in London and Paris in just three months. Fascination with multiple images occurred long before the kaleidoscope. In the seventeenth century, opticians produced "multiplying glasses" (see 1700

optical compendium). These consisted of a lens one side of which is plane and the other convex. The convex surface has a number of plane surfaces inclined to one another each of which presents a separate image of the object viewed through it, so that the object is "multiplied." These early instruments are often called kaleidoscopes as well.

In America, the most prominent maker of kaleidoscopes was Charles G. Bush (1825-1900). Untrained in any of the physical sciences, he arrived in Plymouth, Massachusetts, in 1847 from Culberg, Prussia. He had worked in his father's hemp manufacturing business and proceeded to establish a successful rope business in Plymouth. In later years, after moving to Boston, he pursued interests in microscopes, telescopes, astronomy, and photography. In the early 1870s he began developing kaleidoscopes. Bush manufactured his parlor kaleidoscopes by the thousands and they were recognized as extraordinary even then. These instruments had a barrel of black hardboard with a spoked brass wheel rotating an object cell, mounted on a turned wooden stand. Most noteworthy about the Bush kaleidoscopes were the glass pieces contained in the object case. Bush had a basic mix of about 35 pieces, a third of which were liquid filled. Inside the liquids were air bubbles that continued to move even after the object case was at rest. Both the solid and liquid-filled glass pieces were of brilliant and well-chosen colors, and the patterns they formed were the finest of any nineteenth century kaleidoscope. One unusual piece that comes into view in

a very few of the original Bush scopes is a clear glass disk embossed with a swan. But it is the liquid-filled ampules that are by far the most distinctive feature of the Bush kaleidoscope.



This is a kaleidoscope by Charles Bush. The instrument is supported by a turned wooden pedestal mounted on a tripod base. The tripod is the rarest of the Bush bases. It has a barrel 10 inches long and is 14 inches tall. The main cylinder is made of cardboard covered with black pebbled stamped paper. There is a cardboard eyepiece at one end. It secures an aperture stop and a square cover glass over the end of the inner tube with the mirrors. There are two mirrors of thick greenish glass (about  $\frac{5}{16}$  inch thick) with rear surface silvering. The third side of the triangle formed by the mirrors is made of wood. The mirrors are held together by twine. The cell or chamber box at the far end of the tube is made of brass and can be turned by means of six brass spokes. The chamber houses multi-colored glass twists and rods, cuts of German sheet glass in various forms, and colored liquid-filled ampules. The image formed is a pattern of five points and the measured angle between the mirrors is 36 degrees. The kaleidoscope is marked "C. G. Bush, Claremont, N.H., Pat. Nov. 11, 1873." The instrument is missing one spoke (can be replaced) but is otherwise in fine condition and produces beautiful images.

### Henri J. Noè Stereoscope, c1890

Stereoscopes, also known as stereopticons or stereo viewers, were one of the most popular forms of entertainment in the late 1800s and early 1900s. The first patented stereoscope was invented by Sir Charles Wheatstone in 1838. It was improved in 1849 by Sir David Brewster (1781-1868), the inventor of the kaleidoscope. In 1861, Oliver Wendell Holmes produced a streamlined, much more economical viewer. Called the Holmes Stereo Viewer, it was the most common type of stereoscope from 1881 until 1939. A stereoscope is composed of two photographs mounted next to each other, and a set of lenses through which to view the pictures. Each picture is taken from a slightly different viewpoint that corresponds closely to the spacing of the eyes. The left picture represents what the left eye would see, and likewise for the right picture. When observing the pictures through a stereoscope, the pair of two-dimensional pictures merge together into a single three-dimensional image.

This is a French folding stereoscope, c1890. It folds compactly by means of brass hinges into a box form, then ingeniously unfolds to form a fully functional Brewster style stereo viewer. It was made by Henri J. Noè of Paris who first obtained a patent in 1857. It was produced in great



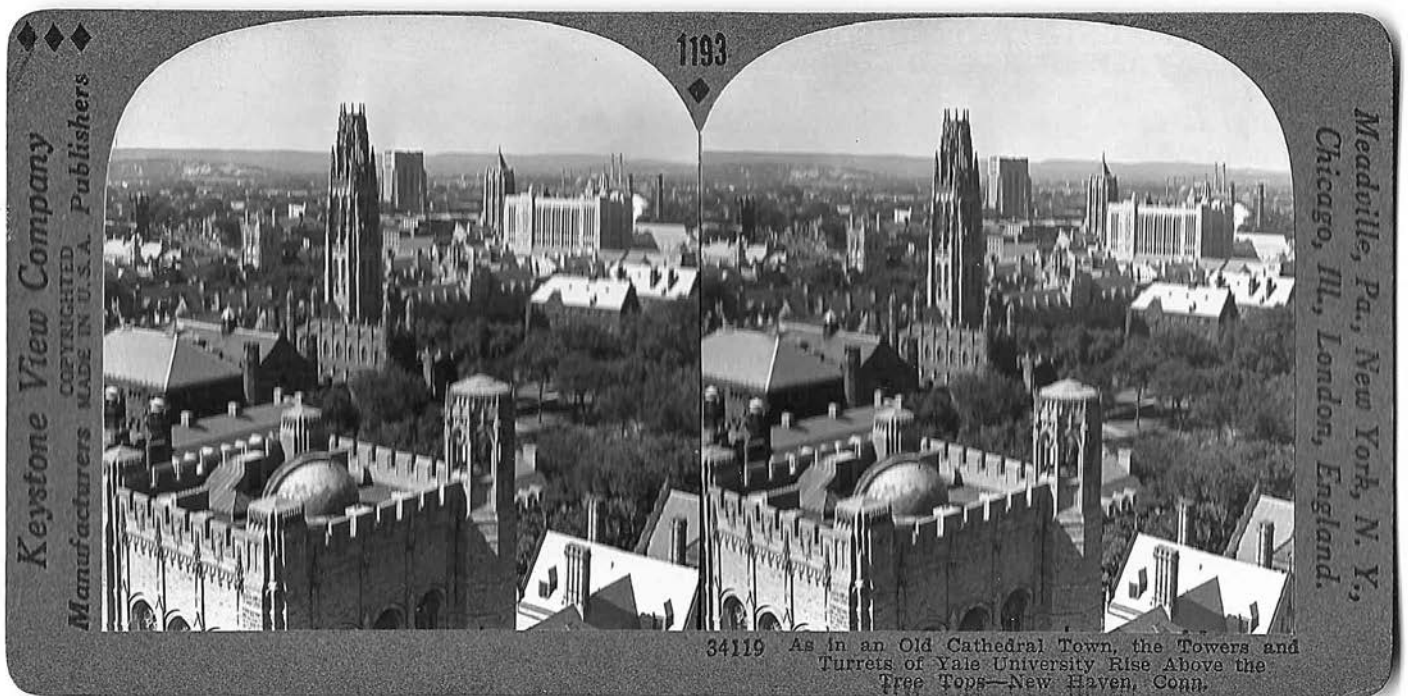
## Optical Instruments

numbers from 1860 to 1900. The folded mahogany case measures  $7 \frac{3}{8} \times 4 \frac{1}{8} \times 1 \frac{1}{2}$  inches. The viewer unfolds to two wood side panels, a wood flap on top, a wood frame holding the prisms, and a black cloth down the middle separating the images on the stereocard. The unfolded viewer is  $6 \frac{1}{2}$  inches long. The top flap bears Noè's monogram "NH" in script and "BREVETE S.G.D.G." It is in excellent condition noting a crack in the top.



Stereoscope

Shown here is a  $3 \frac{1}{2} \times 7$  inch stereocard that would be viewed with a stereoscope. It is titled "As in an Old Cathedral Town, the Towers and Turrets of Yale University Rise Above the Tree Tops—New Haven, Conn." A brief history of New Haven and Yale College is printed on the back. The card was produced by the Keystone View Company which operated from 1892 through 1963. It was the world's largest stereographic company and by 1935 Keystone had approximately two million stereoscopic negatives. c1930.



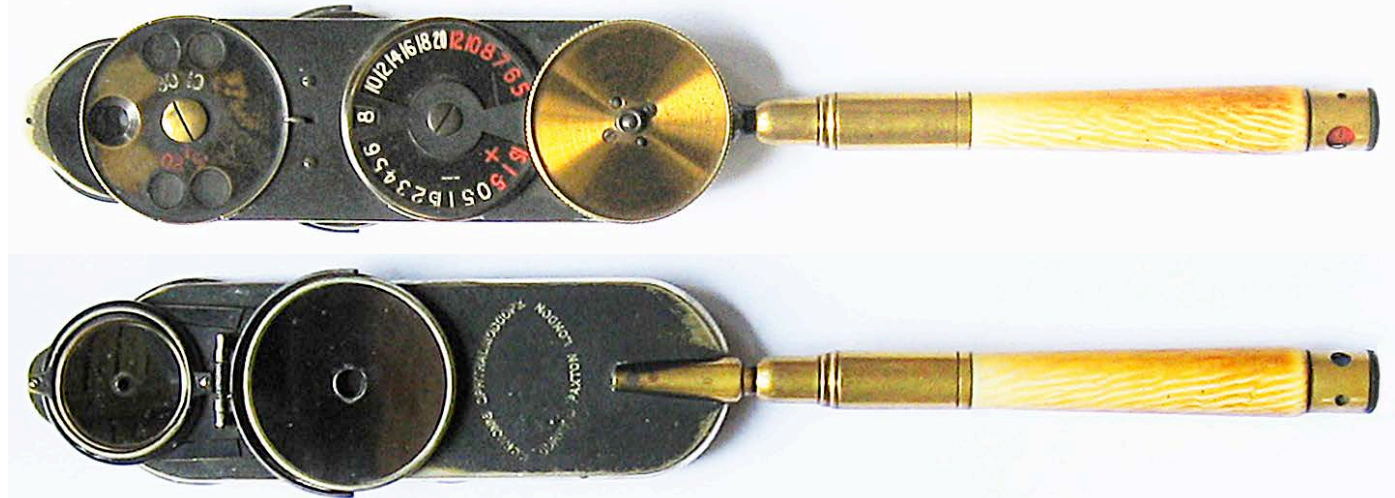
Stereocard



## Ophthalmoscopes

### Morton's Ophthalmoscope, c1890

Another type of magnifying device is the ophthalmoscope used for observing the retina in the eye. The ophthalmoscope was originally invented by Charles Babbage in 1847, but it was not until it was independently reinvented several years later by Hermann von Helmholtz (1821-1894) in 1851 that its usefulness was recognized.

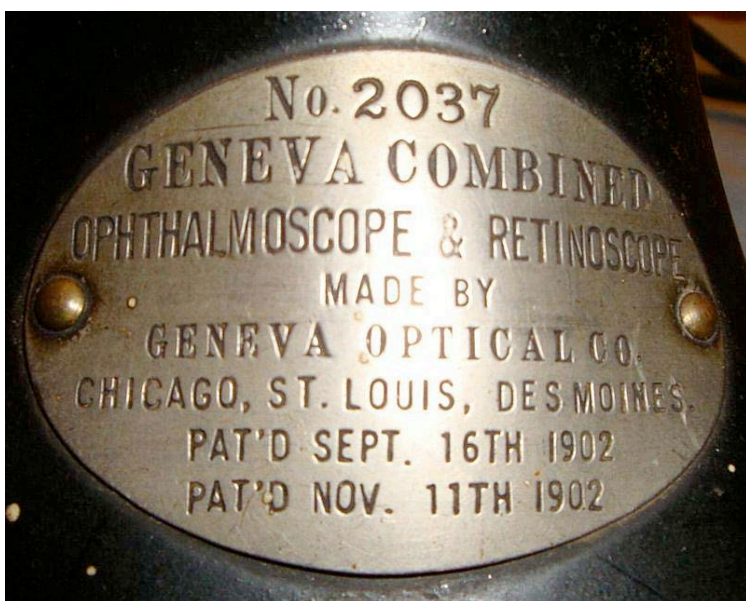


This is Morton's non-luminous ophthalmoscope made by the optical instrument makers Curry & Paxton in London. Andrew Stanford Morton (1848-1927) described his very successful and popular ophthalmoscope to the Ophthalmological Society of the United Kingdom in 1885. The instrument consists of a chain of 29 lenses that move by rotating the lower disk. There are twelve convex lenses and seventeen concave ones. The lenses allow for the estimation of refraction before the days of retinoscopy. The middle disk indicates the strength of the lens in the sight-hole. The upper disk has an empty opening and lenses of plus 0.5 and 20 as well as minus 10 and 30 diopters. On the reverse side are two circular mirrors fixed to a plate that can be rotated around a central pivot. The large mirror is slightly concave on one side and plano on the other and is on a spring hinge and can be flipped. There is also a small angled concave mirror with a short focus distance that can be rotated. The ophthalmoscope, which screws into an ivory and brass handle, is stamped "MORTON'S OPHTHALMOSCOPE CURRY & PAXTON LONDON." The base of the handle rotates four different size openings to test color vision. There is a separate hand held auxiliary condensing lens. The instrument is held in an embossed leather case lined with blue velvet. The lining is signed in gold "Curry Paxton." The instrument is  $7 \frac{7}{8}$  inches long. The case is  $4 \frac{3}{4} \times 2 \frac{3}{8} \times 1 \frac{1}{4}$  inches. The ophthalmoscope is in fine condition with all parts functioning noting wear to the velvet lining.

### Geneva Optical Company Ophthalmoscope-Retinoscope, 1902

This is a combined ophthalmoscope and retino-scope made by the Geneva Optical Company. An ophthalmoscope is used to view the retina of the eye directly. A retinoscope is used to illuminate the internal eye and to measure the rays of light as they are reflected by the retina. Errors of refraction, such as in short- and long-sightedness, as well as astigmatism can be determined. This instrument is 23 inches long and 18 inches high. It consists of a heavy iron base painted with black enamel and stenciled. The base supports two pillars, one for a headrest and the other a frame holding the ophthalmoscope at one end, the illuminator in the middle, and optical

tube at the other end. The frame can be focused by rack and pinion. The instrument was patented in 1902 making it one of the earliest to use an incandescent light. The light bulb is a GE Mazda that was introduced in 1909. The Geneva Optical Company was founded in 1869 by Andrew L. Smith as the A. L. Smith Optical Company of Geneva, New York. The company primarily made spectacles and instruments for opticians and ophthalmologists. The instrument is in excellent condition and fully functional.



Ophthalmoscope-Retinoscope



### Spencer Spectroscope, c1940

Spectroscopy which allows for the identification of elements and substances was introduced as an analytical method in the 1860s. The spectroscope uses a slit and a collimator to collect a parallel beam of light emitted by a substance or from a broad spectrum light passed through an absorption medium. The beam is dispersed by a prism or a grating. The resulting spectrum, emission or absorption, is then observed through a telescope or projected on a screen or photographic paper.



**Spencer Spectroscope**

This is a Spencer Student Spectroscope or Spectrometer. It consists of a heavy iron base with three legs. The instrument is 8 ½ inches high, the telescope and collimator each 7 ½ inches long, and the telescope table 6 inches in diameter. It can use either a prism or grating to produce the spectrum. In this spectrometer, the prism table, the collimator, and the telescope positions may be determined relative to a high resolution graduated circle with verniers. There are leveling screws for the collimator, prism table, and telescope. The telescope is supplied with a Gauss eyepiece which contains an opening on the side of the tube giving access to a semi-transparent diagonal mirror. The light is inserted into the opening to illuminate the cross hairs in the telescope which must be brought into focus. The instrument can be used for the determination and analysis of spectra, in the measurement of angles between prism faces, and the determination of angles of refraction and reflection. The spectroscope bears the serial number 1187 and has its original wooden case. The instrument is in exceptional condition with no defects. The spectroscope is marked "Spencer Buffalo USA." A manual for its use was issued in 1938. The Spencer Lens Company was acquired by the American Optical Company in 1935 and operated under its own name until 1945. c1940.

### Spencer Abbe Refractometer, c1940

Refractometry has been a major tool in the chemical laboratory to determine concentrations of solutions and as an aid in identifying unknown substances since the late nineteenth century.



The most common and universal refractometer for laboratory use is the Abbe refractometer and its variations. The Abbe refractometer provides a quick and easy means for determining refractive index and dispersion for liquids and solids. It is used in the examination of organic compounds (oils, solvents, etc.), solutions, food products, and serum protein concentration. The refractive index is measured by aligning the cross hairs in the telescope with the line of total reflection (seen as the edge between light and dark fields in the telescope). This line is moved by rotating the prism assembly with the alidade. Reading at constant temperature is important, thus the prisms are enclosed in a water jacket which are connected to a constant temperature bath.

This is an Abbe Refractometer by Spencer Buffalo. The instrument stands 11  $\frac{3}{4}$  inches high. The triangular base and pillar are of cast iron with black crinkle finish. The scale and telescope arm, bearing the Spencer logo and serial no. 637, are attached to a vertical bar attached to the pillar. The vertical bar, telescope, and alidade arm are of black enameled brass. All of the control knobs and the alidade handle are in heavy chrome plating. The prism alidade has a tangent screw fine adjustment. The scale is finely engraved on an inlaid German silver strip with scale divisions of 1.300 to 1.710. The readout is viewed with an adjustable magnifier. The Amici color compensating prism scale on the telescope is finished in brushed chrome with black filled engraved divisions (0-60-0) and adjusted with a knurled wheel. The water-jacketed prism holder is finished in brushed chrome with polished chrome tubulatures for connecting to a circulating bath for temperature control. There is a chromed brass thermometer shield and mercury-filled thermometer. The instrument has its original hardwood case which contains the dispersion table. The instrument is in excellent condition except that the screw for the wheel adjusting the color compensating prism is broken.



### **Bausch & Lomb Dust Counter, c1938**

When it became apparent that breathing air that contained particles such as silica, coal dust, and asbestos was hazardous, dust counters became important tools to monitor air quality in the workplace. This is a Bausch & Lomb dust counter, No. 257084, used for counting the number of dust particles in a sample of air. The instrument consists of an upright microscope tube and moistening chamber tube, horizontal piston, base, and dust chamber. The dust chamber is fastened to the underside of the base by three wing nuts and holds the circular specimen slide. To use the instrument, moistened blotting paper is placed in the moistening chamber tube and an attached rubber atomizer bulb is squeezed to clear the chamber of old air and bring a new air sample into the tube. Then pulling the piston handle will impinge the dust in the air sample onto the specimen slide. Twelve samples can be taken on the same specimen slide. There are two windows on the top of the base, one marked "dust" to indicate the number of the sample, and the

other marked "micro" to show the sample to be viewed. A knob on the top of the base turns the sample slide. The microscope can be raised on two swing out legs and a lamp slid under the dust chamber. The number of dust particles with the squares of an eyepiece graticule are counted to determine the number of particles per cubic foot of air.

The dust counter has the original wooden carrying case, a wooden slide box to hold the instrument, and a drawer holding twelve specimen slides. There is the instruction manual and a booklet of data sheets with one filled out and dated 11-28-38. The instrument is in excellent condition and missing only the rubber bulb.



**Bausch & Lomb Dust Counter**

## Non-Optical Scientific Instruments

The instruments in this section do not have optical components. However, some required sighting by eye and were precursors of optical instruments when later models had telescopes attached to them.

### Astronomy

Bronze Razor with Possible Astronomical Markings, Urnfield Culture, Germany, c1200 BC

Roman Terracotta Oil Lamp with Signs of the Zodiac, c200 AD

Sanskrit Astrolabe, 19<sup>th</sup> century

Gunter's Quadrant, second half 17<sup>th</sup> century

Armillary Sphere

Bale & Woodward's Celestial Globe, c1850

### Time Telling

Gothic Nocturnal Compendium, 15<sup>th</sup> century

Portable Universal Equinoctial Sundial, c1600

Universal Equinoctial Ring Dial, last quarter 17<sup>th</sup> century

Diptych Dial, 1648

Hayes Magnetic Azimuth Sundial, 1664

English Silver Pair Case Verge and Fusee Pocket Watch, c1690

Verge Fusee Gold Pocket Watch, French, 1759-1760

Spherical Polar Sundial, French, second half 18<sup>th</sup> century

Universal Equinoctial Sundial, French, c1840

Gothic Style Verge and Foliot Mechanical Clock

Elgin Chronometer, c1918

### Weights and Measures

Roman Balance Scales

DeGrave, Short & Co Diamond Balance, c1860

### Calculation

Napier's Bones

English Ivory Sector, c1780

Gunter's Rule (Scale) Signed Merrifield & Co.

Apple Macintosh 512K Model M0001W Computer, 1985

### Surveying

Alidade, Italian, 1789

Miners Dial, English, 3rd quarter 19<sup>th</sup> century

Plumb Bob Level, c1800

### Geography

Newton's Terrestrial Globe, English, 1823

### Communication

Telegraph Key and Sounder, c1920

Blickensderfer No. 5 Typewriter, 1893

Western Electric Candlestick Telephone, 1918

Atwater Kent Model 40 Radio, 1928

### Philosophical Instruments

Nairne-Type Electrostatic Generator, c1790

Wheel Barometer

### Machines

Medieval Iron Bearded Axe Head, 1000-1300 AD

Singer Model 12 Sewing Machine, 1885

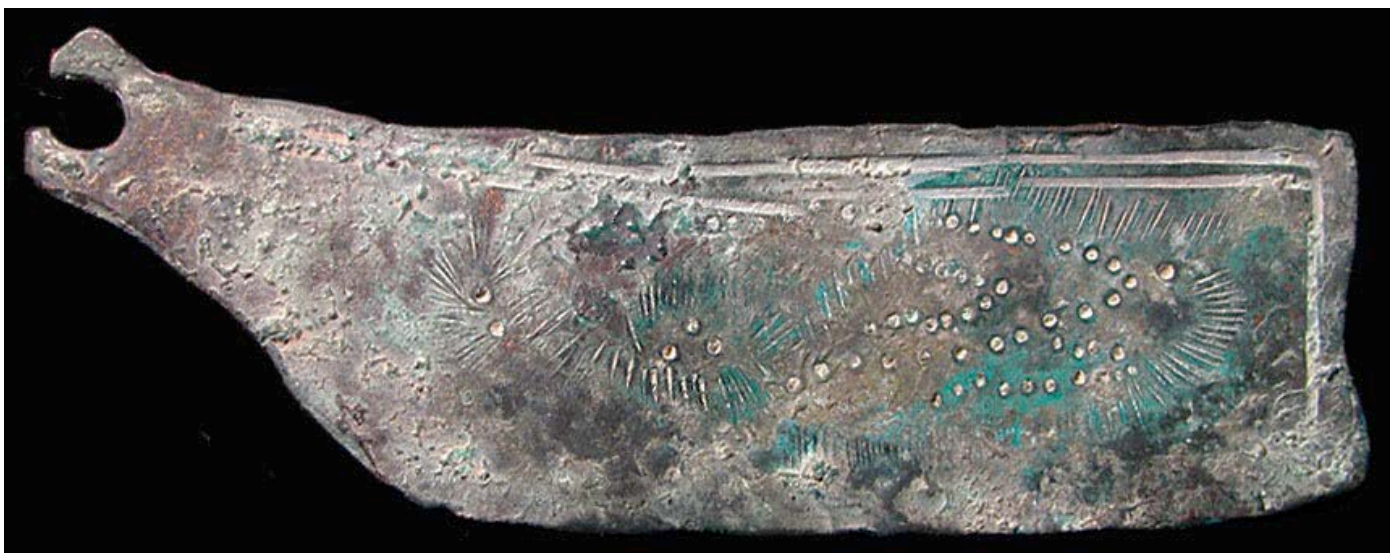


## Astronomy

Astronomy is probably the oldest science. The sky was very prominent and no doubt awe inspiring to early man who could see the sun, moon, planets, and stars and would have noticed their movements. Early cultures identified celestial objects with gods and spirits and related them to natural phenomena such as rain, drought, tides, and seasons. The first true “astronomers” were probably priests and shamans. They were generally regarded as having positive contact with the deities of the religion, often interpreting the meaning of events from their observation of the skies and performing the rituals of their religion. Thus, astronomy had a long association with what is now called astrology. Ancient structures with possible astronomical alignments such as Stonehenge probably fulfilled both astronomical and religious functions. The Babylonians were the first to apply mathematics to the prediction of periodic astronomical phenomena. Astronomy was developed to a highly sophisticated level by the ancient Greeks. Ptolemy of Alexandria (c90-c168 AD) presented a geocentric view of the universe with the earth at the center. The Arabs translated the Greek astronomy texts and greatly advanced knowledge in astronomy and other sciences during the Islamic Golden Age. The Ptolemaic system held until 1543 when Nicolaus Copernicus (1473-1543) published a heliocentric model of the universe that placed the sun, rather than the earth, at the center.

### **Bronze Razor with Possible Astronomical Markings, Urnfield Culture, Germany, c1200 BC**

This is a Bronze Age razor with markings. It is made of bronze and is 10.2 cm long and 3 cm wide. One end narrows and has a notch for fastening to a handle. The piece is uncleaned and has a blue-green patina. One side of the razor is marked with symbols while the back is plain. The markings include a pair of parallel, incised lines along the top edge and a single line at the far end. Below the pair of lines are a series of dots the whole surrounded by a band closely spaced lines. Most of the dots are arranged in three Vs with their apices pointing toward the end of the razor. Toward the near end, there are two dots outside the band of lines. Lines forming rays extend from these two dots. The meaning of these markings is unknown, however, some artifacts of prehistoric societies appear to depict movements of celestial objects such as the sun, moon and stars. Sommerfeld (1994) has interpreted them as numerals associated with a lunar calendar. Found: South/Central Germany. Ex Dr. Friedrich Moog collection.





**Bronze Razor with Markings, Urnfield Culture, Germany**

**Roman Terracotta Oil Lamp with Signs of the Zodiac, c200 AD**

The word *zodiac* is derived from the Greek word *zodiakos*, which means "a circle of animals" or "little animals." In both historical astronomy and astrology, the zodiac is a circle of twelve  $30^\circ$  divisions of celestial longitude, or houses of the zodiac, that are centered upon the ecliptic; the apparent path of the sun across the celestial sphere over the course of the year. The belt of the zodiac extends about  $8^\circ$  north and south of the ecliptic, as measured in celestial latitude, and includes the paths of the sun, moon, and visible planets. Imaginary creatures were traced in the star groups bounded by these rectangles; and because most of them were animal or part animal in form, these constellations were given names that became the signs of the zodiac (Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius, and Pisces). In use, the zodiac is a celestial (or ecliptic) coordinate system, which takes the ecliptic as the origin of latitude, and the position of the sun at vernal equinox as the origin of longitude. The stars forming the signs of the zodiac can be used as a set of observational reference points for the positions of the sun, moon, and planets.

The zodiac was in use by the Roman era, based on concepts inherited by Hellenistic astronomy from Babylonian astronomy of the Chaldean period (mid-1st millennium BC), which, in turn, was derived from an earlier system of lists of stars along the ecliptic. The construction of the zodiac is described in Ptolemy's 2nd century AD work, the *Almagest*. Under the Greeks and Ptolemy, in particular, the planets, houses, and signs of the zodiac were rationalized and their function set down in a way that has changed little to the present day.



This is a Roman terracotta lamp dating to c200 AD and containing an early representation of the zodiac. On the top, the signs of the zodiac surround a central fertility goddess. A maker's mark, "M L C," is on the base. The lamp is 10.3 cm long and 7.3 cm wide. It is in excellent condition with blackening around the spout. Ex Glenn Woods collection, Dallas, Texas.



**Roman Terracotta Oil Lamp with Signs of the Zodiac**

**Sanskrit Astrolabe, Northern India, Nineteenth Century**

One of the earliest astronomical instruments is the astrolabe. An astrolabe shows the relative positions of the sun and stars on a flat surface. Throughout history, astrolabes have been used by astronomers and navigators to locate and anticipate the position of the celestial bodies such as the sun, moon, planets and stars. It has many uses including determining the time of day or night, location of celestial objects, time of sunrise and sunset, surveying, triangulation, and to cast horoscopes. The astrolabe was invented in ancient Greece around 200-100 BC. Ptolemy is believed to have made many of his observations using an astrolabe. Astrolabes were greatly refined and improved by the Medieval Islamic world.

Astrolabes vary depending on the era and maker, but the basic structure is described here. The mater (Latin for mother) is the main body of the astrolabe. The edge of the mater is called the limb on which the degree scale and scale of hours are engraved. The hollowed-out part of the mater is called the womb and contains the rete (Latin for net). Under the rete are brass plates or



tympan or climates that are engraved with altitude and azimuth circles for different latitudes. The plates show the three-dimensional celestial sphere in two dimensions. The whole rotating assembly is fastened together by a pin through the center of the mater, rete, and plates and is secured by a wedge-shaped piece of metal called the horse, after its resemblance to a horse's head. The rete carries the star pointers and ecliptic ring and can be rotated over the latitude plates underneath. The star pointers mark the location of particular stars, which are often labeled on the rete. As the rete is turned, the star pointers mark out the position of these stars against the background of the celestial sphere on the plate. The ecliptic ring, the annual path of the sun through the sky, is scaled in ecliptic longitude and is divided into 30-degree intervals marking the 12 months of the zodiacal calendar. The rule or label seen on some astrolabes is a bar which rotates across the front of the astrolabe and is used to locate positions on the plate or rete, and to relate them to the scale of hours marked on the limb. On the back of the mater there is often engraved a number of scales that are used in the astrolabe's various applications. These vary from designer to designer, but might include curves for time conversions, a calendar for converting the day of the month to the sun's position on the ecliptic, trigonometric scales, and a graduation of 360 degrees around the back edge. The back may include a shadow square to determine distances and heights and zodiac symbols. The alidade is a rotating bar with sight vanes usually found on the back of an astrolabe but sometimes on the front. Altitude is measured by lining up an object, such as a star, in the two sighting holes, and then reading off the altitude in degrees on a scale around the edge. A throne at the top of the astrolabe makes it possible to hold the astrolabe vertically when pointing a star or the sun with the alidade. The throne is usually decorated and is equipped with a ring and a cord for suspension.

This fully functional authentic astrolabe falls within a group known from the city of Kuchaman, near Jaipur in Rajasthan, Northern India. Handmade of thin rigid sheet brass, this large astrolabe is 11 5/8 inches (29.5 cm) in diameter, with integral recurved throne. All notations and numerals are in the Sanskrit language in the highly cursive Devanagari script. The mater and plate are integral, hand-engraved with circumferential degree scale, in 60 numbered segments of 6° each, and bears a projection of the local celestial coordinate system for the single latitude of 27°. The rotatable rete has 22 named star pointers, a nearly complete equatorial circle, a counterchanged east-west bar, and an ecliptic circle divided into twelve named Zodiacal houses, each subdivided into five numbered segments, each of these further subdivided by sixths. The equatorial circle is joined to the tropic of Capricorn by two decorative supporters. The reverse has a semicircular degree scale but is otherwise plain. The astrolabe is complete with rotating alidade with sighting tube and decoratively shaped ends on the back of the instrument, all held together by a simple nut and bolt. Condition is fine noting some light stains to the brass.



Sanskrit Astrolabe, Northern India

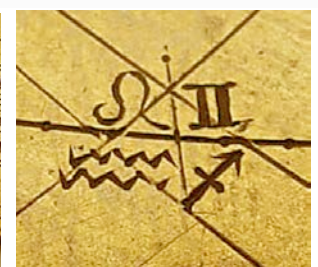
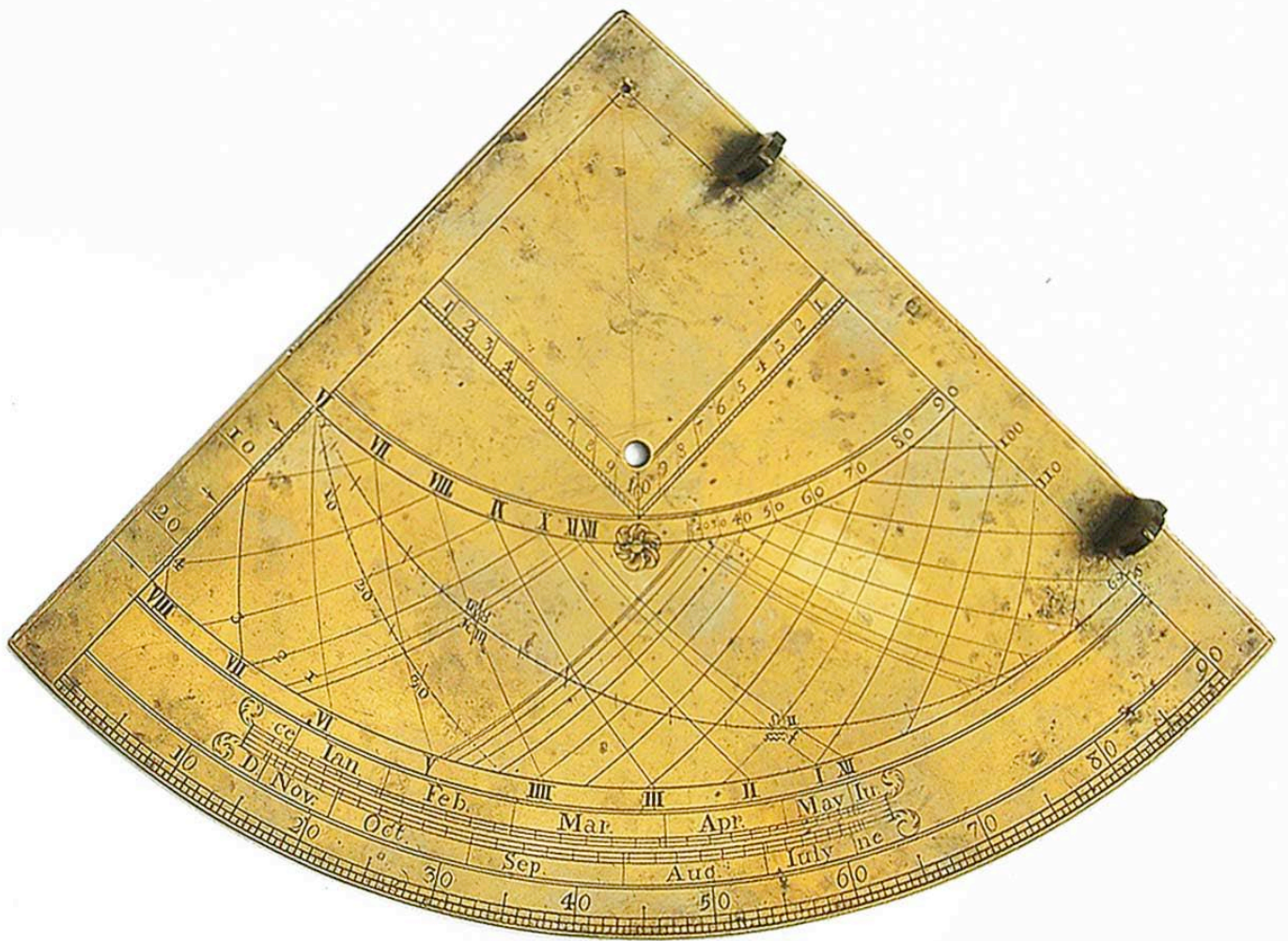
### Gunter's Quadrant, second half seventeenth century

The quadrant was first used by Ptolemy (c90-c168) to measure the sun's position. Around 1460, the astronomical quadrant was converted for nautical use. It was used to determine the altitude of the Polestar or sun and, concurrently, the location of the ship in degrees of latitude. When in use, the navigator would sail north or south until the quadrant indicated he was at the destination's latitude, turn in the direction of the destination and sail to the destination maintaining a course of constant latitude. Along one edge, there were two sights forming an alidade. A plumb bob was suspended by a line from the center of the arc at the top. In order to measure the altitude of a star, the observer would view the star through the sights and hold the quadrant so that the plane of the instrument was vertical. The plumb bob was allowed to hang vertical and the line indicated the reading on the arc's graduations. It was not uncommon for a



second person to take the reading while the first concentrated on observing and holding the instrument in proper position. The accuracy of the instrument was limited by its size and by the effect the wind or observer's motion would have on the plumb bob. For navigators on the deck of a moving ship, these limitations could be difficult to overcome.

Edmund Gunter (1581-1626), a mathematician and astronomer and Professor of Astronomy in Gresham College, London, described his quadrant, a simplified version of the Arabic astrolabe, in *De Sectore et Radio* in 1623. Like an astrolabe, it has a planispheric projection of the celestial sphere and local altazimuth coordinates, but these are "folded up" so as to be inscribed on a quadrant rather than a disk. The instrument was used for observations of the sun (altitude, azimuth, declination, right ascension, position of the sun in the zodiac) and stars, astronomical calculations, time of day, time of sunrise or sunset, and surveying.



Gunter's Quadrant



The substantial brass plate of this quadrant measures  $5 \frac{5}{8}$  inches (14 cm) on a side, and is set with twin shaped sight vanes, and pierced with a hole for the plumb line and a probably later hole for table stand mounting. The plate is hand engraved with Edmund Gunter's full layout, as described in 1623. It is laid out for a vernal equinox of 11 March, consistent with the Julian calendar still in effect in England, and for latitude just under 51 degrees consistent with Portsmouth, Southampton, and Hastings for example. Arranged as a quarter of an astrolabe, for a fixed latitude, the quadrant shows the sky projection between equator and tropics, crossed by the ecliptic (divided with a Zodiacal scale), horizon, azimuth lines, and hour lines. There is an edge scale of solar declination, a shadow square at the apex, a calendar scale, and a quadrantal scale for observing altitudes of sun and stars. The details follow exactly the figure published by Gunter, down to the labeling and frequency of subdivision of scales. The one exception is the maker's addition of a lovely central rose. The reverse is plain but for incised edge lines, typical of seventeenth century work. The quadrant is unsigned, but the lettering and some design features bear close resemblance to instruments by Henry Sutton and Walter Hayes. Condition is fine noting a little old pitting and staining.

### Armillary Sphere

An armillary sphere is a model consisting of a number of rings representing the circles of the celestial sphere. A Ptolemaic armillary sphere has an earth globe at the center, surrounded by celestial circle and zodiac armillary rings, demonstrating the geocentric theory of the universe developed by Ptolemy (c90-c168) and others in ancient Greece and Rome. A Copernican armillary sphere has a sun ball at the center, with planetary and zodiac armillary rings, demonstrating the modern theory of the solar system, first popularized by Nicolaus Copernicus (1473-1543) during the Renaissance.

Armillary spheres were widely used in the late fifteenth century, at the time of the voyages of discovery. Demonstrational armillary spheres were commonly produced in France in the eighteenth and nineteenth centuries to show various basic principles of astronomy. The Delamarche family of cartographers was the most renowned and prolific producers of globes and armillary spheres in France in the nineteenth century. The firm was founded by Charles Francois Delamarche (1740-1817) in the late eighteenth century.

This is a large Copernican planetary armillary sphere with the sun at the center. The sphere is mounted on a turned wooden stand with three legs. The wooden rings are covered with printed paper with writing in French. The horizon or equatorial ring bears the zodiacal signs and months of the year. A meridian ring marked "colure of the equinoxes" and "fixed stars" is set into notches in the horizon ring. Inside the primary sphere, there is a planetary system consisting of five interlocking movable wooden rings and an ecliptic ring around a two inch gilt sphere for the sun. The planetary rings represent the orbits of the "Mercurii," "Veneris," "Martis," "Iovis," and "Saturni" and are marked with the time of revolution around the sun. Between the rings for Venus and Mars, the earth sphere is supported by an arm that can be rotated around the sun. The  $\frac{3}{4}$  inch painted globe shows the continents. At the south pole of the earth, an arm with a disc for the moon is attached. The ecliptic ring, or path of the earth around the sun, bears the twelve signs of the zodiac and months of the year. The armillary sphere is  $32 \frac{1}{2}$  inches high and  $18 \frac{1}{2}$  inches wide. It is unsigned but the design and symbols are in the Maison Delamarche nineteenth century tradition. It is in excellent condition and probably dates to the first half of the twentieth century.







### Armillary Sphere

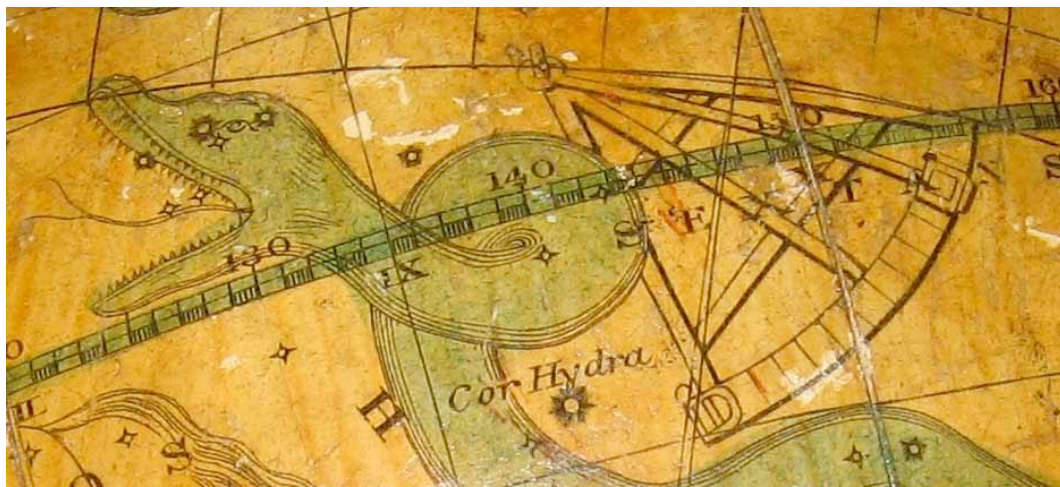
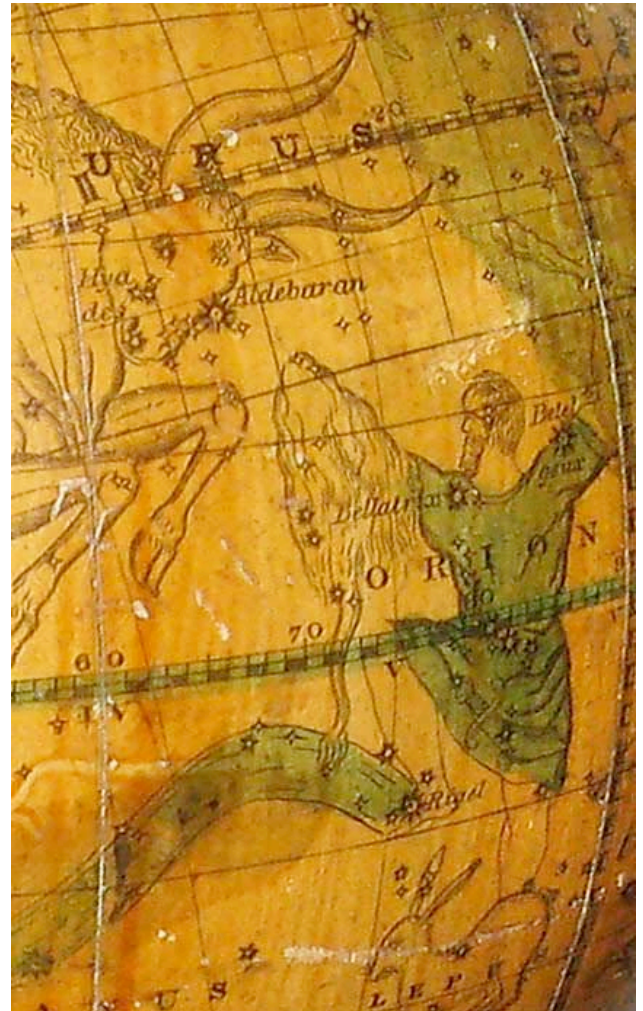
#### Bale & Woodward's Celestial Globe, c1850

This figural celestial globe, English c1850, is signed Bale & Woodward's New Celestial Globe." It is 6  $\frac{3}{4}$  inches (17 cm) in diameter, with a maximum height of 12  $\frac{1}{2}$  inches (32 cm) on stand. The globe is constructed of 12 printed gores showing the Classical constellation figures (Orion, Aries, Taurus, Andromeda, Hydra, etc.) with later additions (Antlia Pneumatica, Fornax Chémica, etc.). Bright stars are named. The globe is light brown and there is green hand coloring



## Non-Optical Instruments

to a number of constellations. It is mounted in a semicircular brass meridian ring divided every  $10^{\circ}$  of latitude supported on a turned mahogany stand in excellent condition. The globe has some old cracks, stains, and repairs partially obscuring some equatorial constellations in one hemisphere, but is otherwise in good condition.



**Bale & Woodward's Celestial Globe**

## Time Telling

The early time telling devices are also astronomical instruments because they depend on the observation of the sun or stars. The astrolabe and the quadrant can also determine time. The sundial is the oldest known device for the measurement of time and the most ancient of scientific instruments. It is based on the fact that the shadow of an object will move from one side of the object to the other as the sun “moves” from east to west during the day. The first device for indicating the time of day was probably the gnomon. It consisted of a vertical stick or pillar placed in the ground. The length of the shadow it cast gave an indication of the time of day. The earliest sundials known from the archaeological record are the obelisks (3500 BC) and shadow clocks (1500 BC) from ancient Egypt and Babylonia. The ancient Greeks developed many of the principles and forms of the sundial. The Greek dials were inherited and developed further by the Islamic Caliphate cultures, including the introduction of equal hours. The onset of the Renaissance saw an explosion of new designs in Europe. Even after the introduction of the mechanical clock in the fourteenth century, the sundial retained its importance. It was an essential tool to determine the correct time at which the clock should be set. Knowing the time of day was important for ecclesiastical time-keeping, travelers, and emerging commercial establishments. The sundial remained the most accurate device for determining time until the advent of the electrical telegraph in the mid-nineteenth century that was used to establish standardized time throughout the country.

The magnetic compass contains a magnetized needle that interacts with the earth's magnetic field pulling one end of the needle toward the Earth's North magnetic pole, and the other toward the South magnetic pole. The compass was invented during the Chinese Han Dynasty between the 2nd century BC and 1st century AD. The first compasses were made of lodestone, a naturally magnetized piece of the mineral magnetite. It was found that if a lodestone was suspended so it could turn freely, it would always point in the same direction, toward the magnetic poles. Early compasses were used for geomancy in the search for gems and the selection of sites for houses, but were later adapted for navigation during the Song Dynasty in the 11th century. Later compasses were made of iron needles, magnetized by striking them with a lodestone. The dry compass was invented in medieval Europe around 1300. The compass greatly improved the safety and efficiency of travel, especially ocean travel where it was used to calculate heading.

### **Gothic Nocturnal Compendium, European, fifteenth century**

The nocturnal is an instrument for telling the time at night. Its operation is based on the fact that the stars, because of the earth's rotation, appear to rotate about the Pole Star which lies along the Earth's axis of rotation. In use, holding the compendium upright, one would sight the Pole Star through the nocturnal's center, align the index arm with the circumpolar star beta Ursae minoris (Kochab), and then count the time interval from the index arm position to the current date. This value would be added or subtracted from midnight to determine the time. This was described by Ramon Llull (c1232-c1316) at the end of the thirteenth century in his book *Opera Omnia*. Only a few such medieval compendia survive. There is similar instrument dated to the fifteenth century at the Museum of the History of Science at Oxford. The Oxford instrument has a hinged chapter ring but this example shows no evidence of having had one. This is a significant nocturnal and compass box from the Middle Ages and warrants further research.





The instrument is made of brass now darkened to a chocolate color, and measuring 1 ½ inches (39 mm) in diameter and just over ½ inch thick. It consists of a cylindrical compass box with engraved compass rose, and hinged lid with six-petal décor to the interior and nocturnal with rotating index arm to the exterior. The nocturnal dial is divided with a circular calendar scale of 12 months or 24 hours, each month denoted by a pointillated “engraving” of its initial letter, and subdivided into sixths (i.e., about every five days, or every 20 minutes of time). The index arm also serves as a closure latch. The compass rose has pointillated engraving of a central four-lobed rose, then a concentric band of cardinal directionals labeled “M” Meridional for south), “S” (septentrional for north), and possibly “OR” (oriental) and “OC” (occidental). Beyond this, another concentric band displays eight directionals, possibly an eastern cross, a western crescent, a southern arrow, and a northern asterism. The four intermediate ordinals are the numerals from 1 to 4, clockwise starting at southwest; the numerals are in clear Gothic shapes. Condition is reasonably good, noting the nocturnal’s central hole plugged with a later rivet, and the base pushed in a bit. Lacking are a compass needle, pivot, and glass.





**Gothic Nocturnal Compendium**

**Portable Universal Equinoctial Sundial, c1600**



**Portable Universal Equinoctial Sundial**

This is an early portable universal equinoctial sundial, which were developed as “watches” in the middle ages. This example is contained in a brass circular case with a lid and a pendant for suspension. The diameter of the case is 5.5 cm. The base is a round brass plate richly engraved with a vine pattern. A compass is inset in the base and viewed through a circular glazed aperture. The cardinal points are in Latin: SE (septentriones, North), OR (oriens, East), ME (meridies, South), OC (occidens, West). The equinoctial hour ring is hinged to the North side of the base plate and the latitude arc is hinged to the West side of the plate. The gnomon is a narrow pointed rod set at the center of a pivoted bar lying across the East-West diameter of the hour ring. The hours engraved in Roman numerals on the ring are from IV to XII and I to VIII. The latitude arc is marked 10 – 80 degrees. The dial is in excellent condition and fully functional. It was nearly black and cleaned at some point. A very similar portable dial in the Science Museum is dated 1588.

### Universal Equinoctial Ring Dial, last quarter seventeenth century.

This is an early brass double ring dial,  $3 \frac{3}{8}$  inches (87 mm) in diameter. The outer meridian ring has a sliding suspension reading against a  $0^\circ$  to  $80^\circ$  scale of North latitudes and on the reverse an auxiliary  $0^\circ$  to  $90^\circ$  scale centered on a pierced hole that is designed for inserting a straw or pin and measuring directly the solar altitude. The inner equatorial ring has a 3 AM to 9 PM scale of hours, divided every 30 minutes. The bridge, with its sliding pinhole, has scales of date by the Julian calendar on one side and of solar declination  $0^\circ \pm 23.5^\circ$  on the other. Condition is good, the brass showing a dark brown patina.



In use, the universal dial functions worldwide and can be used over a wide range of latitudes. To determine time, one sets the pinhole within the bridge to the date, the suspension ring to the latitude on the outer ring, holds the dial in sunlight, and reads the (apparent solar) time where light passing through the pinhole strikes the hour scale on the equatorial ring. The dial can also be used to determine latitude and the date.

### Diptych Dial, 1648



The diptych dial is a small, portable sundial that originated in the fifteenth century. It consists of two hinged plates, a string gnomon, and an hour scale and inset compass in the base plate. This simple brass and wood dial is beautifully engraved "Herman Nuttelman, Anno 1648,"  $2 \frac{1}{4}$  " x  $3 \frac{1}{2}$  " (6 x 9 cm) in size with hinged plain wood top latching upright to form the holder for the string gnomon and plumb line for leveling. An inset glazed compass has a well-shaped needle and simple card with north-south line. The wood has been painted (probably repainted) in gold and red. The fine brass dial plate has a 5 AM to 7 PM hour scale, signature and date, and delicate floral engraving in two corners. Condition is good. The dial was designed for use at approximately 52 degrees latitude (as indicated by the angle the string, representing the earth's polar axis, makes with the horizontal dial plate); this the latitude of central Germany, Poland, and the Low Countries. There is no offset line for magnetic declination on the compass face, but the declination was very near zero in the mid-seventeenth century in central Europe. An interesting dial by a seemingly unrecorded maker.





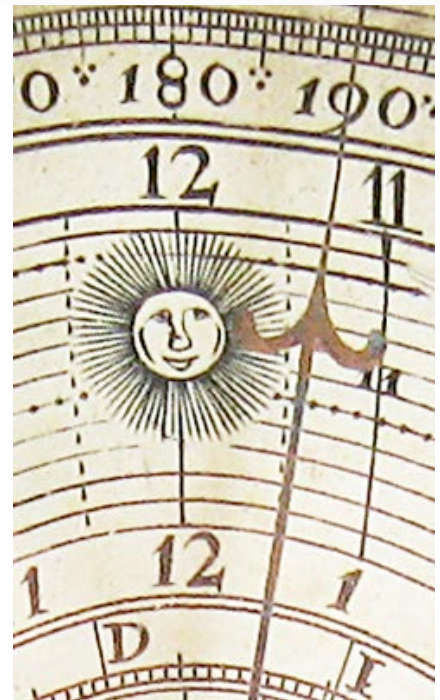
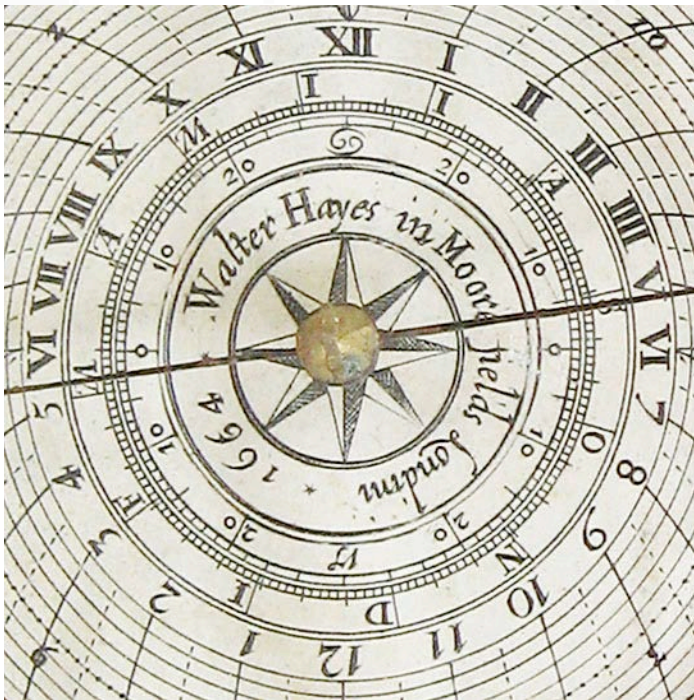
Diptych Dial, 1648

### Hayes Magnetic Azimuth Sundial, 1664.

This glazed compass/sundial is set into a  $5 \frac{3}{8}$  inch (14 cm) square  $\frac{3}{4}$  inch (2 cm) thick wood block that probably had a side mounting for a wooden plane table. Under the old glass is a finely crafted needle with arrowhead and crossbar shapes, and the complex printed card signed "Walter Hayes in Moore fields Londini \* 1664 \*." Reading outwards, concentric rings give scale of solar declination ( $0-23 \frac{1}{2}^{\circ}$ , four times full circle), scale of date (showing 10 March as vernal equinox, consistent with the Julian calendar in use in England until 1752), sundial hour scales for every two degrees of solar declination, degree scale ( $0^{\circ}-360^{\circ}$ ), and degree scale ( $0^{\circ}-90^{\circ}$  four times). Condition is fine, the wood darkened and slightly warped, the putty probably replaced.

A similar dial face is shown on Henry Sutton's 1654 trade card (Science Museum). The trade card contains instructions for determining the time of day. It begins with "Place ye Sun on ye Card toward the Sun in ye Firmament ...", meaning to direct the south side of the compass card, marked with the smiling sun face, toward the sun. The time is read where the north end of the compass needle (in summer, south end in winter) crosses the hour lines along the proper parallel of solar declination as read from the central circular lookup table. The great mathematical instrument maker Henry Sutton (c1624-1665) was made free in the joiners guild in c1648 and after his death from the plague was succeeded by John Marke. Walter Hayes (c1618-c1696), freed in 1642, was probably the foremost instrument maker of his time and made high-quality scientific instruments, especially quadrants and sundials, from 1651 to 1692. He trained many apprentices and was succeeded by Edmund Culpeper. Cowham (2004) has shown that, on occasion, Hayes reused Sutton's printing plate by effacing and re-engraving the name and date. In this example, faint traces of earlier engraving can be seen, including a ten-year change in the date. This is a rare dialing compass with connections to the foremost instrument makers of the seventeenth century in London.





Hayes Magnetic Azimuth Sundial, 1664



### English Silver Pair Case Verge and Fusee Pocket Watch, c1690

This type of movement, with a verge escapement and a fusee was used in watches from around 1600 to the early 1800s. The verge (or crown wheel) escapement is the mechanism in a mechanical clock that controls its rate by advancing the gear train at regular intervals or 'ticks'. All verge watches and spring driven clocks require fusees to equalize the force of the mainspring to achieve even minimal accuracy. The fusee is a tapered cone with a groove machined around its circumference, and into which the chain is guided. As the spring is unwound, the chain moves progressively onto a larger radius of the cone and transmits increased torque to counteract the decreasing power of the mainspring.

This is a fine early English two-hand verge and fusee silver pair case antique pocket watch signed by Francis Colman, Ipswich, c1690. The watch is 55.75 mm in diameter. It has a silver champlévé dial and blued steel beetle and poker hands. The dial plate is firmly attached to the movement by two dial feet, with one missing leaving an unused hole in the dial plate. It has a gilt verge movement with engraved and pierced balance cock and plate and Egyptian pillars. The inner case bears a maker's mark and a later stem and bow. The high dome bull's eye crystal is in good condition. The outer silver pair case has a few small bruises but is in very good condition. Francis Colman or Coleman of Ipswich was reputedly working by 1665, married in 1668, and died in 1709. The shape of the balance cock foot and the pillars, typical of Joseph Windmills, date this watch to the end of the 17th century, probably about 1690. The watch runs well and is in overall excellent condition.



English Silver Pair Case Verge and Fusee Pocket Watch

Verge Fusee Gold Pocket Watch, French, 1759-1760

This is a French 18k rose gold open faced, verge fusee pocket watch signed "Themeze a Versailles." There is a floral arrangement design applied to the back cover. It has gold hands and a

white porcelain dial with Roman numerals for hours and Arabic numerals for minutes. It has an ornately engraved and pierced balance cock and square Egyptian pillars. The inside of the case is hallmarked with the letter T with a crown, used between July 1759 and July 1760, and a duty mark used between October 1757 and September 1762. There is a pendant for suspension. The watch is 47 mm in diameter and 24 mm thick. It is functional and in near perfect condition.



**French Verge Fusee Gold Pocket Watch**

**Spherical Polar Sundial, French, second half eighteenth century**

This is a spherical polar sundial, French, c. second half 18th century. It is made of pewter with brass gnomon, standing 14 inches (35 cm) overall. The spherical sundial reproduces the geometry of the earth in space, with armillary rings defining the celestial projection of the earth's equator, axis of rotation, and local meridian plane. The polar axis of the dial is inclined approximately 43 degrees to the horizontal. The equatorial band is finely marked with Roman numerals in raised relief every hour from 5 AM to 7 PM, and subdivided to 1/8 hour (7.5 minutes). The Roman numerals include "...IX, X, XI, XII, I..." for "...9, 10, 11, 12, 1..." as usual, but also "V, IV, IIV, IIIV,..." for "5, 6, 7, 8,..." in a reversed manner, either in error or in some sense of trying to follow the course of the day with the numeral writing. A rotatable sheet brass gnomon is hand cut and pierced with a sort of handle, and with banner and scroll design, reminiscent of some Alsatian patterns and workmanship. Within the band and rings is a five inch (13 cm) diameter glazed compass, with 32-point rose, again in relief, the 16 principal directionals labeled in French (e.g., Sud, E.S.E., S.S.O., N.Ouest). The "N N Ouest" pointer (at 15 degrees west of North) is also labeled "S S E meridiene" (possibly representing the magnetic declination which in mid-eighteenth century France was 15-20 degrees west). The compass has a circumferential scale divided every degree, and is set with a blued steel needle with raised brass hub and faceted pink stone on glass pivot. The compass directionals are reflected in the design of the attractive pewter stand, with its octagonal baluster and knobs, and eight-lobed base. Condition is very fine throughout, noting one screw replaced.



In use the polar dial would be set up with its compass north point fleur-de-lys pointed toward the geographic north point on the horizon (thus taking into account the offset of the needle - the magnetic declination - toward magnetic north). The polar axis would then be parallel to the earth's axis of rotation (when the user is at the correct latitude for this dial - about 43 degrees North, corresponding to southernmost France, e.g., Perpignan or Marseilles). One rotates the brass gnomon until it is in line with the sun; the gnomon then casts a crisp shadow line on the equatorial hour band, giving immediately the apparent solar time. This is an elaborate openwork form of the relatively rare spherical dial with rotatable gnomon, usually constructed with a solid sphere of turned stone or wood with sheet metal gnomon. There is an eighteenth century French example in the Stewart Museum and a c1810 design by Thomas Jefferson at Monticello.





Spherical Polar Sundial

### Universal Equinoctial Sundial, French, c1840

The seven-sided brass body measures four inches across, set with three leveling screws, two spirit levels, hinged equatorial arc (divided every quarter hour from 4 AM to 8 PM and mounted with pin gnomon), and hinged latitude arc (divided every degree  $0^{\circ}$ – $65^{\circ}$ ). In use, one sets the equatorial arc against the observer's latitude (thus placing the arc parallel to the plane of the earth's equator), sets the gnomon vertically north (in summer; south in winter) and thus parallel to the earth's polar axis, and reads the apparent solar time by the gnomon's shadow on the arc. There is an inset glazed compass for orienting the dial with silvered face and circumferential degree scale, and with a bold arrow for magnetic north. The needle has a red stone pivot and external needle lifter. The dial is housed in a decorative octagonal case. The dial is of the highest quality and is in excellent condition.



Universal Equinoctial Sundial

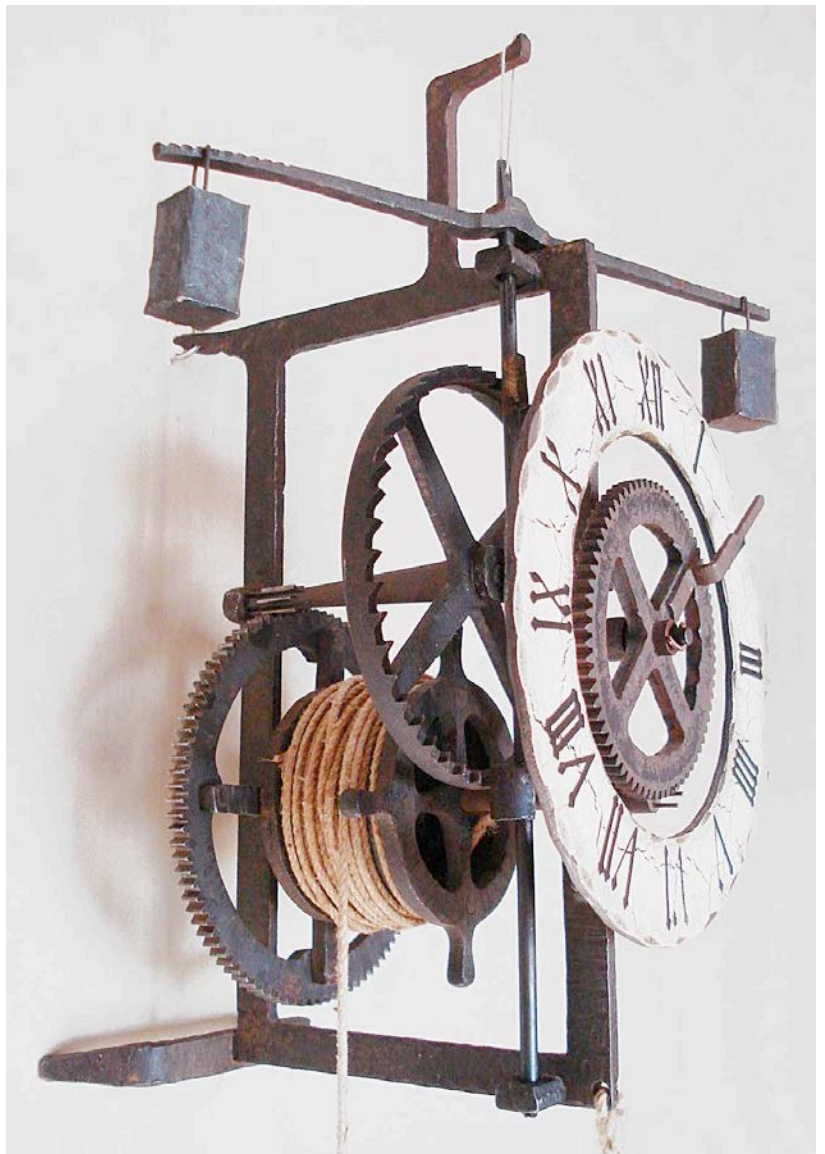
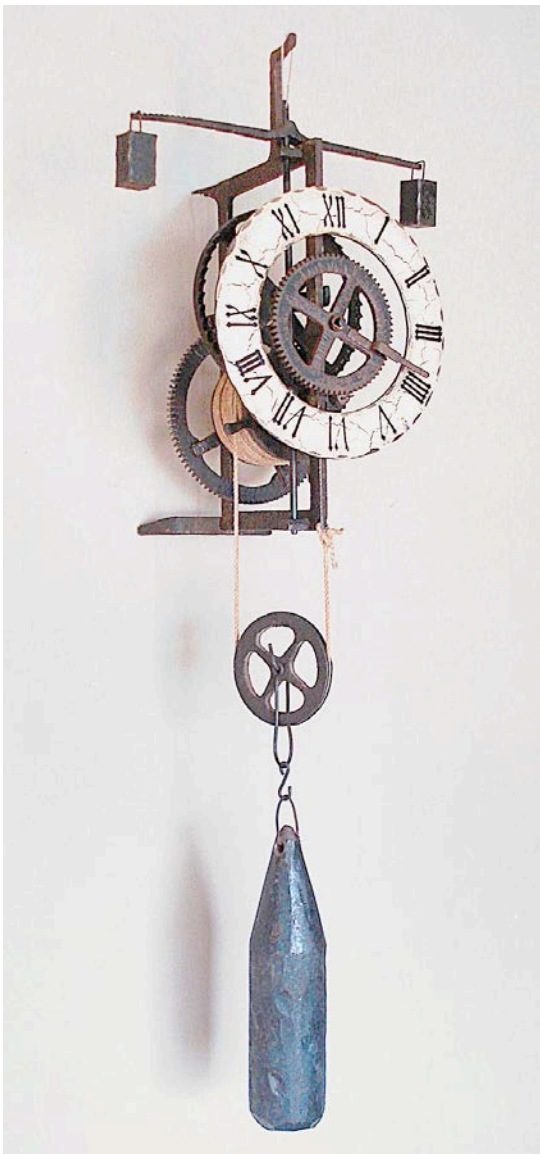
### Gothic Style Verge and Foliot Mechanical Clock

Instruments to measure time originated in antiquity and included the obelisk, sundial, oil lamps with marked reservoirs, candles marked in increments, hourglass, water clock or clepsydra,



## Non-Optical Instruments

and, in the Orient, small stone or metal mazes filled with incense that would burn at a certain pace. The first all-mechanical clocks were probably developed by monks in central Europe in the thirteenth century. They were made possible by the invention of the verge and foliot escapement mechanism that converted energy from a falling weight into periodic oscillations which are then used to measure the passage of time. The first clocks did not have dials or hands and only struck bells on the hour to tell the time for prayers or church attendance. These early clocks were very large and were made of heavy iron frames and gears forged by the local blacksmiths. Large mechanical clocks, with an hour hand only, began appearing in the towers and cathedrals of English and Italian cities as early as 1270. The early clocks were not accurate and could be off by plus or minus an hour a day. The first domestic clocks, in the early fifteenth century, are miniature versions of the cathedral clocks and show the time by means of a single hand on a 12-hour clock face. In subsequent years, the invention of the spring-driven mechanism and the pendulum greatly improved the accuracy of clocks. The development of accurate clocks was of as great importance as was the development of instruments in the advancement of sciences such as astronomy, physics, navigation, and chemistry where accurate time measurements are required.



**Gothic Style Verge and Foliot Mechanical Clock**



This is an old, possibly nineteenth century, replica of an early German mechanical clock (eisenuhr). It may be modeled after a clock in the Mainfränkisches Museum, Würzburg which is dated to 1350. It is a weight driven iron gothic style wall clock with foliot controlled verge escapement and white painted dial. The escapement allows a toothed crown wheel to turn, one tooth at a time, by successive teeth catching against two pallets projecting from the upright rod or verge. The pallets are not parallel, but are oriented with an angle in between them so only one catches the teeth at a time. As the clock's gears turn the crown wheel, one of its teeth pushes on a pallet, rotating the verge in one direction, and rotating the second pallet into the path of the teeth on the opposite side of the wheel, until the tooth pushes past the first pallet. Then a tooth on the wheel's opposite side contacts the second pallet, rotating the verge back the other direction, and the cycle repeats. The result is to change the rotary motion of the wheel to an oscillating motion of the verge. The speed of its oscillation is regulated by a horizontal bar or balance beam known as a foliot attached to the top of the verge. The time taken in the foliot's swing can be regulated by moving weights in or out on each arm. Each swing of the foliot allows the wheel train of the clock to advance by a fixed amount, moving the single hand forward at a constant rate. Power is provided by a single lead weight with pulley unwinding a rope from the barrel and turning the crown wheel. The overall height is 10 inches, dial diameter  $5\frac{1}{4}$  inches, and 6 inch projection from the wall. It weighs about eight pounds with weights. The clock is in very good condition noting only very slight rust in a few places. It works for a duration of less than 12 hours without rewinding. This clock is a useful device for demonstrating the operation of the verge and foliot escapement of the earliest mechanical clocks.

### **Elgin Chronometer, c1918**

A longitude describes the location of a place on Earth east or west of a north-south line called the Prime Meridian. Longitude is given as an angular measurement ranging from  $0^\circ$  at the Prime Meridian to  $+180^\circ$  eastward and  $-180^\circ$  westward. The purpose of a chronometer is to measure accurately the time of a known fixed location, for example Greenwich Mean Time (GMT). This is particularly important for navigation. Knowing GMT at local noon allows a navigator to use the time difference between the ship's position and the Greenwich Meridian to determine the ship's longitude. As the Earth rotates at a regular rate, the time difference between the chronometer and the ship's local time can be used to calculate the longitude of the ship relative to the Greenwich Meridian (defined as  $0^\circ$ ) using spherical trigonometry.

In the seventeenth and eighteenth century, accurate navigation at sea out of sight of land became of critical importance in exploration, colonization, international trade, and warfare. Many ships and lives were lost due to errors in navigation. Accurate navigation at sea out of sight of land was an unsolved problem due to the difficulty in calculating longitude. Navigators could determine their latitude by measuring the sun's angle at noon or, in the Northern Hemisphere, to measure the angle of Polaris (the North Star) from the horizon. To find their longitude, however, they needed a time standard that would work aboard a ship. The difficulty, however, was in producing a clock that could maintain accurate time on a lengthy, rough sea voyage with widely varying conditions of temperature, pressure and humidity. The problem was considered so intractable that the British Parliament in 1714 offered a prize of £20,000 (comparable to £2.66 million in modern currency) for the solution.

John Harrison (1693–1776) set out to solve the problem by producing a reliable clock that could keep the time of the given place across a long sea journey. Harrison was a self-educated English carpenter and later a clockmaker. Between 1730 and 1761, Harrison produced four marine chronometers. The last, a “sea watch,” underwent sea trials and proved highly accurate. Due to bickering between boards and Parliament, Harrison never received the official award, but over

the years he did receive payments of £23,065 for his work on chronometers which made him an extremely wealthy man.

This is a fine and original Elgin chronometer or deck watch in a gimballed mahogany case. Serial number is 21869036. The 21 Jewel Father Time movement is free-sprung stem wind, lever set and adjusted to five positions. It winds and sets smoothly and keeps accurate time. The screw-off bezel has the original beveled glass crystal. The weighted screw-off movement cover is marked U.S.S.B., Ship Watch No. 2191. The original enamel dial and hands are near flawless, noting one small dent at eleven o'clock. The dial has a sub-seconds at the six o'clock position and a 40 hour wind indicator dial at the 12 o'clock position. The mahogany case has "ELGIN" on the front and the ship number (matching) as well as the original key for the inner box (5 x 5 x 5 inches). The outer deck case (7 x 7 x 7 inches) has a large brass locking hook and leather strap.

The United States Shipping Board was established during WW I to build and operate merchant ships to support the war efforts. Towards the end of the war, contracts were placed for over 1000 wooden ships, tugs, and barges, but most of the contracts were cancelled and only 589 ships were completed. Most of these were scrapped in the 1920s. Ship #2191 was the Peshewah, a cargo ship hull, design #1001. It was built by the Coos Bay SB Co. in Marshfield, Oregon. The ship was launched but not completed. The Elgin National Watch Company was a major US watch maker from 1864 until its closure in 1968.



**Elgin Chronometer**

## Weights and Measures

Methods for weighing and measuring were necessary for civilized communities that engaged in barter and trade in order to assess the amount or mass of the goods being exchanged. The first weighing machine was probably derived from the yoke when it was discovered that two equal masses would balance if they were suspended from a beam that was supported at its center. Balances were in use in Mesopotamia as early as 4000 years BC. They consisted of straight pieces of wood suspended by a cord passing through the center. Holes, pierced in the ends of the beam, carried cords suspending the scale pans. One pan was used for the goods to be weighed and the other held the weights. To prevent fraud, accuracy was necessary in the weighing of precious metals, coins, and drugs. The pound weight used by the Romans is derived from the Roman word *libra*, hence the abbreviation "lb" for pound.

### Balance Scales, Roman, 1st - 2nd Century AD

This is a small pair of Roman balancing scales dating from the first or second century AD. Small Roman scales are often described as coin scales or medical scales. The scales are 2 ½ inches wide and made of bronze. Dual hooks that most likely held pans or baskets are suspended from the beam. The scales were suspended on a cord or hung on a hook. The scales may have been used to weigh gold or silver or small quantities of other high value goods. The scales are in good condition noting surface oxidation. Ex Museo Nazionale di Villa Giulia, Rome, de-acquisition, c1950's.

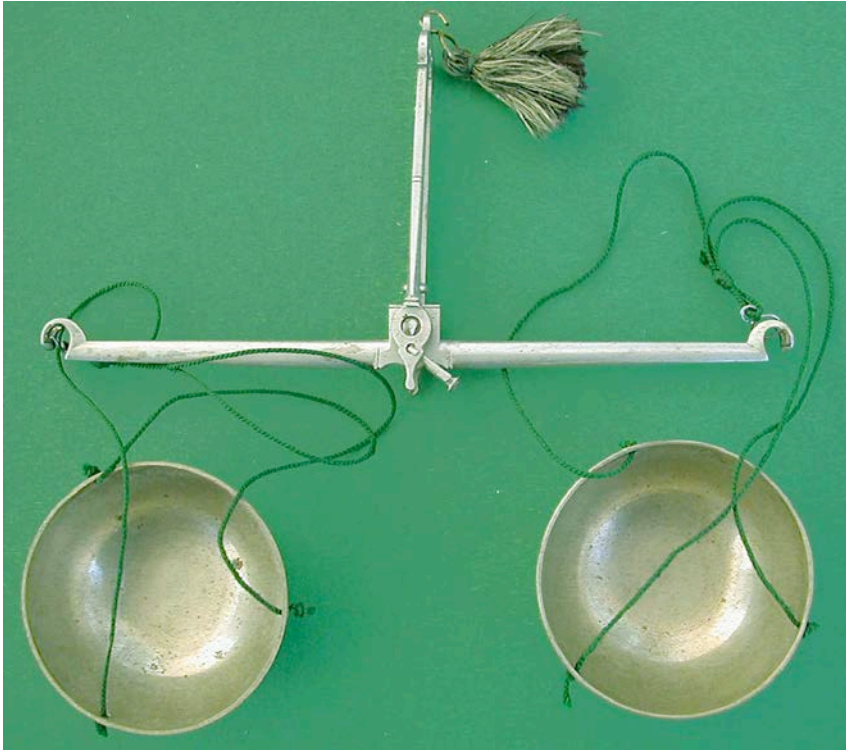


Roman Balance Scales

### DeGrave, Short & Co Diamond Balance, c1860

This a diamond balance by DeGrave, Short & Co, prominent makers of balances in London, in a fitted case. The balance consists of a steel handle and a balance beam, pointer attached to the beam, and two brass pans suspended from the arms by string. The cross beam is 4 ½ inches long and the pans are 1 ½ inches in diameter. There is a complete set of eight weights from one to 64 carats. The weights are held in individual recesses under a hinged wooden cover in the case. The wooden case is 5 ½ x 3 x 1 ¼ inches. Ornate brass tweezers for the handling of gems slide into a recess in the side of the case. A paper table of the monetary value against weight in carats and the maker's name and address is on the inside of the lid. The balance is in excellent condition with no corrosion and the case is very fine.





DeGrave, Short & Co Diamond Balance

## Calculation

### Napier's Bones

This is a large set of Napier's bones, a manually-operated calculating device created by John Napier (1550-1617). Napier is best known as the inventor of logarithms. He also invented the so-called "Napier's bones" and made common the use of the decimal point in arithmetic and mathematics. In 1617, in the book *Rabdologie* he explained the use of his rods to guide one in the old Arabic lattice method of multiplication. In this set, there are 30 rods 6.4 cm long and made of wood bound in paper on all four sides. The papers are printed in ink with a multiplicand digit at the top and its products below. One rod bears the multiplier from 1 to 9. The rod 0 is needed for multipliers or multiplicands having a 0 in them. Several rods can be lined up to multiply a multi-digit number. The set is contained in a cardboard box. The rods are in excellent condition noting only slight discoloration to the paper in places. Nineteenth century.

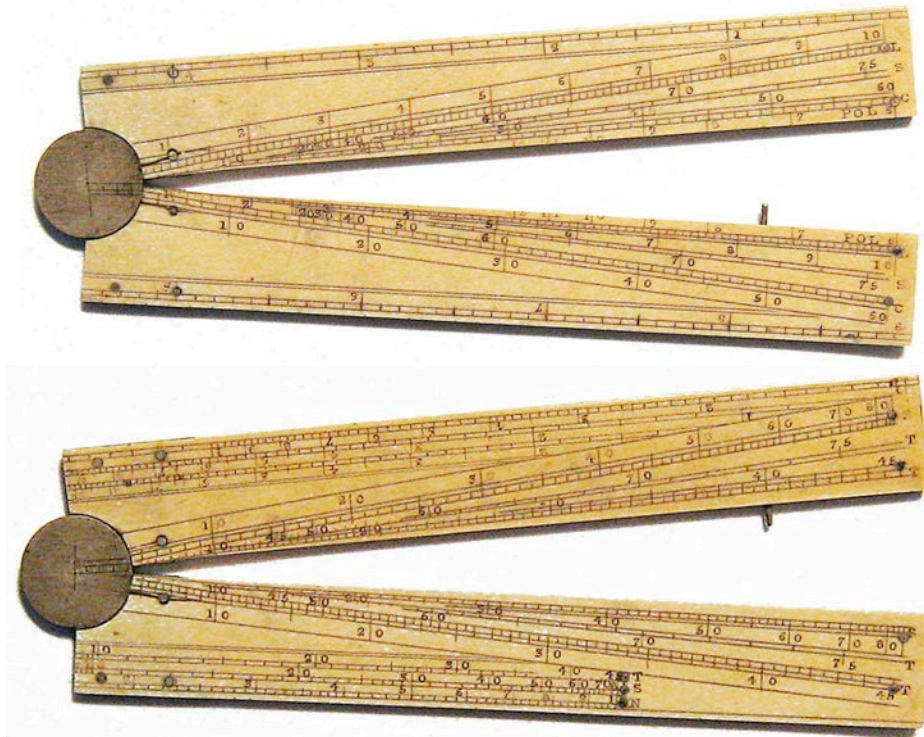
1	0	1	2	3	4	5	6	7	8	9
2	0	2	4	6	8	10	12	14	16	18
3	0	3	6	9	12	15	18	21	24	27
4	0	4	8	12	16	20	24	28	32	36
5	0	5	10	15	20	25	30	35	40	45
6	0	6	12	18	24	30	36	42	48	54
7	0	7	14	21	28	35	42	49	56	63
8	0	8	16	24	32	40	48	56	64	72
9	0	9	18	27	36	45	54	63	72	81



Napier's Bones

### English Ivory Sector, c1780

The sector, also known as a proportional compass or military compass, was a major calculating instrument in use from the end of the sixteenth century into the nineteenth century. It consists of two rulers joined by a hinge with a number of scales inscribed on the rules and is based on the principle of similar triangles. It was used with a caliper for solving problems in proportion, trigonometry, multiplication, and division, and for various calculations such as squares, cubes reciprocals, and tangents of numbers. This is a small ivory sector nine inches long unfolded with a brass hinge and the two arms locking with a pin. Both sides have small inset brass pins at scale starts to protect the rule from the divider points at these frequently used places. There are three types of scales on an English sector: sectoral ones (radiating from the hinge center) that were used for calculation; plane scales (logarithms, sines, tangents) parallel to the edge; and rules (inches, tenths of feet). The scales permitted easy and direct solutions of problems in gunnery, surveying, and navigation. The sector is in excellent condition.



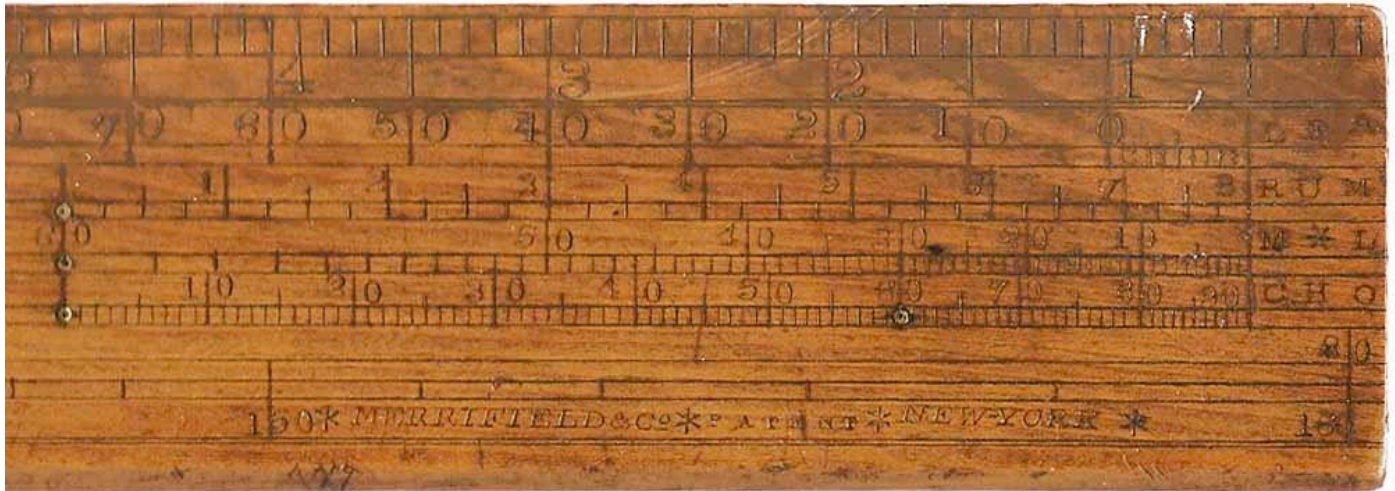
English Sector

### Gunter's Rule (Scale) Signed Merrifield & Co.

In 1614 Scottish mathematician John Napier (1550-1617) announced his discovery of logarithms. Within eight years, Edmund Gunter (1581-1626), an English clergyman who was interested in mathematics, had devised a scale on which logarithms could be multiplied and divided, by measuring the distance between two logarithmic numbers with a pair of dividers. Shortly thereafter, instrument makers were manufacturing wooden rules with standard (or "natural") scales typically used in navigation on one side and Gunter's logarithmic (or "artificial") scales on the other side. This instrument, a precursor of the slide rule, became known as Gunter's rule or scale. Gunter's scale remained popular with ship's navigators until the end of the nineteenth century. Surveyors, mechanics, craftsmen, and retailers also used Gunter's scales to make logarithmic and trigonometric calculations.

This boxwood Gunter's rule is two feet long. The top of one side has a scale of inches, divided to tenths of an inch and numbered by ones from 23 to 1. On the left are 10 inch and 9 inch (divided to  $\frac{1}{2}$  inch) plotting scales with diagonal scales at each end. In the middle are scales for rhumbs, chords, sines, tangents, and semitangents. On the right are scales for leagues, rhumbs, miles of longitude, and chords. Brass inset pins at the zero and  $60^\circ$  marks and elsewhere reduce wear from the points of dividers, which were used to transfer measurements between the scale and the user's drawing. The other side has logarithmic scales: sines of rhumbs, tangents of rhumbs, line of numbers, sines of degrees, versines of degrees, and tangent of degrees. At the bottom edge are a meridional line and a scale of equal parts that divides 23 inches into 17 sections. The sections are numbered by tens from 60 to 10 and from 100 to 0. On the side with the scale of inches, the rule is marked in the lower right corner: \*MERRIFIELD & CO \* PATENT \* NEW YORK\*. Merrifield & Co. sold Gunter's scales in Boston and New York in the early 19th century. The rule is in very fine condition.





Gunter's Rule

### Apple Macintosh 512K Model M0001W Computer, 1985

A computer is a device that computes or calculates. Although rudimentary calculating devices first appeared in antiquity and mechanical calculating aids were invented in the seventeenth century, the first 'computers' were conceived of in the nineteenth century, and only emerged in their modern form in the 1940s. Early devices included the tally stick, abacus, astrolabe, and Napier's bones. Historically, computers as known today evolved from mechanical computers and then from vacuum tubes to transistors. Charles Babbage, an English mechanical engineer and polymath, originated the concept of a programmable computer. Considered the "father of the computer," he conceptualized and invented the first mechanical computer in the early nineteenth century. The principle of the modern computer was first described by computer scientist Alan Turing, who published the idea in his seminal 1936 paper, *On Computable Numbers*. Conventionally, a computer consists of at least one processing element for arithmetic and logic operations, typically a central processing unit (CPU), and some form of memory.

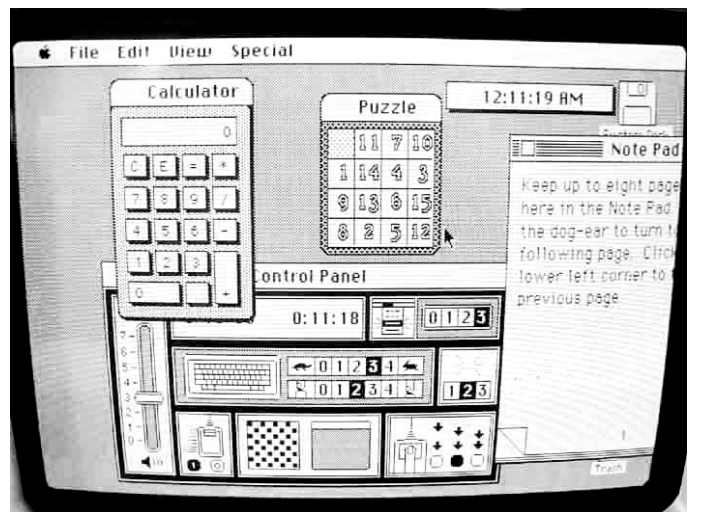
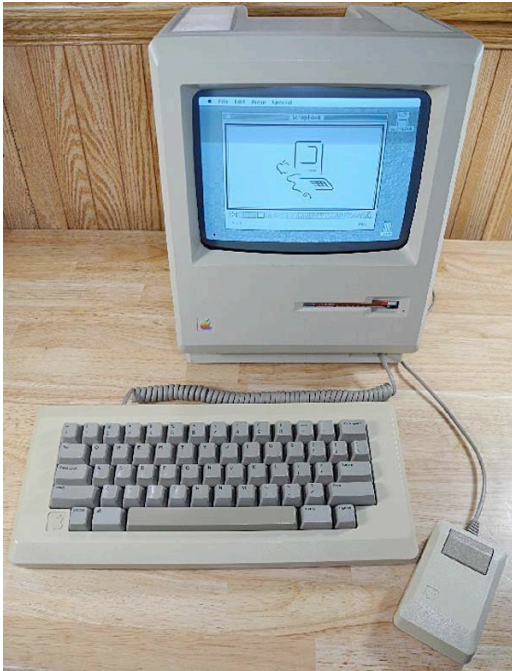
The Macintosh 512K is an example of a computer manufactured by Apple, Inc. Apple was founded by Steve Jobs, Steve Wozniak, and Ronald Wayne on April 1, 1976 to develop and sell personal computers that could be used by individuals. The Macintosh 128K was introduced by the now-famous \$1.5 million Ridley Scott television commercial, "1984." It most notably aired during the third quarter of Super Bowl XVIII on January 22, 1984, and is now considered a watershed event and a masterpiece in advertising. Steve Jobs introduced the Macintosh 128K two days later on January 24, 1984 in the first of his famous Mac keynote speeches. This was the first mass-market personal computer featuring a graphical user interface and mouse. The applications MacPaint and MacWrite were bundled with the Mac. The Macintosh 512K was released on September 10, 1984 at a price of \$3,195 and was the first update to the original Macintosh 128K. It was virtually identical to the previous Mac, differing primarily in the amount of built-in memory (RAM). Because of the increased memory, it was known as the "Fat Mac." Like the 128K Macintosh before it, the 512K contained a Motorola 68000 microprocessor connected to a 512 kB DRAM by a 16-bit data bus. The Mac was particularly powerful in the desktop publishing market due to its advanced graphics capabilities.

This is an Apple Macintosh 512K Model M0001W computer first brought out in 1984. The serial number of F52528SM0001W indicates it was made in Fremont California (F), in 1985 (5), in week 25 (25). The computer has the original 512K RAM motherboard, an available upgrade of a



## Non-Optical Instruments

800K Sony double-sided internal disk drive, Mac short keyboard, and one button mouse. There is a standard non-original power cord, new plain label copies of Mac System software and MacPaint and MacWrite programs on disk. The built-in monitor is monochrome. The exterior case (11 x 9 5/8 x 13 5/8 inches) is the original beige color in fine cosmetic condition. The inside case has the molded signatures of Steve Jobs, Bill Atkinson, and the original Macintosh design team. The computer has been serviced and tested and is fully functional. It is a very fine example of the early development of the personal computer that has revolutionized the processing of information by individuals. Includes original user manuals for Mac computer, MacPaint, and MacWrite.



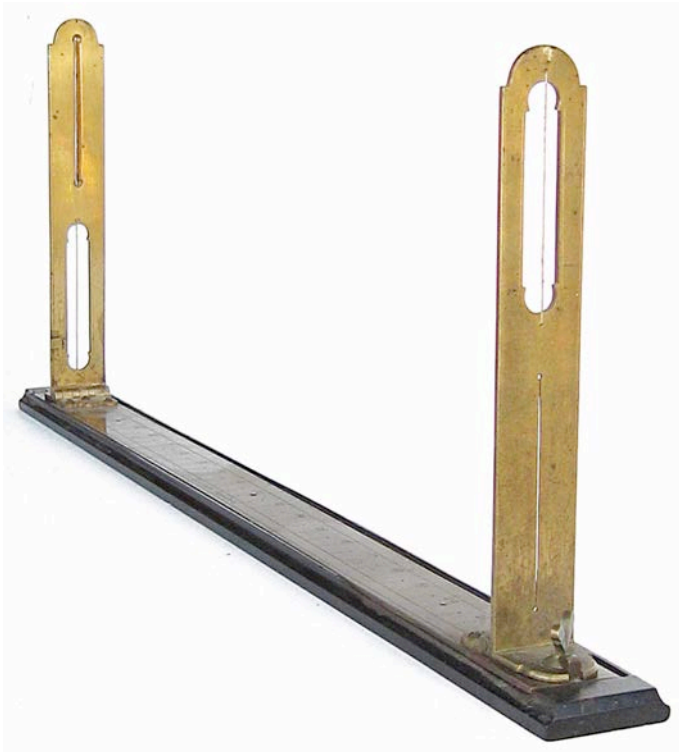
Apple Macintosh 512K Computer

## Surveying

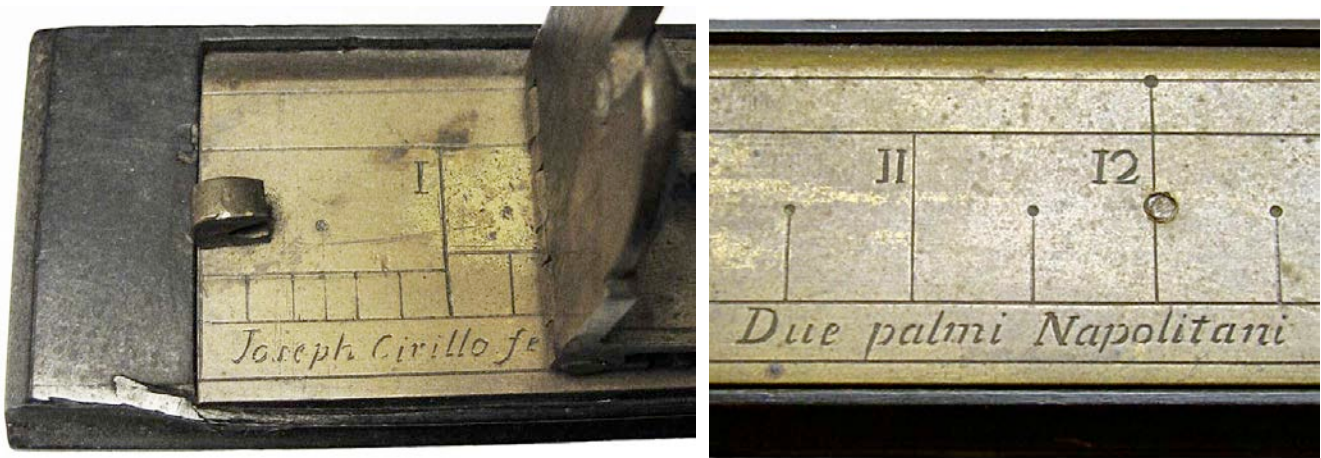
**Alidade, Italian, 1789**

An alidade is a surveying instrument of ancient origin that employs line-of-sight to determine the positional characteristics of a remote object in relation to the observer. The earliest alidades consisted of a bar, rod or similar component with a vane on each end. Each vane has a hole, slot or other indicator through which one can view a distant object. In use, the alidade would be placed on a surveyor's plane table, then sights taken and the directions ruled directly on a paper by running a pencil along the edge of the rule. The sighting arms of other instruments such as astrolabes, sextants, and theodolites are alidades. Telescopes were added to the alidade in the eighteenth century.

This plane table alidade/rule is constructed of brass inset into an ebony base and is 22 inches long overall. The sight vanes are 7 ¼ inches high. The rule is divided linearly from 0 to 24 and labeled "Due palmi Napolitani" (for two Naples hands), and mounted with hinged clampable sight vanes with elegantly shaped bases and clamp mechanisms. It is signed "Joseph Cirillo fecit A.D. 1789." Condition is good noting edge losses to the ebony, an old repair on one sight vane, and lacking one lug to one thumbscrew. It is a rare example of a local Italian instrument, designed for surveying in Southern Italy, by an unrecorded maker.







**Alidade, Italian.** The picture is from the famous 1748 work by Giovanni Battista Nolli, the *Nuova Pianta di Roma* and shows a *putto* using such an alidade on a plane table.

### Miners Dial, English, 3rd quarter 19th century

The miners dial is an example of a surveying instrument using an alidade for sighting. The miner's dial was used by a surveyor to establish the direction in which the mine's underground roadways and tunnels went. When using a dial, a fixed reference point was created (often using a plumb line fixed in the mineshaft). From this starting point a line is drawn to a second point along the tunnel being surveyed. The axis of the dial was laid parallel to this line and the compass bearing noted. The distance between the two points was also measured. The line would then be extended from the second point to a third, further along the tunnel, and the dial again used to measure the bearing. In this way the direction and length of the tunnel was measured.

This dial is signed in script on the silvered compass face "A. Reid, Edinburgh," and was undoubtedly made for use in the Scottish coalmines. Made of heavy polished lacquered brass, this miners surveyor's dial has a silvered compass face, circular bubble level, and 5" long edge bar needle in the 6 1/8" diameter lacquered brass compass housing. The brass base plate frame is 10" long, with twin 9" tall folding sight vanes and a fixed staff mounting underneath. This attractive mining dial is in very good overall condition noting some spots of wear to the lacquer. It is held in its original 11 1/4" x 7 1/2" x 4 1/4" fitted mahogany case with leather carrying strap. It includes the original breakdown mahogany tripod for the dial. The tripod can be used at full height or at half height if necessary in the mine.



**Miners Dial**

**Plumb Bob Level, American, c1800**

The plumb bob is an ancient tool that has remained virtually unchanged for thousands of years and is still in use today. It is made of the simplest possible parts; namely a string and a heavy weight. The weight, usually with a pointed tip at the bottom, is suspended by a string and gravity causes the attached string to establish a perfectly vertical line. It probably originated when early man first started building permanent settlements in order to determine that the stone walls of buildings were built truly vertical. The Egyptians used plumb bobs in wooden frames in their construction of pyramids, buildings, and canals. The plumb bob is a versatile tool and came to be used in astronomical, navigational, and surveying instruments. With a plumb bob level, the frame is placed parallel to the surface being measured allowing the worker to make a more precise visual judgment as to the trueness of plumb or horizontal level. Plumb bob weights being made of stone or metals often survived. Wooden frames or levels that may have been used with a plumb bob, however, are very rare.

This is an early and primitive standing level with line and plumb bob. It consists of a wooden board, possibly pine, that is 55 inches tall, 3 ½ inches wide and ¾ inch thick. The board has traces of red paint. The top has three indentations to hang the twine line. The body has a vertical line running its length. It still has an aged piece of twine or hemp cord. The plumb bob is lead, 2 inches long, and egg-shaped. There is a cutout in the level so the plumb bob can hang free and not rub against the board. This piece is in very good aged condition with an uneven base from wear.

**Geography****Newton's Terrestrial Globe, English, 1823**

Terrestrial globes were first made in Europe probably toward the end of the fifteenth century. The earliest globes were constructed for the use of scholars or explorers, to demonstrate particular theories or to show where a voyage had gone. The geographical discoveries at the end of the century helped popularize globes and they were used to publicize new discoveries and to teach the new geography.

This twelve-inch terrestrial desk globe is made of two hemispheres of papier-mâché, joined at the equator. It is covered with plaster and twelve full gores that are copper-engraved and hand-colored. The globe is mounted on a turned four-legged mahogany stand with stretchers. Overall the globe stands 18 inches tall. It is surmounted by a brass hour disc at the North Pole with a full brass meridian. The horizon band features a colored paper ring showing degrees of amplitude and azimuth, compass directions, days and months of the year, and the names of the signs of the zodiac. The large analemma is "An Improved Analemma shewing the SUN'S declination and place in the Zodiac for every day of the Year." The globe shows new information from the Lewis and Clark expedition. The tracks of major voyages of discovery including Capt. Cook's three voyages are shown and labeled. The Antarctic is blank with the notation "Jan 1773 Many Islands firm Fields of Ice" below the Antarctic Circle. The rectangular cartouche reads: "NEWTON'S New & Improved TERRESTRIAL GLOBE, Embracing every recent Discovery to the Present Time,



MANUFACTURED by J. & W. NEWTON 66 Chancery Lane" and below the cartouche "London Published July 1, 1823." The Newton family of cartographers were among the leading English globe makers of the early nineteenth century. The globe has several defects. The varnish has turned brown, there are abrasions to the varnish not affecting lettering, hairline fractures in the plaster, and a slice missing from the edge of the paper on the horizon band. Nonetheless, this is an intact, restorable example of an important globe.



Newton's Terrestrial Globe

## Communication

### Telegraph Key and Sounder, c1920

The telegraph is a system for transmitting messages from a distance along a wire, especially one creating signals by making and breaking an electrical connection. The Morse system of telegraphy was invented by Samuel Finley Breese Morse (1791 – 1872) in the 1840s in the United States. "Morse Code" is essentially a simple way to represent the letters of the alphabet using combinations of long and short pulses. A unique pattern is assigned to each character of the alphabet, as well as to the ten numerals and punctuation. These long and short pulses are translated into electrical signals by an operator using a telegraph key. An operator at the receiving instrument or sounder "copies" these electrical signals as letters, numbers, or punctuation.

The "key on board" or KOB consists of a telegraph key and a telegraph sounder mounted on a wooden board. KOBs have been produced since telegraphy began in the 1850s. They were



originally used for operator training and practice. The key is a simple bar with a knob on top and a contact underneath. When the bar is depressed against spring tension, it forms a circuit and allows electricity to flow to the sounder. The sounder consists of an electromagnet and an armature. When current flows through the electromagnet, a magnetic field pulls the armature down to strike the frame resulting in a “click.” When the circuit is broken by releasing the key, the armature returns to its original position striking the frame resulting in a “clack.” These sounds are used in the form of Morse code to construct a message.

This is a KOB with a telegraph key (right) and a telegraph sounder (left) mounted on a single wooden board. It is marked on the sounder arm “SIGNAL” for the Signal Electric Manufacturing Company, which was located in Menominee, Michigan. It dates to around 1920. The board measures 4 ½ x 7 inches and is marked 4 ohms. The holes in the board between the key and the sounder were used for affixing the KOB to a desk or table. The instrument is in good condition with some rusting to the metal.



Telegraph sounder (left) and key (right)

### Blickensderfer Model 5 Typewriter, 1893

The Blickensderfer typewriter was designed by George Canfield Blickensderfer (1850–1917) in 1892. The typewriter was far ahead of its time in that it was portable and used a type wheel. George Blickensderfer spent much time traveling by train while pursuing his conveyor business. He realized the need for a lightweight portable typewriter so that businessmen could type letters and invoices while traveling on the train or while in their hotel. Instead of the common mechanism with letters on the end of individual bars connected to the keys, the Blickensderfer uses a cylindrical wheel with letters embossed on it. Pressing a key causes the type wheel to turn positioning the correct letter, sending it in an arc down toward the platen, and brushing past an ink roller before striking the paper. The mechanism is very similar to the IBM Selectric design introduced decades later. Like the Selectric, one could easily change the typeface on a

## Non-Optical Instruments

Blickensderfer simply by changing the type cylinder. Early Blickensderfers were also notable for their keyboard layout. The bottom row of keys contained the most commonly used letters, DHIATENSOR, to increase efficiency. This keyboard was called the "scientific" keyboard. The Blickensderfer system dramatically reduced the complexity of typewriter design. A typical example contained many fewer parts than a standard typewriter. It was much smaller, lighter, and cheaper than other typewriters. It could be considered the laptop of its time. The first successful production model was the Blickensderfer 5, introduced at the 1893 World's Columbian Exposition. Models 1-4 may have been prototypes and no examples are known.

This is a Blickensderfer No. 5 portable typewriter in its original case. The metal label reads "No. 5, BLICKENSDERFER, STAMFORD, CONN., U.S.A." The typewriter has the DHIATENSOR keyboard and three rows of keys. There is a key for capital letters and one for numerals. The keys, carriage, slider, and all other parts of the typewriter are functional. There are three type wheels and two cases for the wheels built into the case. The last patent date is 1892 and the serial number is 88419. The oak case is 12 ¾ inches wide, 9 ¼ inches deep, and 6 ¾ inches high. The typewriter is in excellent condition with only slight rusting on a few metal parts in the back. The case was refinished at some point and the leather handle is broken.



**Blickensderfer No. 5 Typewriter**



### Western Electric Candlestick Telephone, 1918

A telephone is a communications device that permits two users to conduct a conversation when they are separated by a great distance and cannot be heard directly. A telephone converts sound, typically the human voice, into electronic signals suitable for transmission via cables or other transmission media over long distances, and replays such signals simultaneously in audible form to the user. As with other major inventions of the nineteenth and twentieth centuries such as the radio, television, light bulb, and computer, there were several inventors who did pioneering experimental work that led to a workable model. Several people did pioneering work on voice transmission over a wire and improved on each other's ideas, but Alexander Graham Bell was the first to be awarded a United States patent for an electric telephone in March 1876.



Western Electric Candlestick Telephone

The candlestick telephone was made by the Western Electric Company. Western Electric was an American electrical engineering and manufacturing company and the supplier to AT&T from 1881 to 1995. The candlestick telephone is a style of telephone that was common from the late 1890s to the 1930s. Candlestick telephones featured a mouth piece (carbon granule transmitter) mounted at the top of the stand, and an ear piece (electromagnetic receiver) that was held by the user to the ear during a call. When the telephone was not in use, the receiver rested in the fork of the switch hook protruding to the side of the stand, thereby disconnecting the audio circuit from the telephone network. Candlestick telephones required the nearby installation of a subscriber set or ringer box which housed the ringer to announce incoming calls and the electric circuitry (capacitor, induction coil, signaling generator, connection terminals) to connect the set to the telephone network. In the early days, businesses, banks, depots, and installations requiring multiple telephones and lines were equipped with various ringers such as round bells, cow bells



and liberty bells producing distinctive sounds so users could tell which phone to answer. When automatic telephone exchanges were introduced, the base of a candlestick also featured a rotary dial, used for signaling the telephone number of an intended call recipient.

This is a Western Electric solid brass dial candlestick telephone. The last patent date on the side of the base is 1918. The phone is 11 ½ inches high. The upright, base, and mouthpiece are polished brass. The dial is a Western Electric #4 that clicks when rotated. The finger wheel is polished solid brass. The ringer box is oak and bears sleigh bell ringers, the rarest type of ringer. The phone was restored by Richard R. Marsh. All of the cords have been replaced with cloth cords. The phone has been supplied with a modern modular line cord that can be plugged into a modular jack to make the phone functional.

### **Atwater Kent Model 40 Radio, 1928**

Radio is the wireless transmission of signals from a transmitter through space by electromagnetic radiation. The electromagnetic wave (radio wave) is intercepted by a receiving antenna. A radio receiver receives the radio waves and converts the information carried by them into sound. The development of the radio was an incremental process based on many discoveries and inventions in the nineteenth century. There are several claimants for the first workable wireless radio, although credit is usually given to Guglielmo Marconi (1874–1937).



**Atwater Kent Model 40 Radio and E3 Speaker**

Arthur Atwater Kent, Sr. (1873–1949) was an American inventor and prominent radio manufacturer based in Philadelphia. His business was called the Kent Electric Manufacturing

Company, which he began in the back room of his father's machine shop, and from which he sold small electric motors, generators, fans, and later automobile ignition systems. In 1921, Kent produced his first radio components, selling the do-it-yourself kits consisting of "breadboards" that could be assembled by early radio enthusiasts. In 1923, the Atwater Kent Manufacturing Company started producing complete radio sets and by 1925, it became the largest maker of radios in the United States. Atwater Kent radios were of high quality and the onset of the Great Depression greatly hampered sales of Atwater's premium radio sets. Kent dissolved his design engineering facility in 1931 and shut down his radio factory in 1936.

This is an Atwater Kent Model 40 AM tabletop radio, serial number 2775504, made in 1928. It uses a tuned radio frequency (TRF) amplification type receiver with a tuning knob and volume knob. Power is AC, one of the first to use AC, and voltage is 110 volts. It has seven tubes: 26 (4), 27, 71A, and 80 and there is an extra set of tubes. The receiver is in a metal cabinet 17 x 10 x 7 inches in size. The speaker is an Atwater Kent E3 serial number 442106 and is 11 inches in diameter. The radio is in excellent condition. The cords for the radio and speaker are original and worn and the connection to the speaker is loose. There is a small tear in the cloth at the back of the speaker. With a long copper wire antenna, reception is excellent.

## Philosophical Instruments

In the eighteenth century, philosophical instruments referred to apparatus that was used to make observations and discoveries in nature and to perform experiments for developing and exhibiting natural forces. The fields in which philosophical instruments were used included mechanics, magnetism, pneumatics, models of the heavens, hydrostatics and hydraulics, heat and meteorology, spectroscopy, electricity, sound and light, and optics. Lectures using a large quantity of instruments were given to demonstrate physical effects both at universities and as a form of popular entertainment for the public. The instruments were also used in scientific research that led to constant improvement in their function. In 1789, Yale had a philosophical cabinet for teaching a course of Experimental Philosophy and Astronomy that included an air pump, reflector, a complete set of surveying instruments, brass quadrant, microscope, electrical machine, and planetarium. A representative from Yale was sent to London and spent £300 to purchase additional instruments for the cabinet. The term philosophical instrument is not widely used today but such instruments are still used today in both teaching and research.

### Nairne-Type Electrostatic Generator, c1790

An electrostatic generator, or electrostatic machine, is a mechanical device that produces static electricity, or electricity at high voltage and low continuous current. Development of electrostatic machines began in earnest in the eighteenth century, when they became fundamental instruments for studies in the new science of electricity. Electrostatic generators operate by transforming mechanical work into electric energy. The charge is generated by one of two methods; either the triboelectric effect (friction) or electrostatic induction.

Edward Nairne (1726-1806) was an optician and scientific instrument maker. He did his apprenticeship with Matthew Loft. He worked on his own from 1749 until 1774 when he entered into partnership with Thomas Blunt. Nairne patented several electrical machines, including in 1782 a "Nairne Patent Medical Electrical Machine." The device consisted of a glass cylinder mounted on glass insulators and could supply either positive or negative electricity and was intended for medicinal use. In the eighth edition of the instruction manual for this device he claimed that "electricity is almost a specific in some disorders, and deserves to be held in the highest estimation for its efficacy in many others." He recommended its use for nervous disorders,

bruises, burns, scales, bloodshot eyes, toothache, sciatica, epilepsy, hysteria, agues, and other ailments.

This is a Nairne-type electrostatic friction generator of the cylinder type. The machine is 16 ½ inches long, 8 ½ inches wide, and 11 inches high. It consists of a base with two uprights at the ends supporting a 10 x 7 inch blown glass cylinder with extensions on each end fitted into turned wood sheathed caps. Two uprights on a long side hold a wooden bar with attached leather friction pad against the cylinder. A hand crank turns the cylinder against the friction pad. A tray rests on the base beneath the cylinder. All of the wood parts are made of mahogany or other hardwoods. A glass pillar, possibly broken off, holds a brass conductor. There are several accessories including brass pieces with wooden handles to apply charge to a patient's skin. A T-shaped brass conductor is mounted on a turned wood stand. A small cardboard container contains mercury used to smear with lard on the surface of the leather pad. A silk apron was placed over the cylinder to prevent escape of electrification from the glass. A brass clamping screw that attaches to the base and with a string permits adjustment of the frictional pressure offered by the cushion against the glass cylinder. The machine has its original wooden case with iron handles at each end and painted in a mustard color. The machine is intact and in good condition in view of its age. There are some cracks and splits in the wood fixtures. Plaster is missing on one crank handle collar. This machine came out of the earliest house in Holyoke, Massachusetts.



**Nairne-Type Electrostatic Generator**

**Wheel Barometer, c1840**

One class of philosophical instruments demonstrated effects of heat and meteorology. For example, an apparatus showing the effects of heat was the thermoscope, devised by Galileo around 1592, which used a column of water in a spiral glass tube which rose as air in a bulb expanded with heat. The thermometer, derived from the thermoscope, is used to measure temperature. The hygrometer, devised by Robert Hooke in 1663, demonstrates the humidity of the



air. The barometer, invented by Evangelista Toricelli of Florence Italy in 1643, is designed to measure the pressure or weight of the air. These instruments did not become widely available to the general public until 1800. In the nineteenth century, they were often combined in attractive mahogany cases.

This is a five dial wheel or banjo barometer measuring 39 inches high by 10 inches wide. It is in a banjo-shaped, mahogany-veneered case with boxwood stringing to the edge and a swan neck pediment and brass finial. The top dial is a hygrometer with silvered and engraved scales showing Damp/Dry. Next is the spirit thermometer on a silvered brass plate with various levels of temperature engraved on it. The third is a three-inch diameter mirror in a wood surround. The fourth is the barometer with a silvered and engraved eight-inch dial, showing the weather patterns and labeled Chanóe. Just beneath the dial is a turn key for the Rise/Fall indicator on the dial (knob missing). The last dial is the spirit level. The barometer mechanism is enclosed behind a door in the rear of the case. Wheel barometers are mercury column barometers operating with a "J" tube. A float in the mercury column rises and falls with changes in air pressure. The float is tied on a string that goes over the wheel and is held taught by a counterweight. As the wheel turns, the hand on the dial is moved giving the reading. There is a paper label pasted on the back explaining use of the barometer. The barometer is very attractive and in generally good condition. A defect is that the wooden scrolls on the pediment are missing and have been remodeled in clay and painted. The mercury tube and wheel mechanism in the case are intact.



**Wheel Barometer**

## **Machines**

A machine is a tool containing one or more parts that uses energy to perform an intended action. A simple machine (lever, wheel and axel, pulley, inclined plane, wedge, and screw) is a non-powered mechanical device that changes the direction or magnitude of a force. Renaissance scientists regarded the simple machines as the elementary "building blocks" of which all more complicated machines are composed. Perhaps the first example of a human made device designed to manage power is the Acheulean hand axe, made by chipping a stone to form a wedge. Machines today are usually powered by mechanical, chemical, thermal, or electrical means, and are often motorized.

### **Medieval Iron Bearded Axe Head, 1000-1300 AD**

The axe is an example of a simple machine, as it is a type of wedge. The wedge functions by converting a force applied to its blunt end into forces perpendicular (normal) to its inclined surfaces. It can be used to separate two objects or portions of an object, lift up an object, or hold an object in place. The first example of the wedge is the Acheulean hand axe. When used for cutting

or splitting wood, the handle of the axe also acts as a lever allowing the user to increase the force at the cutting edge.

This is an iron axe head from the European medieval period, 1000-1300 AD. This type of axe is referred to as a bearded axe because the cutting edge extends below the width of the butt to provide a wide cutting surface while keeping the overall weight of the axe relatively low. The top is relatively straight from the butt to the toe of the blade. The 4 ½ inch blade curves downward slightly to the rear. The beard of the axe from the heel of the blade is straight inclining upwards before curving upwards sharply to the narrow eye. The length of the axe is 7 ½ inches. There appears to be a maker's or armourer's mark resembling a "W." Many axes doubled as tools and weapons. This type of axe is most closely associated with the Vikings. It is in generally very good condition with slight pitting and rusting.



**Medieval Bearded Axe Head**

### **Singer Model 12 Sewing Machine, 1885**

A machine is a tool containing one or more parts that uses energy to perform an intended action. A sewing machine is a machine used to stitch fabric and other materials together with thread. In 1790, the first workable sewing machine was invented and patented by the British inventor Thomas Saint. Saint's machine, however, never progressed beyond the patent model stage. In 1830 a French tailor, Barthelemy Thimonnier (1793-1857), patented the first practical sewing machine. By 1841, eighty of his machines were being used to sew uniforms for the French army. However, his factory was destroyed by a mob of tailors, who saw the new machines as a threat to their livelihood. Elias Howe (1819-1867) of Massachusetts originated significant refinements to the design concepts of his predecessors, and on September 10, 1846, he was awarded the first United States patent for a sewing machine using a lockstitch design. Howe could not find investors for his machine in America and England. Other entrepreneurs began manufacturing sewing machines, all infringing on some part of his 1846 patent. In 1851, Issac M. Singer (1811-75) patented the first rigid-arm sewing machine. Parts of Singer's new machine were based on Howe's work. Singer was sued by Howe for infringement of the latter's patent rights, but a compromise was reached where Singer paid Howe a royalty. Both men became extremely



wealthy. Singer's company became the world's largest manufacturer of sewing machines by 1860. He was awarded 20 additional patents, spent millions of dollars advertising his machine, and initiated a system of providing service with sales. By the 1850s, Singer sewing machines were being sold in opulent showrooms. Because the \$75 price was high for the time, Singer introduced the installment plan to America and sold thousands of his machines in this way.

The sewing machine gained popularity amid the industrial boom in America. It sped up the production of everything with stitching—from umbrellas to tents—and most especially clothing. Ready-made clothing replaced the idea of owning only a few items of clothing. Increased efficiency meant cheaper costs of production and, along with a rise in fashion, people began to own more mechanically-stitched clothes. As evidenced by the dramatic increase in production and decrease in time it took to make articles of clothing, the sewing machine revolutionized the modern world. The sewing machine also produced a revolution in household labor by offering women a relief from the countless hours and tedium of hand sewing.

This is a Singer Model 12 sewing machine. The serial number is 6732654 showing it was made in 1885 in the Singer factory in Elizabeth, New Jersey. The Singer New Family Sewing Machine or Model 12 came onto the main market towards the end of the American Civil War in 1865 and lasted until 1902. It was one of the first reliable and easy to use lockstitch sewing machines. It would become the best selling machine of the age and was imitated by most other manufacturers. This example was portable and fits into a walnut case. It is made of cast iron painted in Japan black lacquer. These machines are known as fiddlebacks because of the shape of the base. It is operated by a hand crank. Singer applied decorative decals to his machines but did not name them. Collectors later assigned names to the patterns and this is known as "Acanthus Leaves." Almost all of the decals are intact with only wearing in one corner where cloth was pushed in for sewing. The machine is complete with shuttle, needle, and bobbin. It is in excellent condition and functional and can sew. The case is 17 x 10 x 11 inches.



Singer Model 12 Sewing Machine



## Microscopy Accessories

### Miscellaneous

- Slide-Making Outfit and Zentmayer Student Microscope, American, 1879
- Folding Portable Microscope and Slide-Making Outfit, W. F. Stanley, c1890
- Microscope Table, The Adjustable Table Co., Grand Rapids, Michigan, c1905

### Microtomes

- Valentin Knife
- Hand microtome, c1880
- Bench microtome, c1880
- Table microtome, c1880
- Microscopic Section Cutter, c1880
- Microtome Knife, c1900, Arthur H. Thomas Co., Philada, U.S.A. Blade with handle.
- Cambridge Rocking Microtome, c1900. The Cambridge Scientific Instrument Co Ltd, Cambridge, England
- Cambridge Rocking Microtome, Knife, Cambridge Instrument Co., Ltd., Cambridge, Wilkinson Sword Co Ltd, Made in England
- Bausch & Lomb Minot Microtome, Arthur H. Thomas Co., 1904
- Minot-pattern Rotary Microtome, Spencer Lens Co., Buffalo, 1929
- Wiebach & Pietzsch Lever Microtome, Philadelphia, c1895
- Bausch and Lomb / Arthur H. Thomas Sliding Microtome, 1905
- Spencer Sliding Microtome, Model 860
- Ivan Sorvall Servall Microtome, 1953
- Porter-Blum MT-1 Microtome

### Projection Instruments

- Solar Microscope, c1772
- Cary Camera Lucida, c1810
- McAllister Magic Lantern, 1886
- Baird Magic Lantern, c1890
- Lantern Slide Projector, Bausch & Lomb Model C Balopticon, Rochester, c1905
- Projection Microscope, Williams, Brown, & Earle, Philadelphia, c1900
- Projection Microscope, Bausch & Lomb, 1<sup>st</sup> quarter 20<sup>th</sup> century

### Lighting Devices

- Candle Lamp
- Bockett Kerosene Microscope Lamp, Collins London, c1875
- Kerosene Microscope Lamp, c1880
- Brass Electric Lamp, 1909
- Candle Holder and Shade, c1820
- Mechanical Arc Lamp, Bausch & Lomb, c1925

### Other Accessories

- Slider Holder
- Slide Ringing Table
- Stage Forceps
- Aquatic Box
- Fish Plate
- Compressorium
- Livebox

### Nineteenth Century Microscope Setups

The microscope was not appreciated as a useful scientific instrument until the middle of the nineteenth century. Some notable discoveries had been made with the microscope, especially Hooke's observation of capillaries connecting arteries and veins in 1665. This confirmed

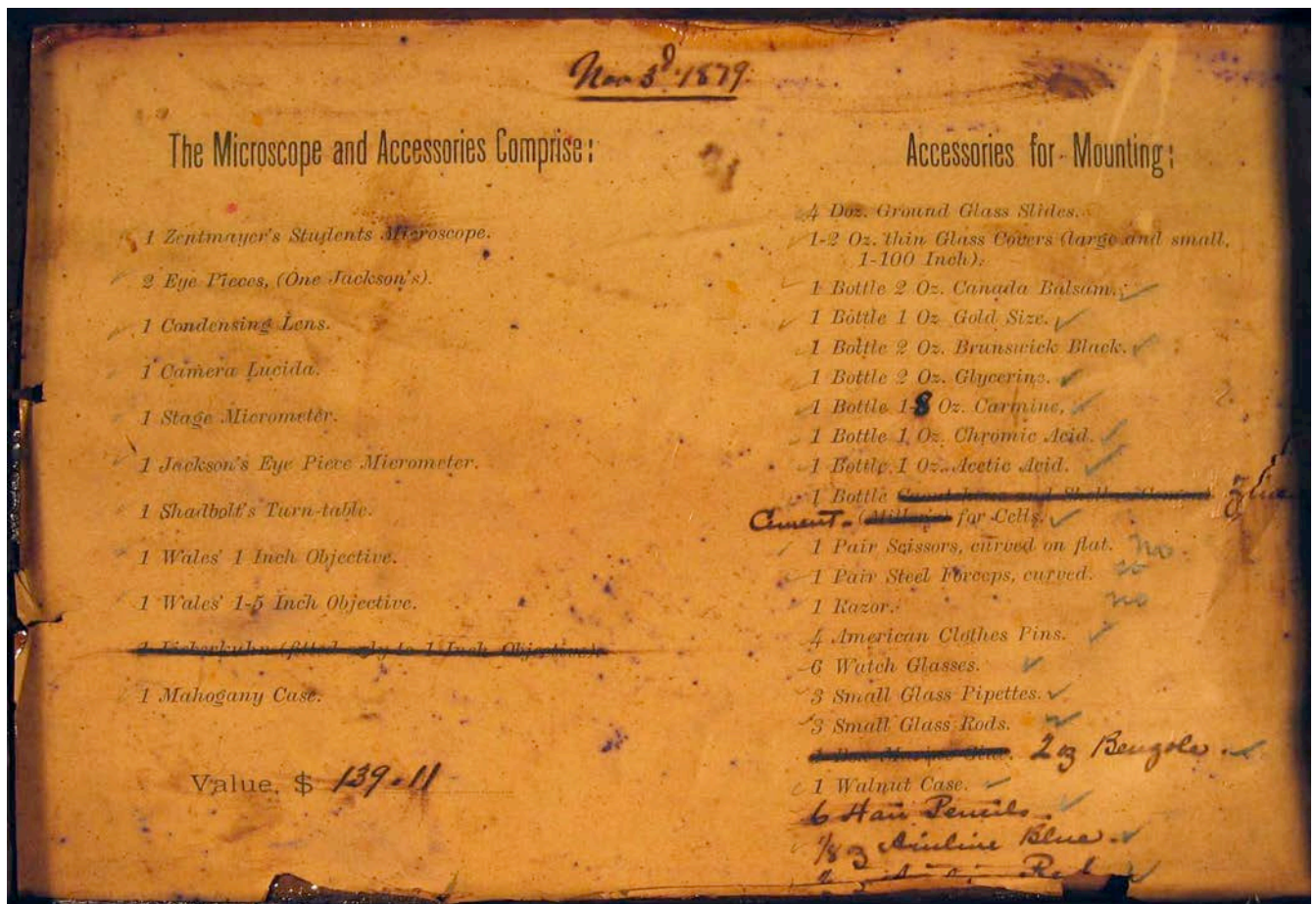
Malpighi's hypothesis of the continuous circulation of blood. Leeuwenhoek observed spermatozoa with his simple microscopes. However, there were no descriptions of tissues and their cells. This was largely blamed on the aberrations and low resolution of the early microscopes. Early observers did observe and publish pictures that showed considerable details of whole objects such as fleas and other insects. The fact that there was no information on tissues was not due as much to defects in the optics of the microscope, but to the lack of methods for adequate fixation and sectioning of tissues. With a modern slide, the basic structure of a tissue is easily observed with the early microscopes. Hooke made his observations on the thin tail fin of a fish. Fish plates for the observation of the circulation in the tail of the fish were supplied with microscopes from around 1700 until the end of the 19<sup>th</sup> century. Similarly, the first electron micrographs of cells by Keith Porter were made on intact thin tissue culture cells. It was not until the middle of the 19<sup>th</sup> century when effective techniques for thin sectioning of tissues became available that it became possible to accurately describe the detailed structure of tissues and cells. Similarly, the subcellular structure of cells was not clearly discerned with the electron microscope until the development of adequate fixation, embedding, and sectioning by the ultramicrotome.

### American slide making kit and Zentmayer Students microscope, 1879

This is a slide-making kit and Zentmayer Students Microscope that were sold as a set. The label glued within the lid of the chest has a hand-written date of November 3, 1879, and the same hand records the sum of \$139.11 following the printed word "value." The label lists the contents of the cabinet and accessories for the microscope. Not all of these are present and there are additions and replacements. Labeled bottles are Oil of Cedar Wood, Gold Size, Canada Balsam, and Alcohol. Stains made by Dr. G. Grubler & Co., Leipzig are Hämatoxylin pur cryst, Scharlach R. (Michaelis), Crystallviolett, Malachitgrün, Fuchsin S, and Hämatein purise. This set is important because it illustrates the types of materials used for slide making at that time in America. The Students Microscope was reported in the American Naturalist in 1877. This microscope is in exceptionally fine condition and has its own case.







Stanley Folding Portable Microscope and Slide-Making Outfit





Stamped in the lid "W.F. STANLEY, OPTICIAN." The mahogany case has a hinged drop-front and ten drawers (1 for tools and 9 for completed slides). The case contains many separate items, including a bull's eye condensing lens on a table stand, three objectives for the microscope, folding brass slide warming table, 5 empty chemical bottles, some small tools and supplies, and 54 finished slides filling the 9 slide trays. The accompanying folding portable microscope is made of black oxidized brass, with polished lacquered brass fittings, and stands 9 ¼" tall on its folding tripod base. The microscope is in very good overall condition in its original fitted mahogany case.

The W.F. Stanley Company was started in 1853. They were the largest and best engineering instruments dealer (drafting, surveying, etc) in England, but they also sold meteorological instruments, telescopes & other optical instruments, and some microscopes.

### Microscope Table, The Adjustable Table Co., Grand Rapids, Michigan, c1890



This is a table designed for use with Victorian microscopes and library telescopes. The table has a very heavy cast iron base with three cabriole style legs with wheels. The height is adjustable by faucet handles. The table is 27 inches high (adjustable), 23 ½ inches long, and 15 inches wide. The rotatable top is walnut framed milk glass for easy cleaning.

### Microtomes

A microtome (from the Greek *mikros*, meaning "small", and *temnein*, meaning "to cut") is a sectioning instrument that allows for the cutting of extremely thin slices of objects to be examined under the microscope. The ability to make sections of tissues

was equally important to the advancement of histology as improvement in the optical qualities of microscopes. Prior to the development of the microtome, objects to be examined with the microscope were sliced with a knife or razor, teased apart, or compressed. The first book substantially devoted to microscopy was Robert Hooke's *Micrographia* published in London in 1665. With a finely sharpened knife, Hooke cut very thin slices of cork and observed its porous structure calling the holes "cells." About a century after Hooke published his researches, the first microtomes for systematically cutting specimens for the microscope were developed. The first microtome was constructed for John Hill to make specimens described in his book on the structure of timbers (1770). The instrument resembles a pepper mill with a cam-shaped blade at the top for cutting sections of wood. Hill also introduced methods for fixation, clearing, and staining. Unfortunately, these methods were ignored until they were rediscovered separately decades later. In the first half of the nineteenth century, the Valentin knife and simple hand, table, and bench microtomes became available for sectioning. Other designs of microtomes were developed but their use remained very rare until the second half of the nineteenth century. The expansion of universities and the development of research laboratories, together with improvements in the optical qualities of microscopes, created an expanding market for microscopes in the nineteenth century. The scale of manufacture increased enormously in the closing decades of the century and microtomes likewise were being designed and manufactured for biological and medical work. Numerous different designs of microtomes were produced. Many are very fine mechanisms and still functional today.

The three main types of microtomes are the rocking, the rotary, and the sliding microtome. Each type of microtome has a special sharp steel knife to cut the specimen, which is usually embedded in a paraffin or celloidin block. In a rocking microtome, the knife is in a fixed horizontal position. The block is attached to the end of an arm pivoted near the knife and is moved or rocked in an arc past the knife edge. On a rotary microtome, the specimen moves up and down in a vertical plane. A large hand wheel in which one rotation produces a complete cutting cycle advances the specimen. A sliding microtome has a fixed specimen holder and the knife slides back and forth on a slide way. All three types of microtomes are still manufactured today.



**Valentin Knife**

The Valentin knife was invented in 1838 and for 20 years was virtually the sole instrument for sectioning animal tissues. It is a double-bladed knife and the distance between the two blades, and hence the thickness of the section, could be adjusted by two thumb screws. The section was made by a smooth pass of the knife through the specimen embedded in cork or carrot. The knife remained in use up to the twentieth century. This knife is  $7\frac{3}{4}$  inches long with an ivory handle. It is signed Weedon London and has its own case.



**Hand microtome**



**Bench microtome**



**Table microtome**

The hand microtome was one of the first microtomes introduced in the mid-nineteenth century. The bench microtome was clamped onto a laboratory bench. The table microtome consists of a heavy base and a round platform supported by pillars. These microtomes operated in the same manner. In the center, there is a tube containing a piston raised by turning a screw at the bottom. A piece of cork, carrot, or pith containing the specimen sat on top of the piston. As the specimen was raised, a knife was passed by hand across the platform and through the specimen to make a section. Some histologists became very adept with the use of these and continued to use them even after more sophisticated microtomes became available.

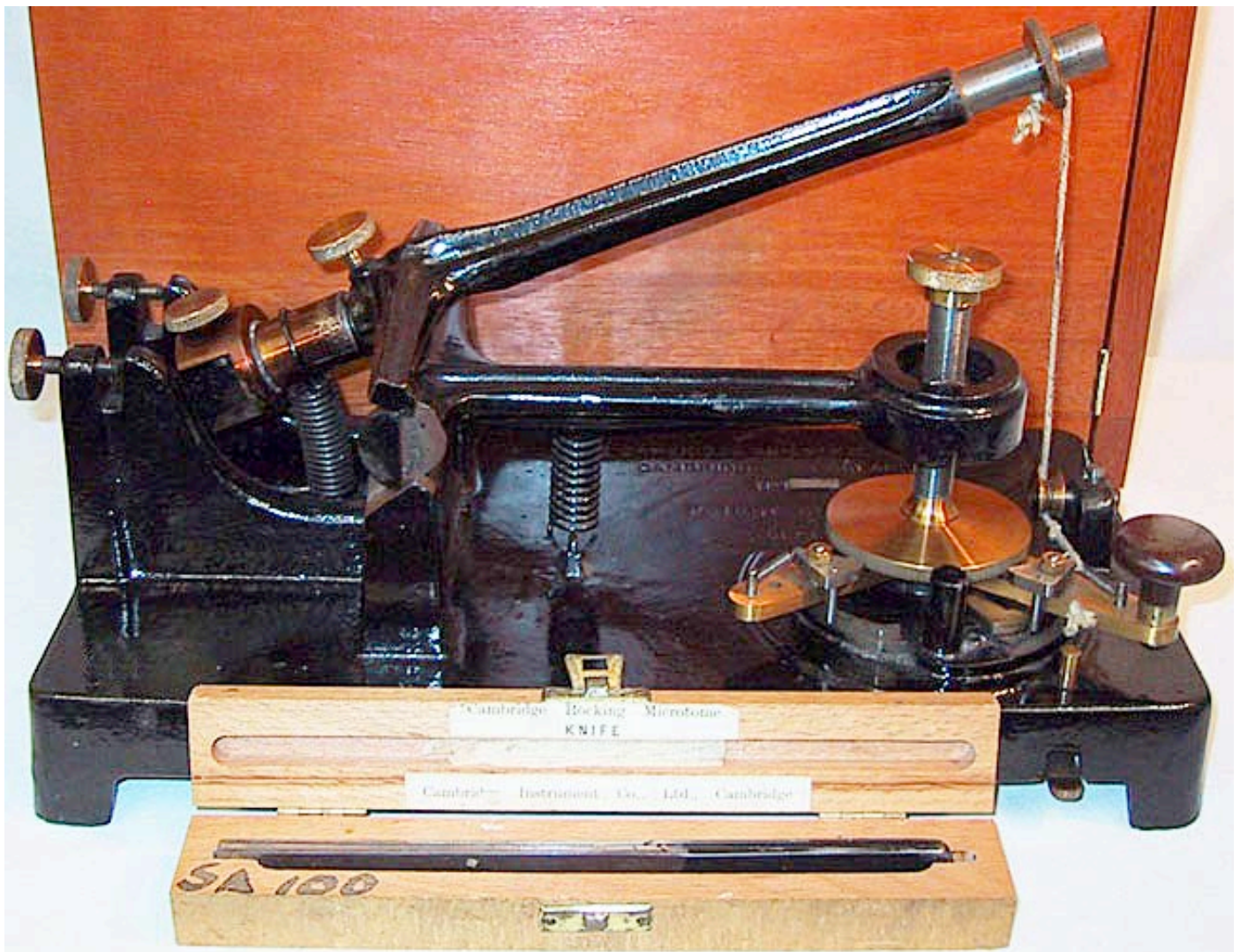


**Microscopic Section Cutter, c1880.**



Special knives were made for use with these hand microtomes. The "Microscopic Section Cutter" is a folding knife with a curved blade for collecting the specimen. Another example (not shown) of a blade with a handle is by the Arthur H. Thomas Co., Philadelphia, c1905.

**Cambridge Rocking Microtome and Knife, 1899**



The Cambridge Rocking Microtome, or Cambridge Rocker, is one of the most famous of all microtomes. First designed in the 1880s, it and the Minot microtome were based on the new principle that the object moves to and fro rather than the knife. It was designed by Horace Darwin, younger son of the famous Charles. The rectangular main frame stands on four short

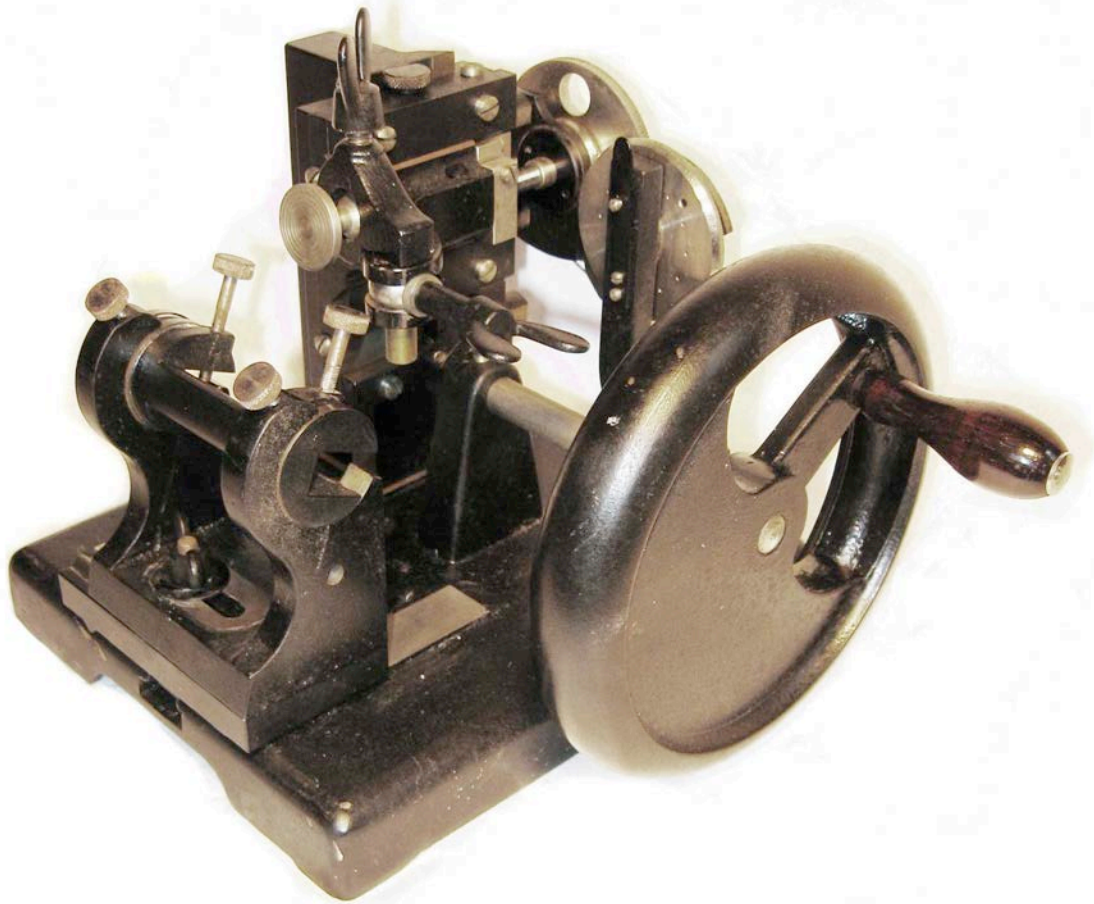


legs. There are two levers, a specimen holder, and a knife holder. The instrument is operated by a hand lever which drives the ratchet and pulls the tail of the upper lever down, ultimately advancing the specimen holder toward the knife. Construction is of cast iron with small parts made of brass. It was very popular because of a high degree of accuracy and reliability and relatively low cost. It could cut serial sections and sections as thin as 2  $\mu\text{m}$ . It comes with Cambridge Rocking Microtome, Knife, Cambridge Instrument Co., Ltd., Cambridge, Wilkinson Sword Co Ltd, Made in England.

### **Bausch and Lomb/Arthur H. Thomas Minot Rotary Microtome, 1904**

The Minot microtome is constructed on the basis of a stationary knife and a block with the specimen moving up and down and advancing at the top of each stroke produced by turning a wheel. Charles Sedgwick Minot (1852-1914) was the James Stillman Professor of Comparative Anatomy at the Harvard Medical School and was best known for his research and textbooks of embryology. He designed an automatic rotary microtome in 1886. It became the model for most subsequent microtomes. This microtome differs little from the original and was manufactured unchanged for many years.

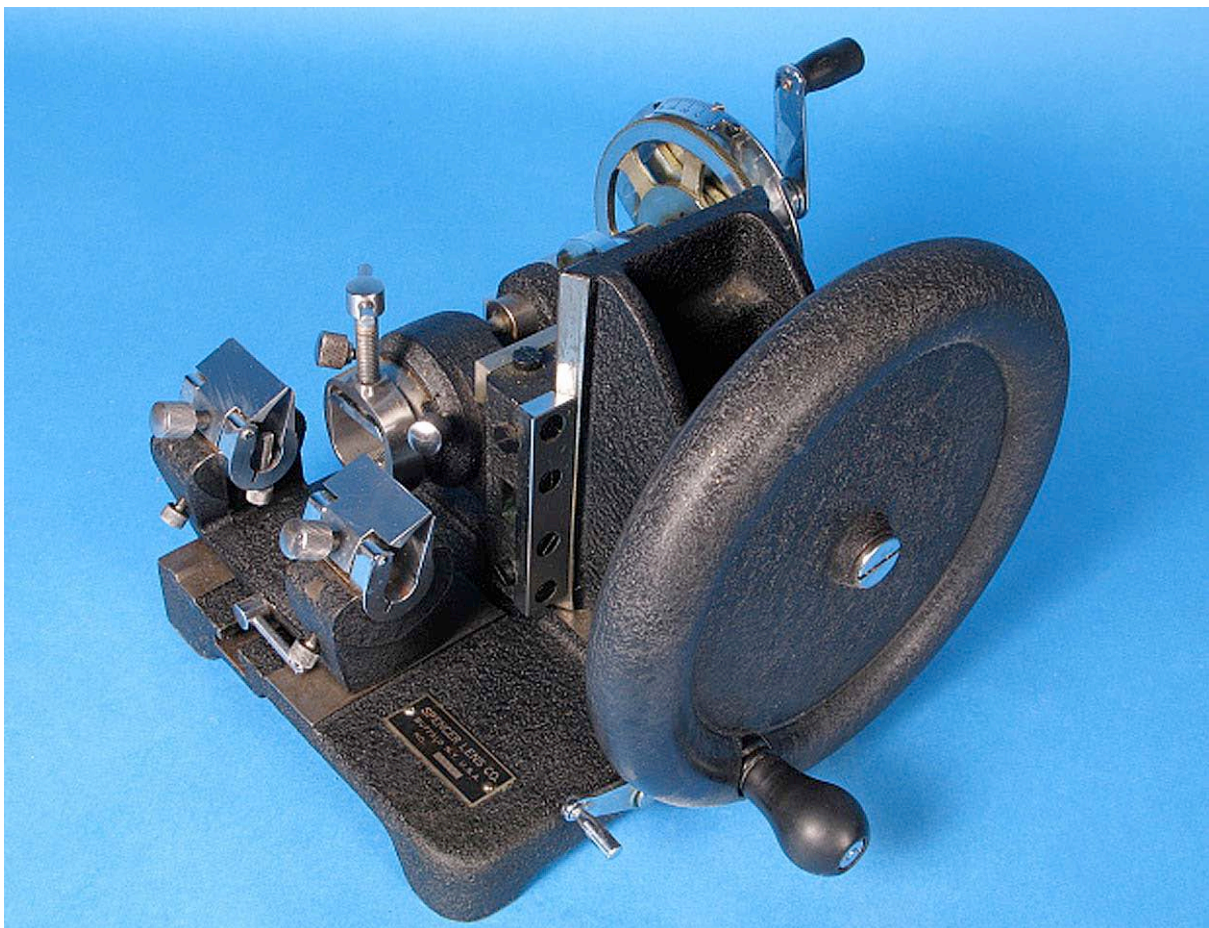
In 1892, Arthur H. Thomas joined the microscope department of the James W. Queen Company, a leading supplier of optical and scientific equipment in the second half of the nineteenth century. It is there that he met Mr. J. Edward Patterson, who had joined the company in 1890. After the death of Mr. Queen, the business began to decline, causing many employees to leave for other businesses or to start their own. In 1899, Mr. Thomas left to start his own company and Mr. Patterson joined Charles Lentz & Sons, who were agents for the Bausch & Lomb Optical Company.



Mr. Patterson would often visit Mr. Thomas and cooperation between the companies continued. This eventually led to a landmark meeting on December 7, 1900 at the Hotel Walton in Philadelphia. In attendance were Mr. Thomas, Mr. Patterson, William and Charles Lentz, along with William Drescher and Henry Bausch of the Bausch & Lomb Company. A new company and partnership was organized and incorporated as the Arthur H. Thomas Company. William Howell, who had also been at the Queen Company, joined the group as head bookkeeper and the company opened its place of business in the Freeman building at 12th & Walnut Streets in Philadelphia. The first customer was Frank J. Keeley (see Keeley slide collection under slides.)

The instrument is constructed of blackened cast iron with nickel plated fittings. It has a square base, a hand wheel, an automatic feeding mechanism comprising a micrometer screw driven by a ratchet wheel and steel pawl, a specimen holder block, and a knife holder with two clamps for gripping the knife blade. The drive wheel has a wooden handle. This microtome is labeled "BAUSCH AND LOMB OPTICAL CO., ROCHESTER, N.Y., MADE FOR ARTHUR H. THOMAS CO., PHILADELPHIA, PA., No. 6325." A wheel is stamped "Pat. July 26. 04."

### Spencer Minot-Pattern Rotary Microtome, Model 815



The Spencer Lens Company was founded by Herbert R. Spencer (1849-1900) in 1895. The company was the continuation of the firm established in the 1840s by his father, Charles A. Spencer (1813-1881), who was one of the first American microscope makers. In 1935, it was bought by the American Optical Company. The microtomes made by the Spencer Lens Company and American Optical were probably the most popular and successful microtomes. Every histologist

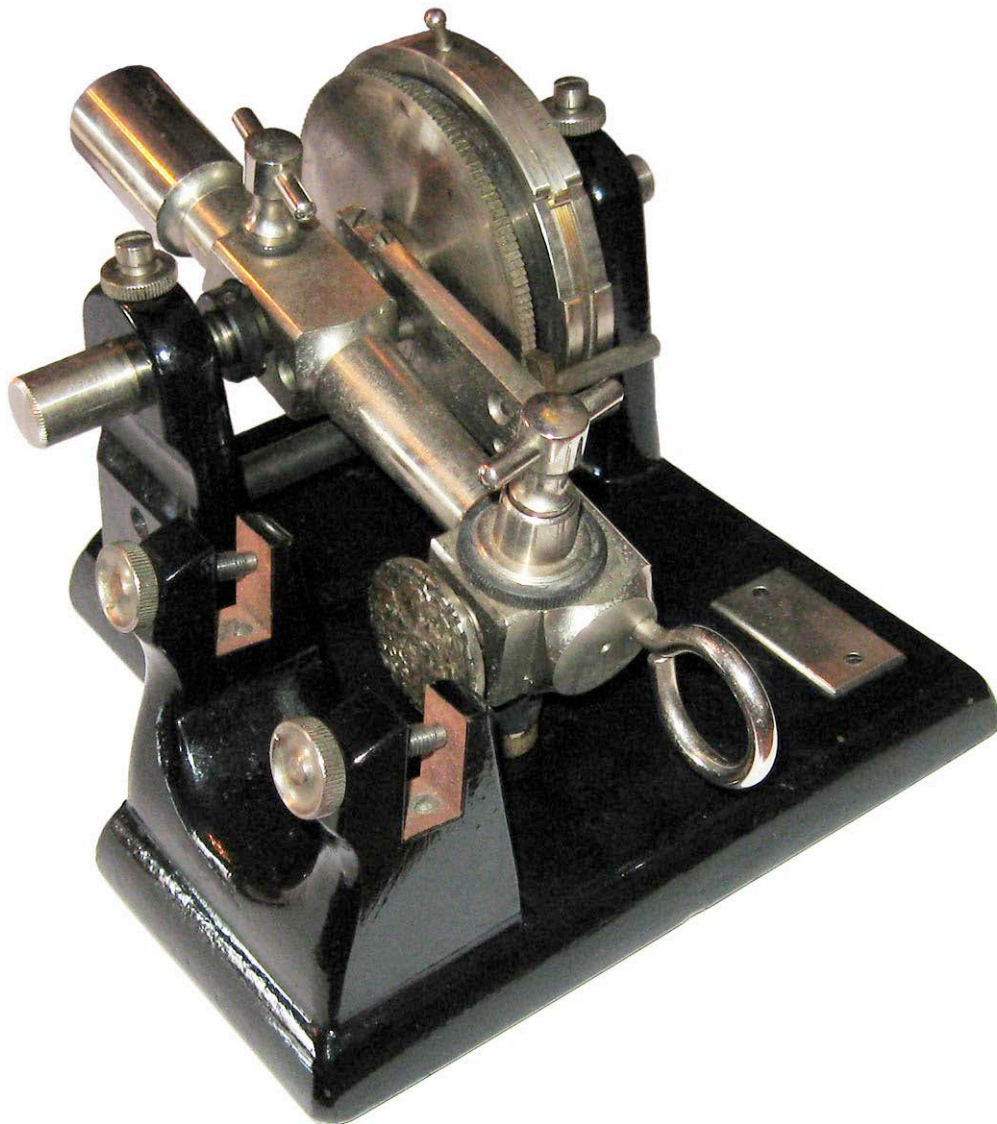


of the twentieth century was familiar with the black Spencer rotary microtomes. This model differs little from the original Minot microtome.

This microtome is another example of the Minot rotary automatic microtome. This is model 815. The instrument is constructed of blackened cast iron finished in black enamel with nickel-plated knobs and levers. It has a square base, a hand wheel, an automatic feed mechanism comprising a micrometer screw driven by a ratchet wheel and steel pawl, a specimen holder block, and a knife holder. Any thickness may be cut in multiples of two microns up to 40 microns. The object holder moves on a vertical slide actuated by a crank on the drive wheel. It bears a metal tag with Spencer Lens Co., Buffalo, N. Y., USA. It cost \$175.

Interestingly, all of the types of microtomes in this collection, the hand microtome, bench microtome, table microtome, rocking microtome, sliding microtome, and rotary microtome, are still manufactured today. This attests to their good design and functionality.

**Wiebach & Pietzsch Lever Microtome, c1895**





This is an automatic lever microtome for paraffin sectioning. It was sold by Edward Pennock who ran a scientific instrument company and previously worked for Queen & Company. The microtome is a modification of a microtome designed by John Adams Ryder in 1887. Ryder was a professor of Histology and Embryology in the School of Biology of the University of Pennsylvania. He designed a relatively simple and inexpensive microtome meant primarily for the use of students. The main casting is formed of cast iron with black lacquer finish. The rest of the instrument is nickel-plated brass. The central lever can be lifted by the ring at the end near the specimen holder to drive the ratchet and ratchet wheel. The instrument is stored inside an oak case with a handle and a celluloid label for Edward Pennock, Philadelphia. The case is 6 1/4 x 10 x 8 1/16 inches.

**Bausch and Lomb/Arthur H. Thomas Sliding Microtome, 1905**



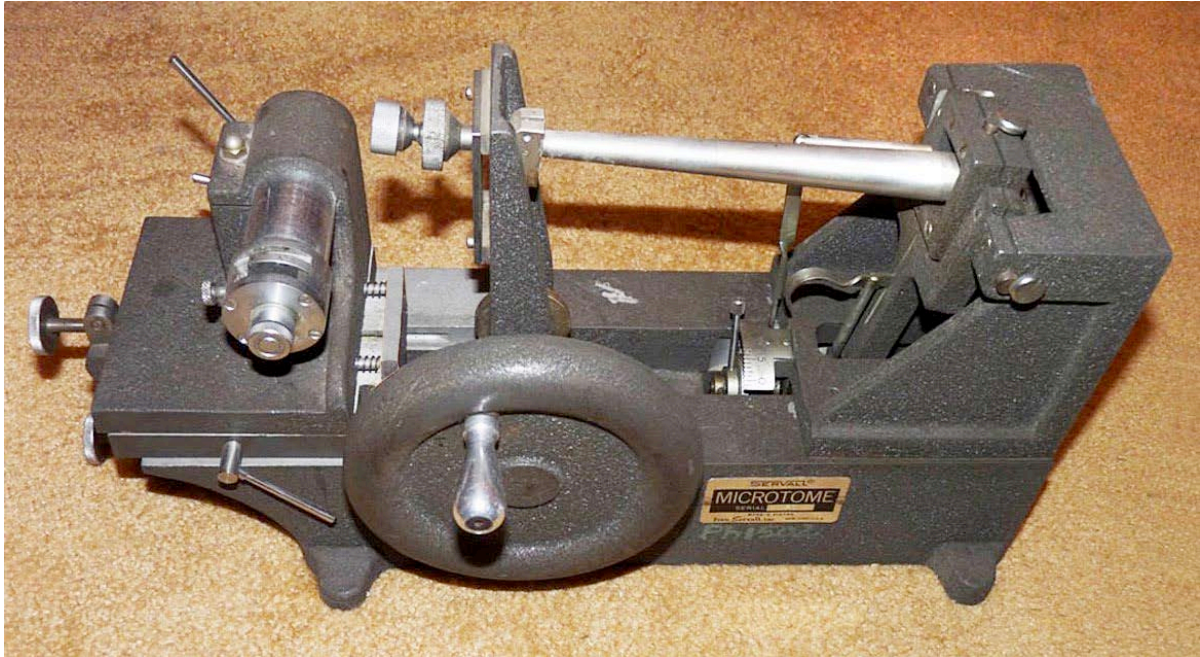
This sliding microtome is labeled Bausch & Lomb Optical Co. and Arthur H. Thomas Co., No. 4411. A label on the case says "From Edward Pennock, Optical and Other Scientific Instruments, Philadelphia." This type of microtome was brought out by Bausch & Lomb around 1885 and this example was made circa 1905. It is called a student microtome by B & L. The microtome has a screw rise for the object and a knife attached to a sled or sledge which slides in a V-shaped groove to pass the knife through the object which is held in a clamp. The microtome could be used for making frozen sections and there is a copper pan for catching any drops of water. A related microtome is the sledge microtome in which the object is attached to the sled and the knife is fixed. The microtome is accompanied by a booklet *Use and Care of Bausch & Lomb Microtomes*. The booklet has instruction for use of the sliding microtome and the Bausch & Lomb Minot rotary microtome.

**Spencer Sliding Microtome, Model 860**

This is a Spencer, heavy-duty precision sliding microtome, model 860, manufactured for use in hospitals and research laboratories. It is designed to cut sections of bone, wood, frozen celloidin, and paraffin preparations. The knife block slides on a horizontal surface on top of the main casting. There is a knife holder, an object clamp, and a circular feed mechanism. The thickness of specimen sections can be adjusted from 1 to 40 microns using the automatic advance mechanism. The entire apparatus sits on a rectangular hardwood base. It is signed on a metal label on the base "SPENCER LENS CO., BUFFALO N.Y., U.S.A." The serial number is 10328. There are two microtome knives in wooden cases. The microtome weighs 60 pounds. Dimensions (H x W x D): 33.5 x 54 x 29 cm (13 3/16 x 21 1/4 x 11 7/16 in.) The instrument is in very fine condition and dates to before 1945. Donated by James B. McCormick.





**Ivan Sorvall Servall Microtome, 1953****Ivan Sorvall Servall Microtome, 1953, the First Ultramicrotome**

Several advancements made the observation of cells at the subcellular level with the electron microscope possible. These included the development of methacrylate as an embedding medium, the use of glass knives for sectioning, buffered osmium tetroxide for fixation, and the development of a microtome capable of producing extremely thin sections. This microtome is an early example of one of the most important scientific instruments of the twentieth century. It allowed the making of ultrathin sections of tissues that could be examined with the electron microscope thereby revealing the subcellular structure of cells. Development of a suitable ultramicrotome was achieved in 1953 by Keith Porter and Josef Blum, the head instrument designer at the Rockefeller Institute. The experimental or prototype model incorporated a horizontal steel bar, which was suspended in a gimbel at one end and held the specimen in a chuck at the other. The specimen was advanced toward the knife by thermal expansion of the horizontal rod. The heat was supplied by a 60 watt bulb in a goose-neck reading lamp. This was followed shortly by a derived and improved model that was similar but used a mechanical advance that could move the specimen at increments of  $0.025\mu$ . This microtome is an early example of the improved model and was the first commercially available ultramicrotome. It was manufactured by Ivan Sorvall as the Servall microtome. It bears the label Servall Microtome, Serial 140, Ivan Sorvall, inc., New York, U.S.A. This model was later provided with a cover and was known as the Porter-Blum MT-1 microtome.

**Porter-Blum MT-1 Ultramicrotome**

Improvements were made to the Sorvall Servall microtome which became known as the Porter-Blum MT-1 microtome. This is a fine example of the Porter-Blum MT-1 microtome. It was manufactured by Ivan Sorvall Inc., Norwalk Conn. The microtome is completely encased and has a fluorescent lamp. It has a mechanical advance and the typical thickness of sections is between 40 and 100 nm for transmission electron microscopy. This microtome includes the accessory stand for a Bausch and Lomb binocular stereomicroscope. The accessory stand has a base to hold the microtome, a pillar holding an arm which holds the stereomicroscope for viewing the sectioning.



Most electron microscopists of the twentieth century used this microtome because of its simplicity and reliability.



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## Projection Instruments

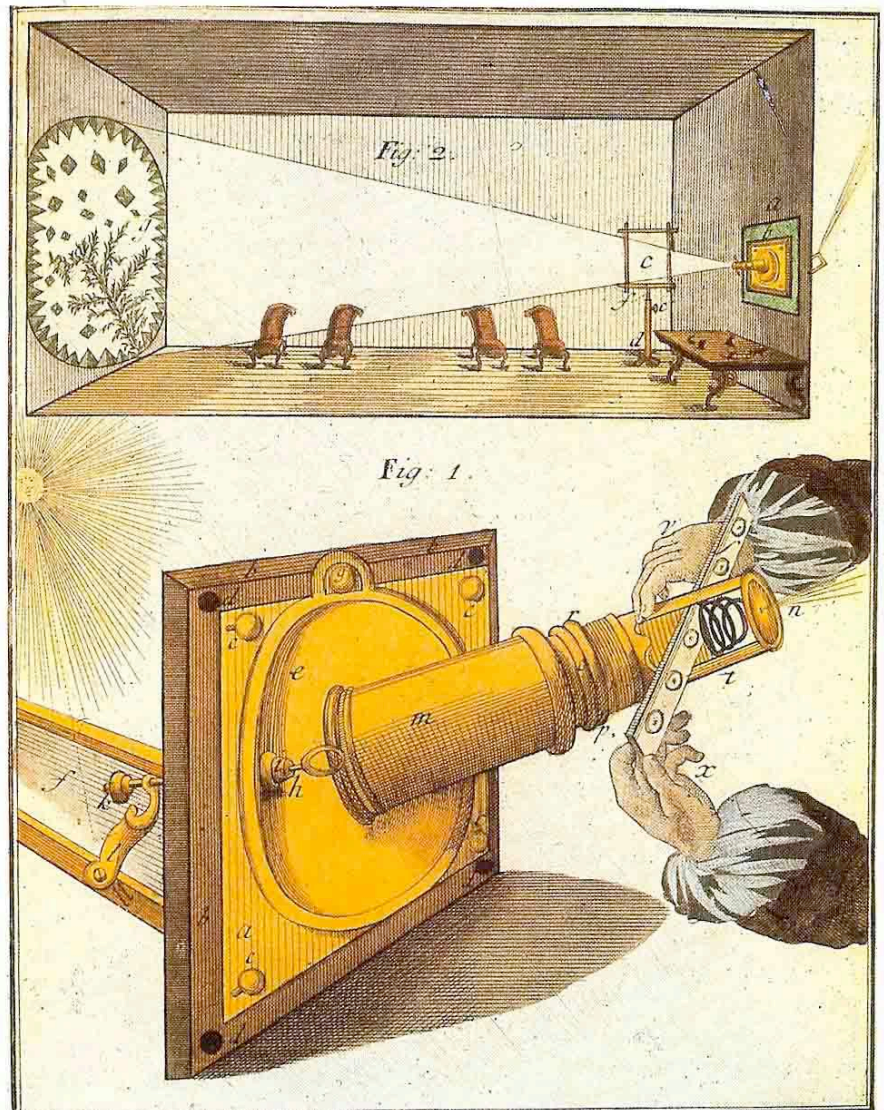
The desire to project images is universal and ancient. It probably began in prehistoric times with the casting of shadow finger images on the walls of caves using fire as the source of light. The precursor of instruments used to project images is the camera obscura. The first instrument used to project microscopic images was the solar microscope.

### Solar Microscope, c1772

The solar microscope is a projection microscope. It differs little from the projection microscopes of the early twentieth century except that the source of illumination is the sun instead of a carbon-arc magic lantern or lamp. The forerunners of the solar microscope are the camera obscura, sciopic ball, and the magic lantern. A simple screw-barrel microscope was attached to a sciopic ball fitted into a window shutter. By adding a mirror to the sciopic ball to collect sunlight, the solar microscope was formed. The definitive solar microscope was made by John Cuff around 1740 but was copied by other London instrument makers in the eighteenth century. In Cuff's microscope, the microscope tube was fixed and the mirror was moveable so as to be able to follow the sun.

A plate from M. F. Ledermüller *Nachlese seiner Mikroskopischen Gemüthe- und Augen-Ergötzung* (Nürnberg, 1762) shows how the solar microscope was used. The microscope was attached by a plate to a window shutter with the mirror outside to reflect sunlight into the microscope. The light passes through an object in a slider and the image is magnified by a screw-barrel microscope and projected onto the opposite side of the room. A drawing of the image could be made by placing a paper on the screen in the corner. The solar microscope seems to have been used mainly in exhibitions for the amusement of the public, and less for educational or scientific purposes.

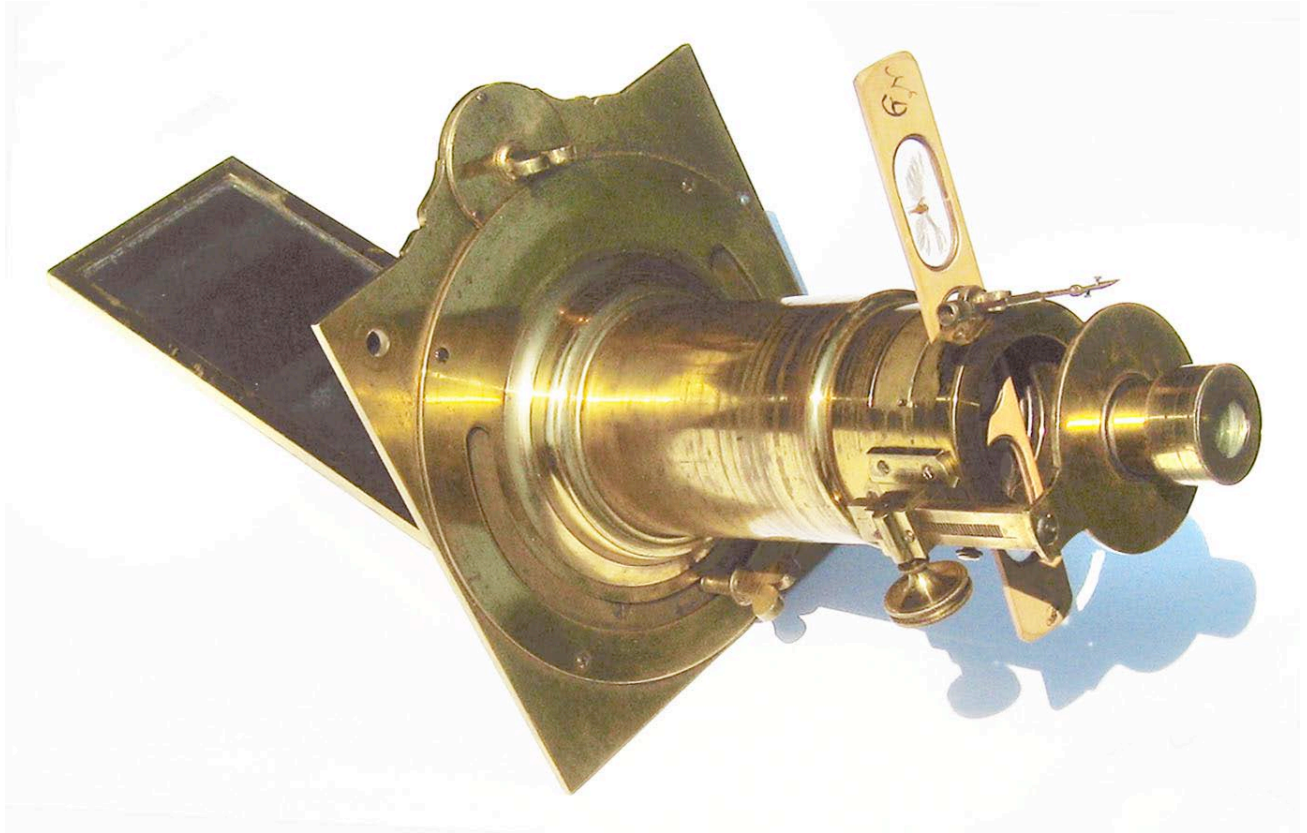
This solar microscope is unsigned. It has its original mahogany fitted case. It is a substantial instrument. The mirror framed in brass is 3 5/8" wide x 9 3/4" long. The heavy brass plate is 6 3/4"





## Microscopy Accessories

square. The mirror is inclined by an "endless screw" and rotated by a Cuff-type rack and pinion. A condenser tube,  $2\frac{3}{4}$  " in diameter and  $4\frac{1}{2}$  " long, screws into the plate. A 3" long Bonani-type spring stage with rack and pinion screws into the tube. There are six eye lenses that screw into the end of the spring stage. The microscope is in excellent condition with much of its original lacquer finish remaining. A handwritten list of the contents of the box is dated 1 March 72.



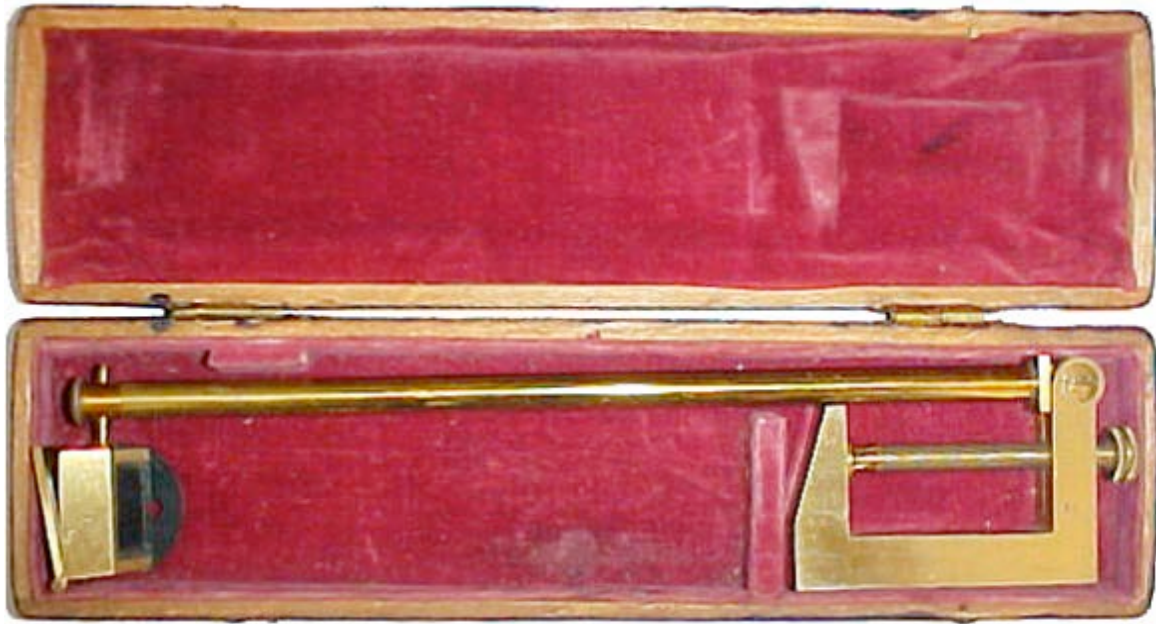


## Microscopy Accessories

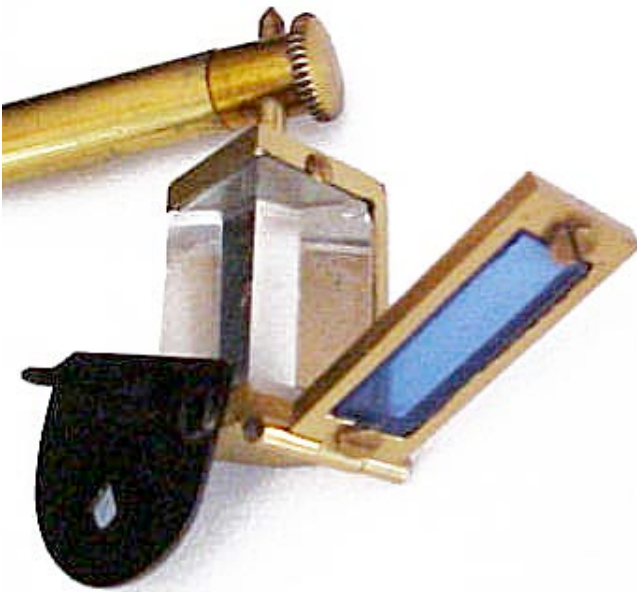
The case has a fitted drawer with a very fine collection of 16 ebony, 15 boxwood, and 11 glass sliders. These sliders are much larger than those used with the conventional microscope. The glass sliders are  $\frac{1}{2}$ " x 5" (only one with specimen). The ebony sliders are  $\frac{3}{4}$ " x 6" (some specimens missing). The boxwood sliders are  $\frac{7}{8}$ " x 7" (all specimens present). Most of the specimens are minerals, plants, insects, and wings of insects.



## Cary Camera Lucida, c1810.



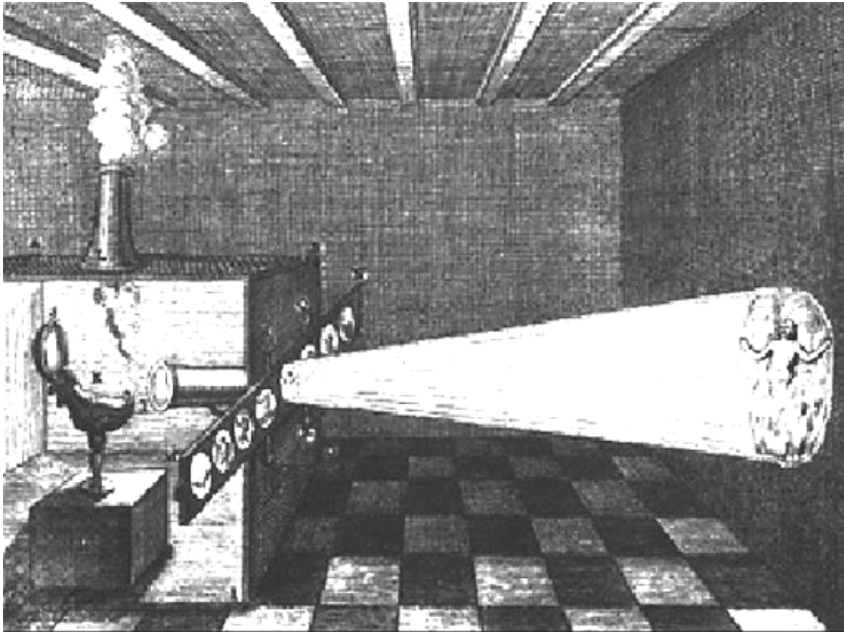
The camera lucida is an optical device that by means of a prism allows an artist or scientist to see both the subject and a transparent image of the subject reflected onto a paper or canvas, so that the image can be traced; thus, making an accurate drawing of the subject. A camera lucida can also be used with a microscope. In the nineteenth century, before photomicroscopy, most illustrations of cells and tissues were drawings made with a camera lucida. The concept of the camera lucida was first recorded by the German Scientist Johannes Kepler in his *Dioptrice* (1611). Kepler's description apparently fell into oblivion and the camera lucida was rediscovered and patented by William Hyde Wollaston (1766 -1828) in 1807. Wollaston called the device a camera lucida, light room in Latin, as opposed to camera obscura or dark room. Wollaston was an English chemist and physicist who is famous for discovering palladium and rhodium and for developing a method to process platinum ore among many other important scientific discoveries.





This is a brass camera lucida signed Cary London. It consists of a telescoping column with a clamp at one end and at the other a unit with the prism, blue folding filter, and light reducing black metal shade. The sharkskin case lined by red velvet measures  $8 \frac{3}{4} \times 2 \frac{3}{8} \times \frac{3}{4}$  inches. The instrument is in exceptional condition and seems to have received little, if any, use. The construction is very early and probably shortly after the Wollaston patent of 1807.

### Magic Lantern



The magic lantern is the precursor of the modern slide projector. The first projection lantern is shown in 1420 in *Bellicorum Instrumentorum Liber* by a Venetian engineer, Giovanni de Fontana. The illustration shows a man holding a lamp or lantern with a transparent image of the devil on its side, and on the wall is a large projected picture of the devil. In later years, several individuals, including Italian scholar, polymath and playwright Giovanni Battista della Porta (1589), polymath Jesuit scholar Athanasius Kircher (1646), Dutch Physicist Christiaan Huygens

(1659), and the Danish mathematician Thomas Rasmussen Walgensten (1660), and others, improved the magic lantern. Walgensten was the first person to use the term "Laterna Magica" and to travel in Europe giving shows.

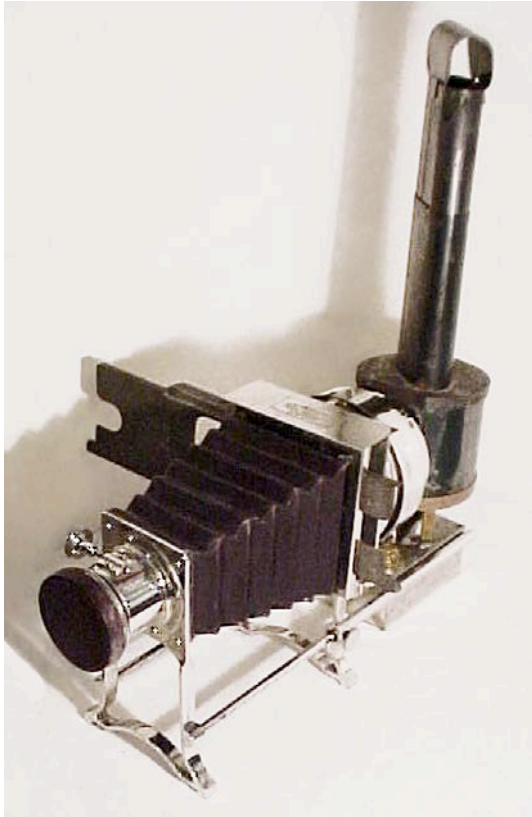
Kircher published *Ars Magna Lucis et Umbrae* (The Great Art of Light and Shadow) in 1646, in which he described arrangements to project using candle light or sunlight from a mirror and using a convex lens as an objective to focus the images. In the 1671 edition, he illustrated a magic lantern that has no projection lens. The illustration shows a smoking oil lamp and projected images from handpainted glass slides onto a screen.

In its early development, the magic lantern was mostly used by magicians and conjurers to project images, making them appear or disappear, transform from one scene into a different scene, animate normally inanimate objects, or even create the belief of bringing the dead back to life. In the late eighteenth century several showmen used the lantern to produce horror shows. These were known as "Phantasmagoria" shows. A variety of horrific images were projected to frighten the audience, examples being ghosts projected on smoke to give a frightening appearance and images that would move around the walls.

The original sources of light were candles and oil lamps which were quite inefficient. The invention of the Argand lamp in 1780 helped to make the projected images brighter. Further improvements in light sources in the nineteenth century brought changes in the style of shows. Limelight, produced by burning oxygen and hydrogen on a pellet of lime, provided much better illumination and began to be used around 1830. It was followed in the 1880s by the carbon arc lamp. The improvements in illumination made it possible for the projectionist to create huge images and elaborate effects using multiple lanterns and double and triple lens projectors in front

of large audiences. Simpler types of lantern were also improved with the introduction of the kerosene lamp. This allowed people to present shows in small halls and churches and in the home.

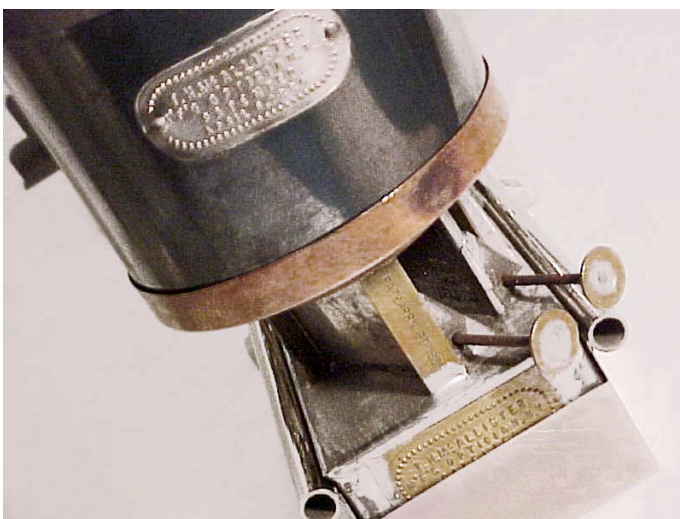
### McAllister Magic Lantern, 1886



The magic lantern was not used extensively for educational purposes until the second half of the nineteenth century. In the middle of the century, the photographic positive on a glass plate was developed. These plates could be projected onto a screen or wall from a magic lantern which later became known as a lantern slide projector.

This magic lantern bears the labels "T. H. M<sup>C</sup>ALLISTER, M<sup>F</sup>G OPTICIAN, NEW YORK" and "PAT<sup>D</sup> APRIL 6<sup>TH</sup> 1886." Thomas H. McAllister (1824-1898) established a scientific supply house in New York around 1866. He manufactured and supplied microscopes, magic lanterns, lantern slides, microscope slides, and other optical and scientific equipment. The firm went out of business in the 1890s. The metal of the projector is nickel-plated. The burner for this projector is an oil lamp and is built into the projector. There are two wicks each two inches wide and the back of the lamp housing is polished metal. The lantern is 20 inches long with the bellows extended and the chimney is 21 inches high. The slide holder takes 3¼ x 3¼ inch slides. The lantern fits compactly into a tin case with a handle. It is in exceptional condition and seems to have received little

use. Although the light source is a lamp, such a projector with dual wicks, a reflector, and large condenser lens is quite effective in a dark room. The projector represents the culmination of 250 years of development of oil lamp-illuminated magic lanterns. It was replaced by the carbon arc and electric light lantern slide projectors.



McAllister Magic Lantern

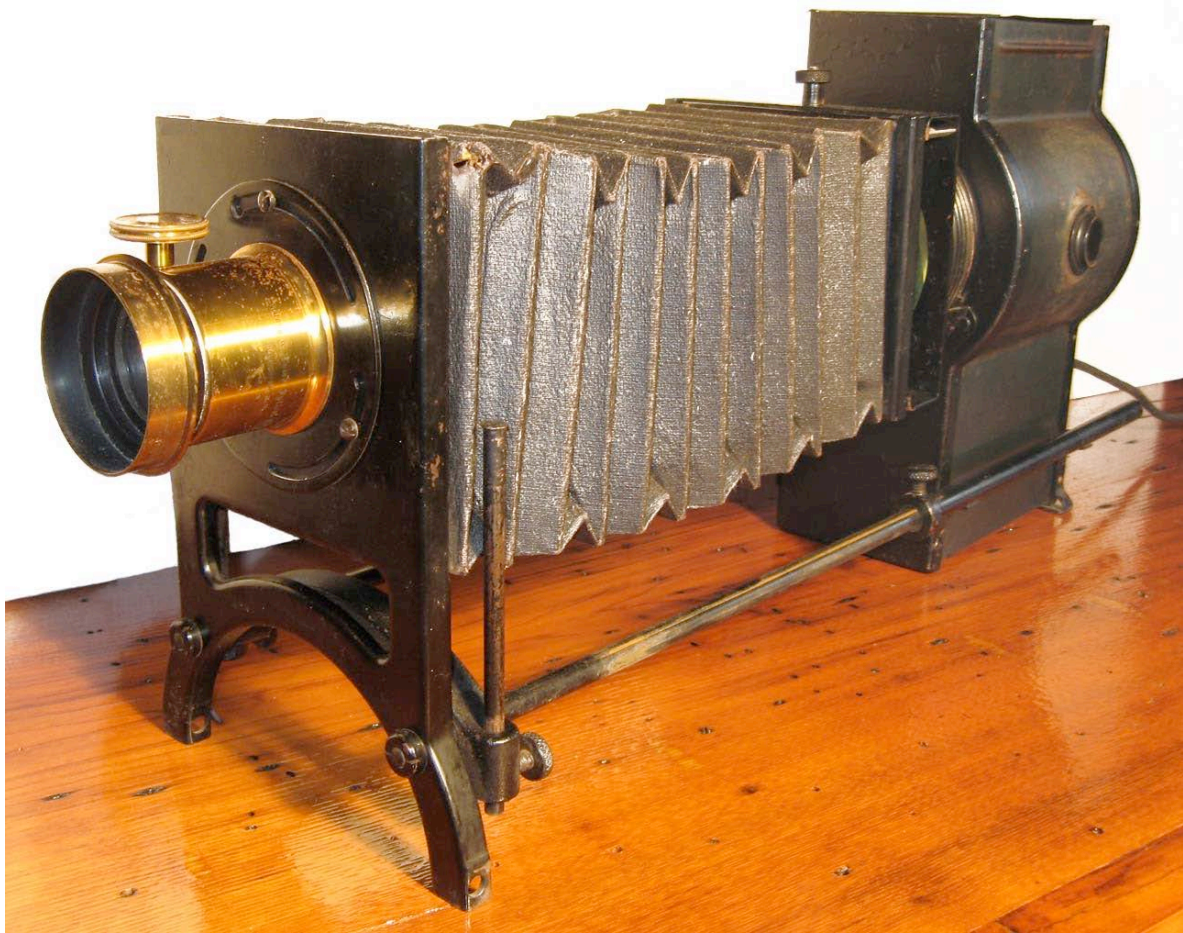


**Baird Magic Lantern, c1890**

This is a large wooden magic lantern that would have been used to project images in theaters and classrooms in the latter part of the nineteenth century and early twentieth century. The lamp housing and base are made of mahogany. The base is 12 x 22 inches with a pull out extending the length another 15 inches. The lamp housing is 12 x 12 inches and 20 inches high to the top of the chimney. The wooden lamp housing contains a metal box with a space between the metal and wood sides. The metal box dissipates the heat of the lamp and allows the lantern to have a wooden body and not catch on fire. The light source is a carbon arc lamp that fits into a slot in the base of the inner metal lamp housing. The lamp unit is made by Ross, London and is marked "B Eclipse Patent Arc Lamp No 497". It is unusual for lanterns of this period to have the original arc lamp as most arc lamps were replaced with incandescent lighting when it became available. There is a pair of condenser lenses, holder for 3 ¼ x 3 ¼ inch lantern slides, and a brass lens assembly. The lens assembly has two slots, one for a filter and one for a slide. There is a velvet curtain at the back of the lamp housing that the projectionist would have thrown over his head while adjusting the carbons. During a slide show, the carbon rods burned and had to be brought into proximity periodically.



The lantern is labeled "A. H. Baird Scientific Instrument Maker Edinburgh." Andrew H. Baird was a major manufacturer of high quality magic lanterns and all types of photographic equipment including cameras from c1890 to 1937.

**Bausch & Lomb Model C Balopticon Lantern Slide Projector c1910**

The Bausch and Lomb Balopticon was the utilitarian standard for lantern slide projectors in the first part of the twentieth century. The projector consists of a base with feet and horizontal sliding rods, slide carrier, lamp housing, and bellows. The light source in this early model was originally a carbon arc. The brass lens with rack and pinion focusing is marked Bausch & Lomb Optical Co., Rochester, N. Y. The round windows on the sides of the light housing were for viewing the position of the carbons. The arc was replaced with incandescent lighting at an early date.

**Projection Microscope, Williams, Brown & Earle, c1900**

The projection microscope projects the image of a slide onto a screen. This well-engineered instrument is signed Williams, Brown and Earle, Philadelphia on the barrel. This firm was established in 1885. H. S. Williams and N. H. Brown previously worked for James W. Queen & Company. The microscope is in exceptional condition and housed in a very fine case. Front and rear footed standards hold two horizontal rods along which the microscope can slide. The brass body tube focuses by rack and pinion. There are two objectives, one marked 32 & 14 MM and the other marked Williams Brown & Earle, Phila. Pa. U.S.A., 1-12 Homog. Imm. 1.35 N.A. in a matching brass canister. There are two stages. One has a circle of stops, a mechanical stage, and a condenser. The other has a circle of stops and attaches to a ring that fits around the lens piece of a magic lantern. The projection microscope can be attached to the Balopticon lantern slide projector in this collection and is fully functional.

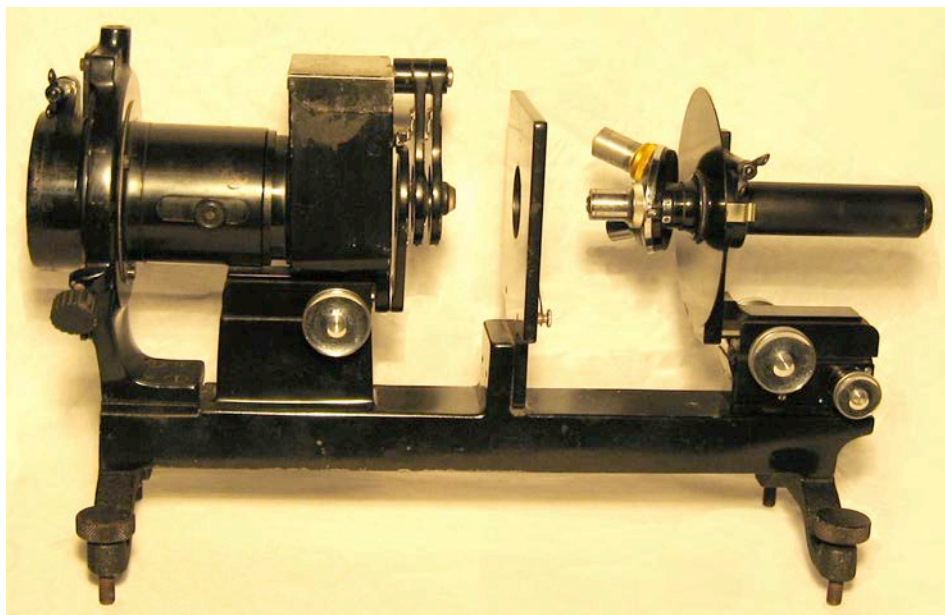




**Williams, Brown & Earle Projection Microscope**

**Projection Microscope, Bausch & Lomb**

The projector consists of a heavy base carrying an illuminating unit support, stage, and microscope moveable by rack and pinion. A magic lantern or carbon arc lamp served as the source of illumination. A rectangular box behind the condensers held a glass container (missing) that was filled with water to cool the beam of light before it struck the specimen. Three swinging condenser lenses are behind the stage. The microscope has three objectives and an eyepiece.



## Lighting Devices



Candle lamp



Bockett kerosene microscope lamp



Kerosene microscope lamp

A limitation in the use of early microscopes was the lack of a suitable light source. The early tripod microscopes were simply held up to the sun. Candles were used early on and were made into lamps by placing a condenser or prism in front of the flame. The brass candle lamp is nine inches high and stamped R&MB Sweden. By the nineteenth century, oil and kerosene lamps were developed that provided adequate illumination. The Bockett microscope lamp has a brass base and an upright rod to hold the lamp and a condenser lens that focused the light from the lamp onto the mirror of the microscope. A chimney fits on top of the lamp. Collins of London manufactured these lamps between 1866 and 1900. Another kerosene lamp is 10 ½ inches tall minimum, with separately adjustable height of the assembly and of the porcelain shade. Electric lamps replaced kerosene lamps in the early twentieth century.



Brass Lamp, No 237, 1909

## Candle Holder and Shade, c1820

This is an early nineteenth century brass candle holder and shade. It consists of a folding base, telescoping stand, candle holder, and fan. Light from the candle is focused onto the specimen by a condenser on the microscope stage or on a stand. The cloth shade is positioned to protect the user from the glare of the flame. Assembled, the unit is 20 inches high. It folds into a red Moroccan leather case. Cosmetically the set is in good condition with some wear to the



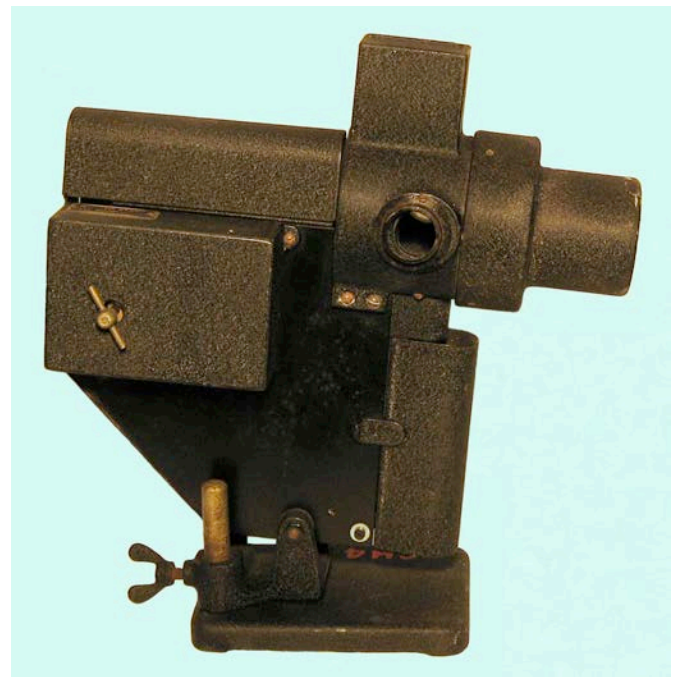
lacquer. The fan has a few small splits and the cord used to keep the center tight is loose. The case is good with some minor scuffing.

### Bausch & Lomb Mechanical Arc Lamp

The carbon arc was used at the end of the nineteenth century and beginning of the twentieth as a light source for magic lanterns and lamps for projection microscopes. Even after incandescent light bulbs became available, carbon arcs continued to be used because they were brighter. This lamp was manufactured by Bausch & Lomb. The box on the side contains a clock mechanism that automatically advances the two carbons as they burn. The clock is wound by the key on the side. A patent for this mechanism was applied for by Allan F. Martin in 1925 and granted in 1931. A copy of the patent application is included. The round windows on the sides are for viewing the carbons and admitting air.



Candle holder and shade



Carbon arc lamp

## Other Accessories

### Slider Holder



This slider holder is a rare and unusual microscope accessory. It is a brass channel just over six inches long and  $\frac{3}{4}$  inch wide and equipped with a long spring. The inside of the channel has been painted matt black and inscribed "To hold the Ebony Sliders with Opake Objects." Condition is very good with virtually all the external lacquering present.

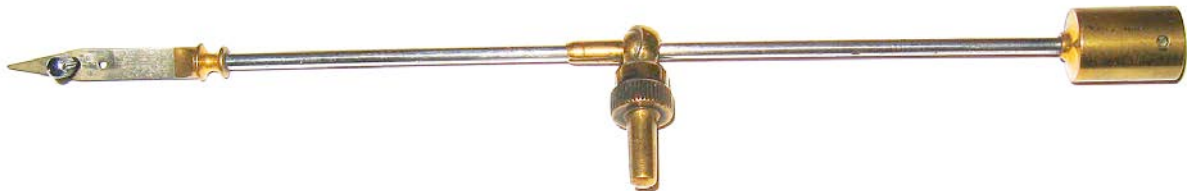
### Slide Ringing Table



The slide ringing table was used for various tasks in the construction and finishing of microscope slides, but primarily for placing ringing cements around the circular cover slips to seal and finish them. A slide is held on the round brass stage by the slide clips. Circles engraved in the center of the brass plate help center the slide. The stage is spun and while it is turning a paint/asphalt ring is applied on the edge of the coverslip with a brush. The wooden base functions as a hand and brush support. Ringing was widely used in the second half of the nineteenth century but began to go out of favor in the twentieth century even though ringed slides seem to stand the test of time

better than those without rings.

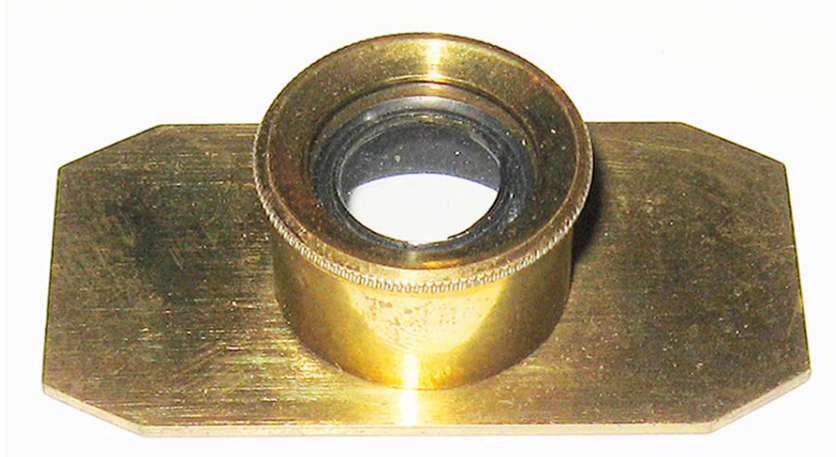
### Stage Forceps



The stage forceps was used for holding small objects for observation under the microscope. The stem is held by a ball joint with a pin that fits into a hole on the edge of the stage. One end of the stem has two blades which can be tightened by a screw for holding an object such as a fly wing or flower petal. The stem can be turned, rotated, or moved forward or backward for precise positioning of the object under the objective. The other end of the stem has a small cylinder holding cork and perforated with holes on its side. Pins holding objects such as insects can be attached to the cork.



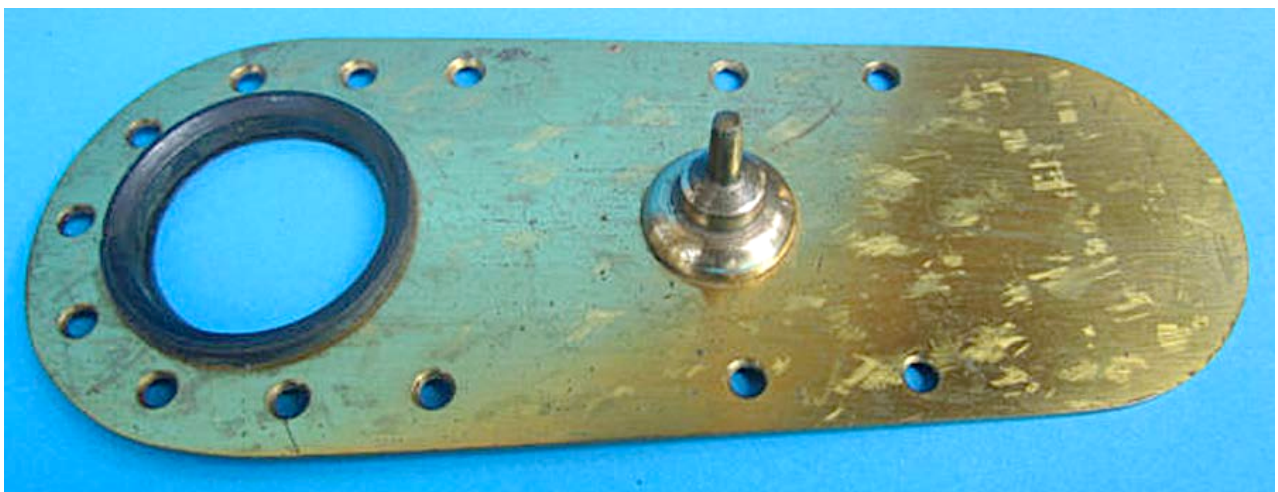
### Aquatic Box



The aquatic box or animalcule cage was used for examining small organisms in pond water. It consists of a brass cylinder with glass at one end mounted over an opening in a brass plate. A second cylinder with glass at one end fits over the first cylinder. A drop of water is placed on the glass of the inner cylinder and the outer cylinder is pressed down over the water causing it to spread out. The box is placed under the objective for observation.

### Fish Plate

A fish plate is a device for strapping down a small fish so that the blood circulation in the tail fin can be observed, thus repeating Marcello Malpighi's microscopical discovery of capillaries in 1661. A ribbon is passed through the holes around the edge and used to tie down the fish. The tail is placed over the glass circle. There is a pin on the bottom allowing the plate to be inserted onto the microscope stage. The fish plate is brass and four inches long and two inches wide. John Marshall introduced the fish plate on his Great Double Microscope at the end of the seventeenth century. It became a standard microscope accessory for nearly 200 years. c1850.



### Compressorium

A compressorium is an instrument by which objects under observation can be gradually compressed between two parallel plates of glass to immobilize them or make them thin enough

for light to pass through. It is 1 x 3 inches in size. A screw lowers the upper plate onto the base. c1875.



**Livebox**

A livebox, very similar to the aquatic box, is a compartment for holding a living organism such as an insect for viewing with a microscope. This brass livebox is 30 x 55 mm. The top can be pushed down to restrict the specimen's movement.



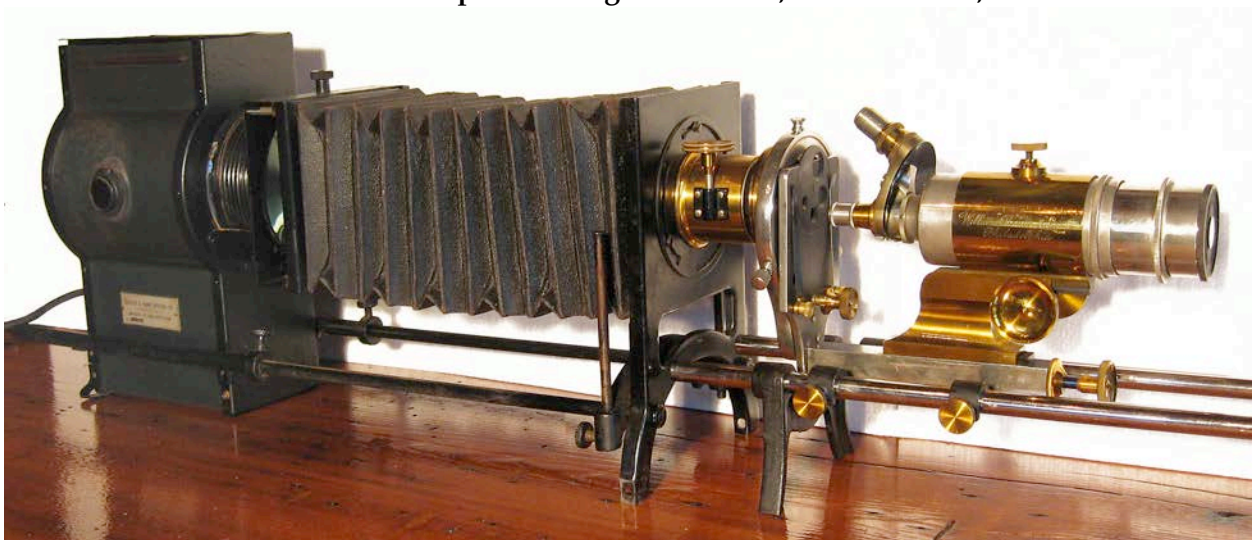
## **Nineteenth Century Microscope Setups**

This is an early nineteenth century brass candle holder and shade. It consists of a folding base, telescoping stand, candle holder, and fan. Light from the candle is focused onto the specimen by the condenser on the stage of the microscope. The cloth shade would be positioned to protect the user from the glare of the flame.



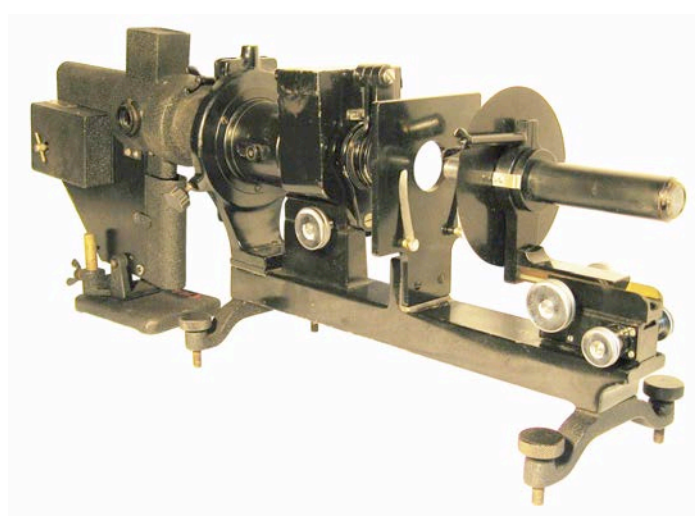


**Chevalier microscope with stage condenser, candle holder, and shade**



**Balopticon lantern slide projector and Williams, Brown & Earle projection microscope**

The projection microscope projects the image of a slide onto a screen. This well-engineered instrument is signed Williams, Brown and Earle, Philadelphia on the barrel. This firm was established in 1885. The Balopticon lantern slide projector serves as the light source.



**Bausch & Lomb carbon arc lamp and projection microscope**



**Microscope Oil Lamp, B & L Universal Microscope, Microscope Table**

A Bausch & Lomb Universal microscope stands on a microscope table. Microscope tables are low, have a heavy iron base for support, and an easily cleaned hard surface. The Bockett microscope lamp, Collins London, c1875, burns kerosene and has a condenser to focus light onto the mirror. It is nearly as effective as an electric lamp.



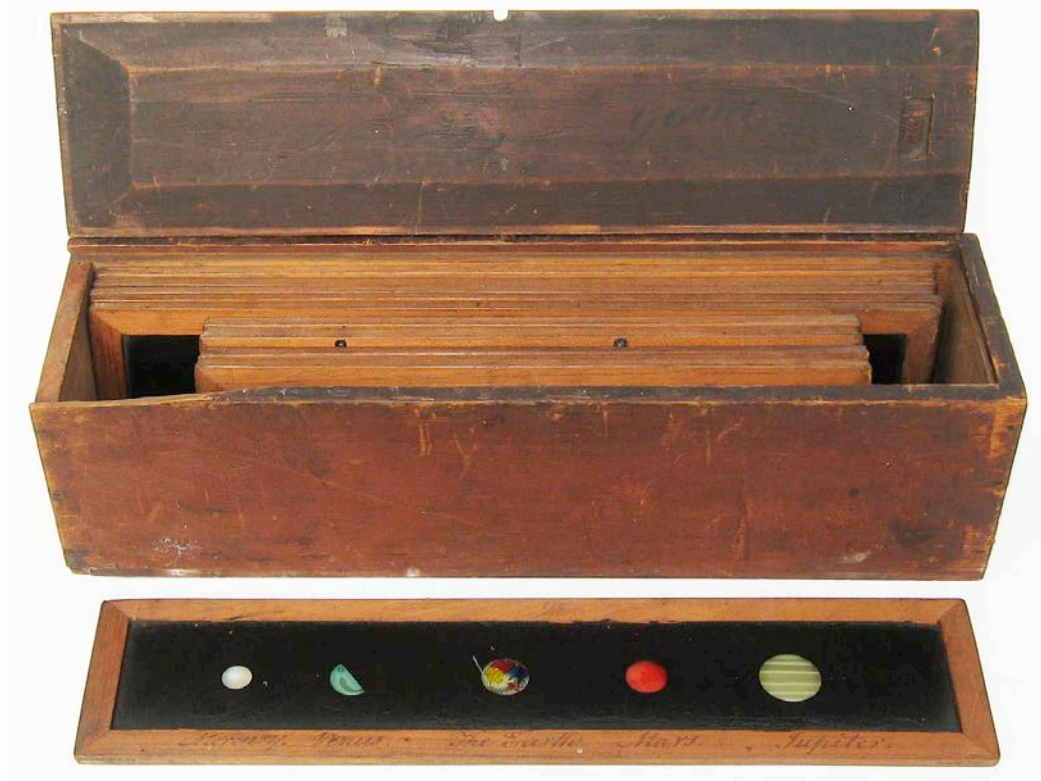
## Lantern Slides

### Carpenter Astronomy Lantern Slides, c1825

Lantern slides are positive images on glass that are intended to be projected for viewing. Many early slides are individual, hand-painted works. The finished product was placed within a lantern slide projector to be viewed on a wall or screen. The first projectors used oil lamps for light. By the mid nineteenth century, limelight, produced by burning oxygen and hydrogen on a pellet of lime, offered a better, although more dangerous, form of illumination. In the 1880s, the invention of the carbon arc lamp, followed by electric light, provided a safe method for displaying the lantern slide image.

The practice of projecting images from glass plates began centuries before the invention of photography. As early as the seventeenth century, the magic lantern was used to project painted images on glass for children's picture shows, religious displays, and for phantasmagoria shows. Astronomical lectures were popular forms of entertainment. The general content of the lectures represented an outline of the astronomical knowledge of the time, couched in non-technical language.

Around 1820, Philip Carpenter (1776-1833) developed a method to mass produce lantern slides using a copper plate printing process. This enabled outline images to be repeatedly printed onto glass and thus create reproducible sets of slides. These outline images could be more easily and quickly hand painted ready for sale. His first set of slides, offered around 1823 was of zoological subjects. Then, sometime in the mid 1820s, he offered a set of astronomical slides that covered all the basic principles demonstrated by the popular lecturers. The set of ten slides included strip slides (each with three or four images), slip slides, and a lever slide showing the rotundity of the earth. A booklet *A Compendium of Astronomy* accompanied the set and states on its title page "A Series of Diagrams exhibited by the improved Phantasmagoria Lantern."



This is a remarkable set of Carpenter's astronomical slides, c1825. The slides are as follows:

Strip slides, 4" x 17"

Zodiack, Comets Path, Solar System

Demonstrations of the Sun's Superior Magnitude

Mercury, Venus, The Earth, Mars, Jupiter

Saturn, Georgium Sidus [original name of Uranus], Comet 1680 [Newton's Comet], Comet 1811 [The Great Comet of 1811]

Milky Way, System of Ptolemy and Tycho Brake

Ursa Major, Orion

Slip slides, 4" x 13 "

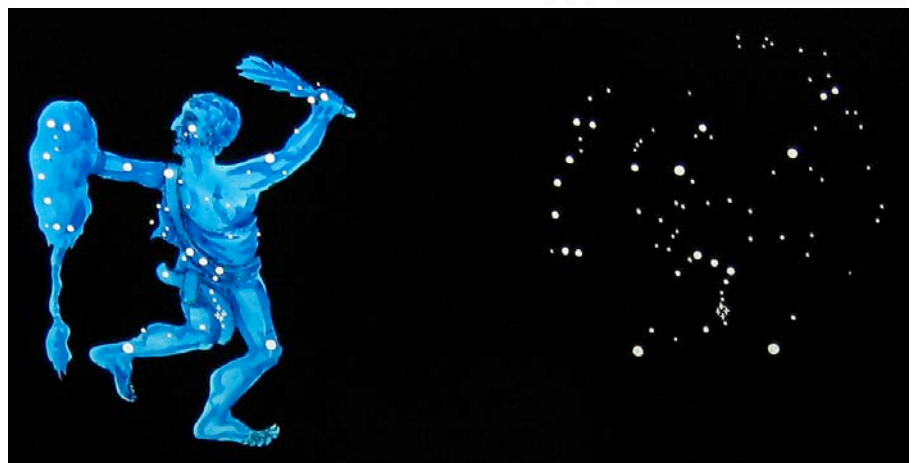
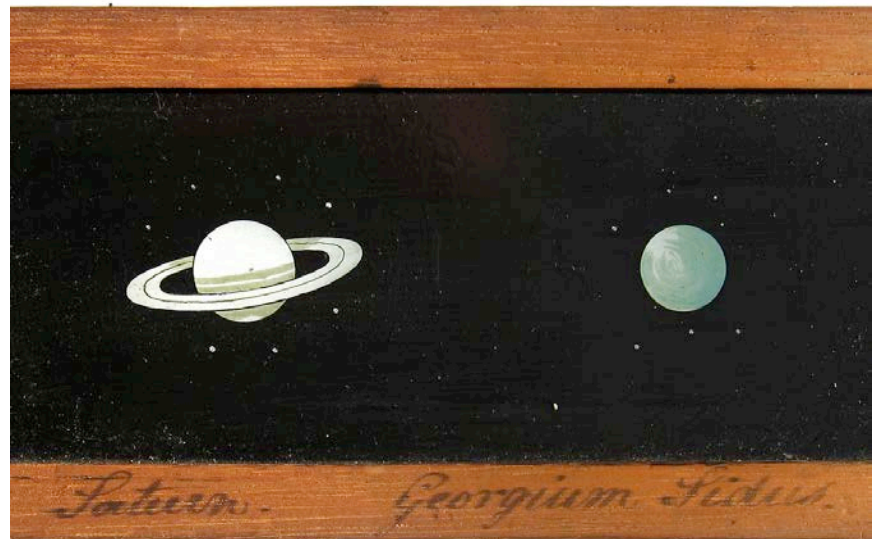
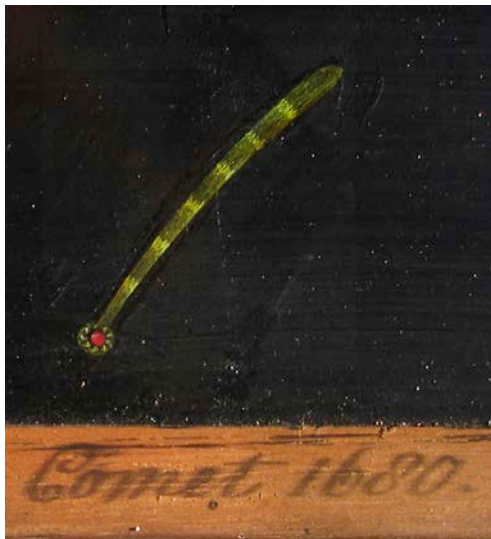
Moon's Eclipse

Moon [showing waxing and waning phases]

Sun [showing eclipse]

Lever slide, 4" x 13"

Tides, Earth's Rotundity. This slide shows an observer standing on the earth with a line of sight to the horizon. A ship is on a second glass disc attached to a lever handle. Raising and lowering the handle causes the ship to disappear or appear over the line of sight.







The slides are housed in their original pine box. The slides are labeled in large black script below the image. Overall, the slides are in excellent condition. One image has slight chipping of paint and another has a scratch. The lever slide has a large triangular section of glass missing not affecting the images.

#### Lantern Slides, 1840-1910

Philip Carpenter died in 1833 and his sister Mary Carpenter continued the business alongside her husband, Philip's former apprentice William Westley. The company was named "Carpenter and Westley" in 1835 and operated until 1914. The company was highly regarded for its detailed lantern slides. This is a wooden lantern slide of "Lightning" 6  $\frac{7}{8}$  x 3  $\frac{3}{4}$  inches. It is labeled "CARPENTER & WESTLEY, 24 REGENT ST, LONDON" and "J W QUEEN, PHILAD" and dates to c1860.



In the 1840s, Philadelphia daguerreotypists, William and Frederick Langenheim, began experimenting with the magic lantern as an apparatus for displaying their photographic images. Because the opaque nature of the daguerreotype prevented its projection, the brothers looked for a medium that would create a transparent image. They employed the discoveries of the French inventor, Niépce de Saint-Victor, who had discovered a way to adhere a light sensitive solution

onto glass for the creation of a negative. By using that negative to print onto another sheet of glass rather than onto paper, the Langenheims were able to create a transparent positive image, suitable for projection. The brothers patented their invention in 1850 and called it a Hyalotype (hyalo is the Greek word for glass). The following year they received a medal at the Crystal Palace Exposition in London.

The Langenheims envisioned their slides as forms of entertainment, charging a fee to watch their picture shows. However, within a few years, lantern slides began to fulfill a variety of purposes. While entertainment remained an important function well into the twentieth century, lantern slides had the greatest impact on educational lectures, especially in visual disciplines. They played a vital role in the development of disciplines such as art and architectural history. They were used in universities for teaching botany, anatomy, histology, and anatomy. In the Yale catalogue of 1886-87 under the description of the course in Normal Histology, it is stated "Lectures illustrated with the lantern are a special feature of the instruction, the transparencies being made from photographs of typical preparations and diagrams."

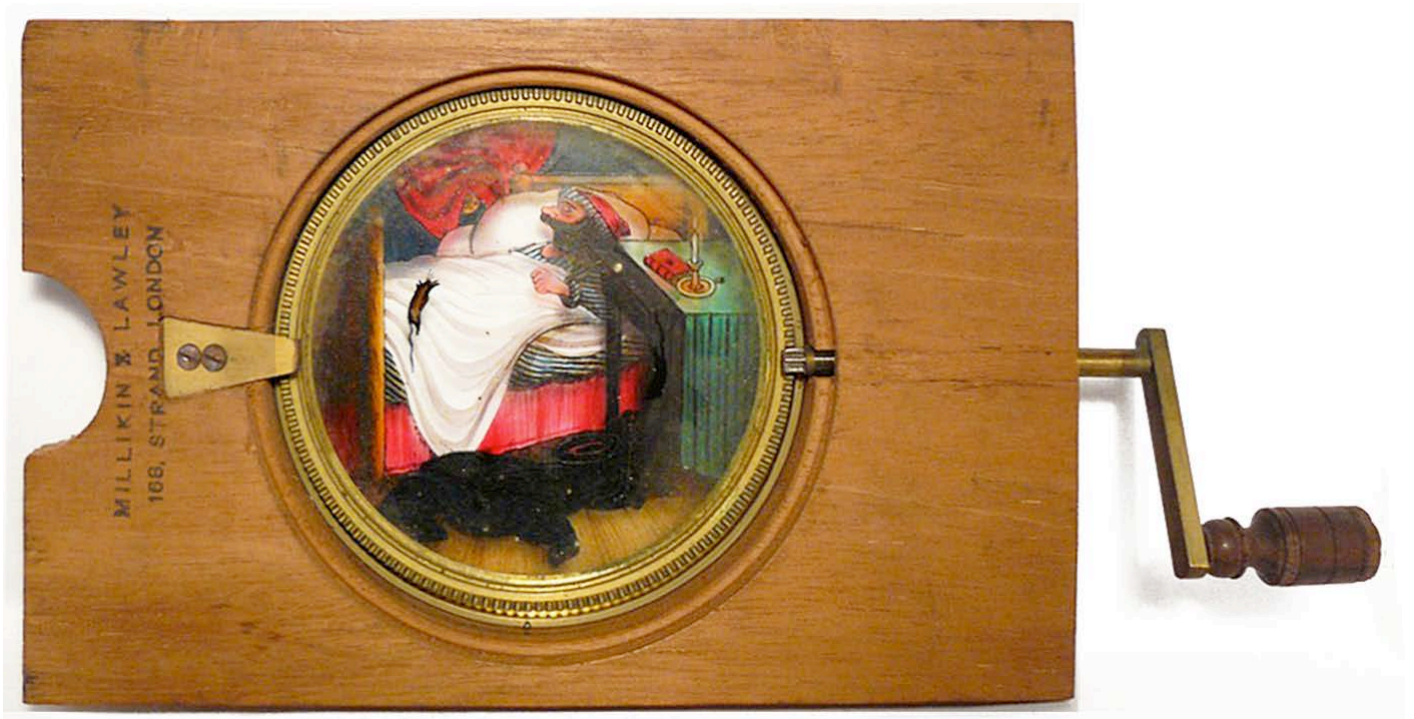
Mechanical slides were devised to make the images move. One type was the slip slide that consisted of two painted glass slides placed one on top of the other. One slide would remain stationary and the other contained the part of the picture that would move. This c1870 slip slide is 4 x 7 inches in a wooden frame and labeled "166 Bucking Donkey." It shows a woman sitting on a donkey. When the second slide is pulled aside, the donkey is bucking. It is in excellent condition and brightly painted. A second slide shows a bird with her nest of eggs. When the slide is pulled, baby birds appear in the nest.



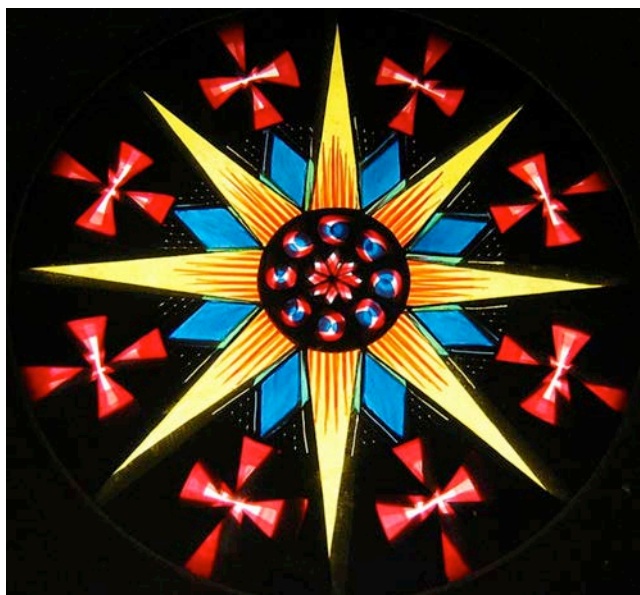


## Lantern Slides

In a second type of mechanical slide, images are painted on two discs, one of which is moveable. The glass slides are placed one on top of the other in an orderly fashion and a hand-operated wheel is used to turn the movable disc. In this c1870, mahogany framed, humorous mechanical slide by Millikin & Lawley, London, a man is sleeping on a bed with his mouth open. A mouse is on the bed and when the crank is turned, the mouse moves over the bed into the man's mouth. The slide is 4 ½ x 7 inches, brightly colored, and the crank turns freely. Mechanical slides such as this slide were the forerunner of the motion picture.



This is another mechanical lantern slide. The mahogany slide measures 4 x 7 inches and has a brass and wood turned handle. When the handle is turned, a colored pattern changes giving a kaleidoscopic effect. The slide is stamped "J F A" at one end. The slide is in excellent condition and functions perfectly. c1870.





## Lantern Slides

After the middle of the nineteenth century, lantern slides were mounted in a permanent wooden carrier which was inserted into a special opening for it in front of the condenser of the magic lantern. These slides are usually 4 x 7 inches. At the end of the century, lantern slides were 3 ¼ x 3 ¼ inches. Later, the standard size became 3 ¼ x 4 inches. The smaller lantern slides were inserted into a carrier. The photographic emulsion is protected by a second piece of thin glass, and the unit is secured around all four edges with black paper tape.

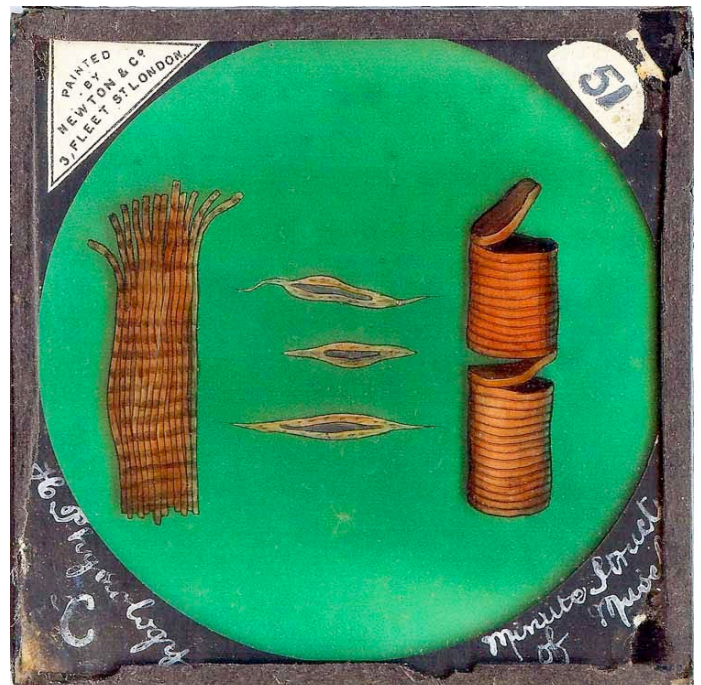
Lantern slides were increasingly used for educational purposes. This collection contains 75 lantern slides mostly on histology, microbiology, and botany. Some bear the label Newton & Co. 3, Fleet St London. Most are 3 ¼ x 3 ¼ inch slides and date from c1885 to c1910. Some are hand-painted. This is an example of a large wooden lantern slide of a photograph of the proboscis of the housefly. The slide is 4 x 7 inches and bears a label Bausch & Dransfield. This optical firm operated in Rochester, New York from about 1863 to 1885. E. E. Bausch was the brother of John Jacob Bausch of Bausch & Lomb. The slide is also an example of early photomicroscopy.



Housefly Proboscis



Blood Corpuscles



Minute Structure of Muscle

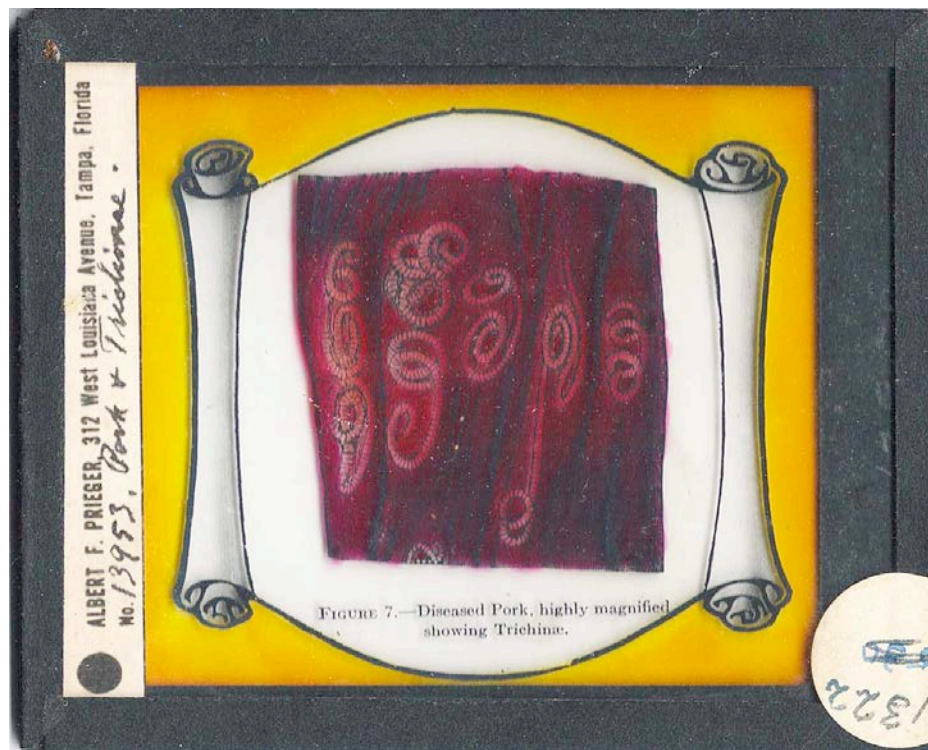




Anthrax bacilli in renal glomerulus



Spirochetes in blood



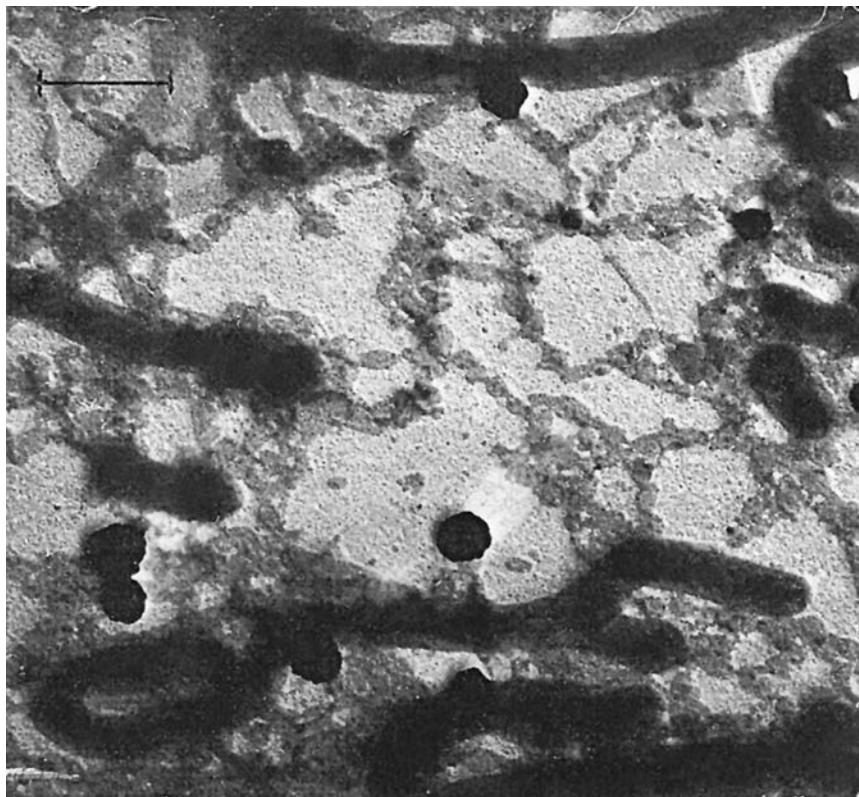
Trichinae

Diseased Pork, highly magnified showing Trichinae, Albert F. Prieger, Tampa Florida, 3 ¼ x 4 inches, colored, c1900.

Use of lantern slides lasted throughout the remainder of the nineteenth century and until the 1950s when their popularity began to decline with the introduction of smaller 2 x 2 inch transparencies. Finally, the discovery of the Kodachrome three-color process made 35mm slides less expensive to produce than lantern slides.

**Electron Microscope Lantern Slides****Palade Collection**

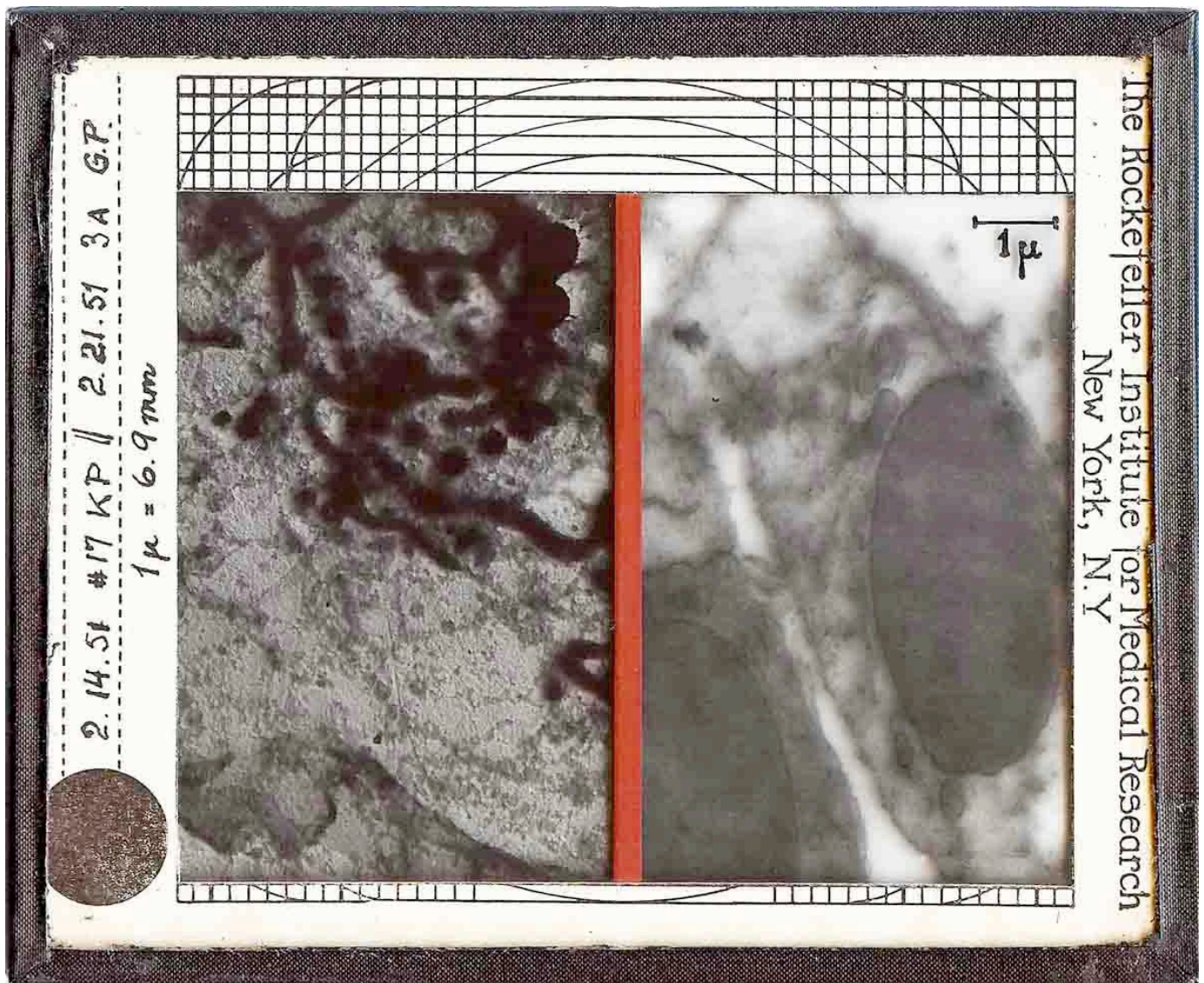
In 1973, George Palade and his associates were recruited to Yale to form a new Section of Cell Biology. George E. Palade (1912-2008) received his M. D. from the School of Medicine of the University of Bucharest, Romania. He was a member of the faculty of that school until 1945 when he came to the United States for postdoctoral studies. He joined Albert Claude at the Rockefeller Institute for Medical Research in 1946 and was appointed Assistant Professor at the Rockefeller in 1948. He progressed from Assistant Professor to full Professor and head of the Laboratory of Cell Biology until 1973 when he moved to Yale as Professor and chair of the Section of Cell Biology. He was Sterling Professor of Cell Biology from 1975 to 1983. He became a Senior Research Scientist, Professor Emeritus of Cell Biology and Special Advisor to the Dean in 1983. In 1990, he moved to the University of California San Diego as Professor of Medicine in Residence, and Dean for Scientific Affairs. Palade's studies, using an integrated approach using cell fractionation, electron microscopy, and autoradiography, led to the identification of the compartments of the secretory pathway. He received a number of honorary degrees and prizes, which include a Nobel Prize in 1974 and the National Medal of Science, USA, in 1986.

**George E. Palade 1970****The first electron micrographs of cells, Keith Porter, 1946**



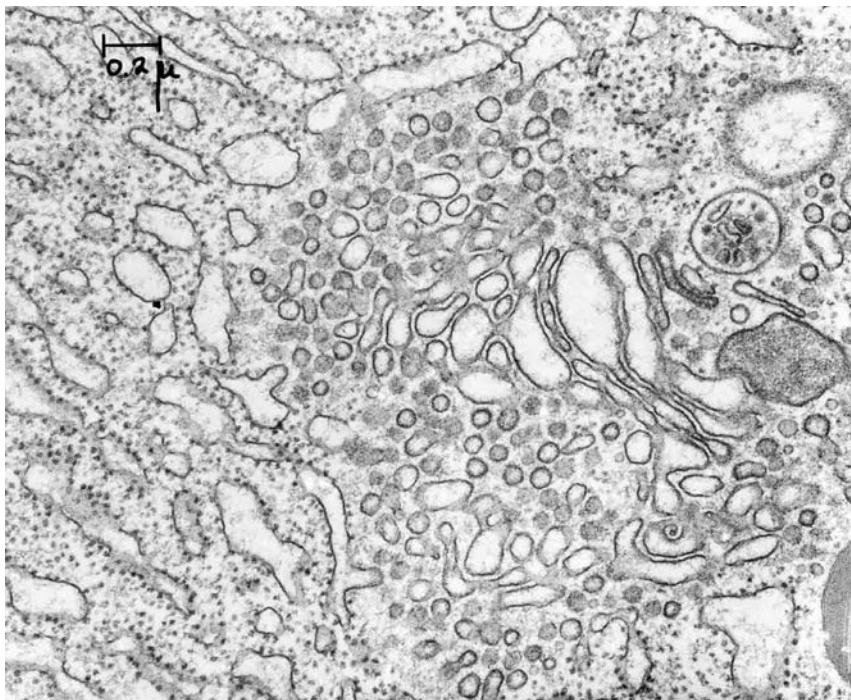
Lantern slide, electron micrograph of a tissue culture cell by Keith Porter. Before sectioning of tissues was effective, Keith Porter at the Rockefeller Institute was able to take advantage of the extreme thinness of cultured cells by fixing them with  $\text{OsO}_4$  vapors and viewing them under the electron microscope. As shown in this lantern slide, Porter was able to see mitochondria (dark rods) and the endoplasmic reticulum (delicate tubules).

The following lantern slide is of great historical importance. The image on the left is a cultured cell taken by Keith Porter (K.P.); that on the right is a thin section of a cell taken by George Palade (G.P.). These are among the first electron micrographs of cells.



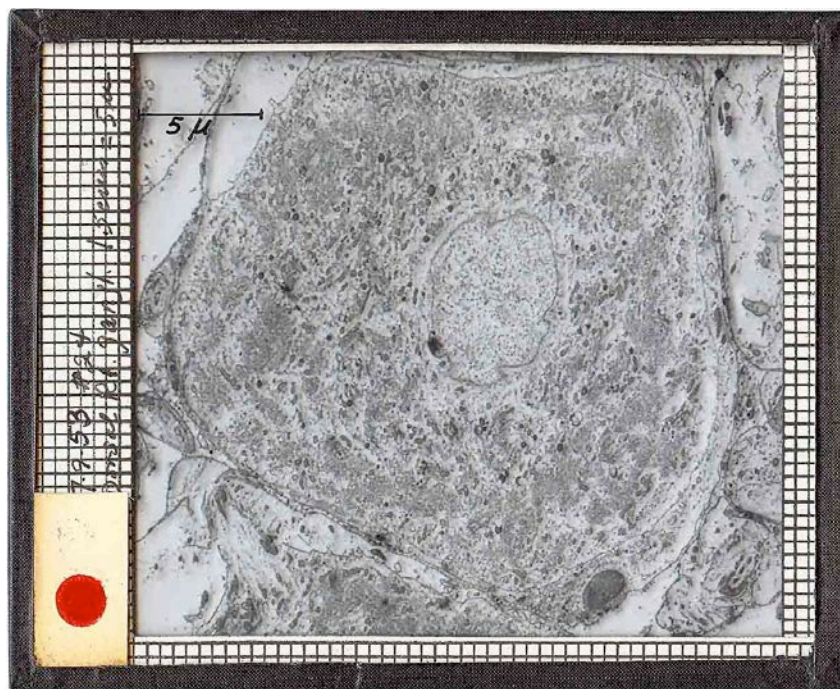
Porter-Palade Lantern Slide, 1951





Lantern Slide, Pancreas, George Palade, 1966

Pancreas showing rough endoplasmic reticulum, transitional vesicles, and Golgi apparatus. By this time, techniques for the fixation, embedding, and sectioning of tissues and the resolution of the transmission electron microscope had been perfected to the point where the quality of an electron micrograph such as this has not been surpassed.

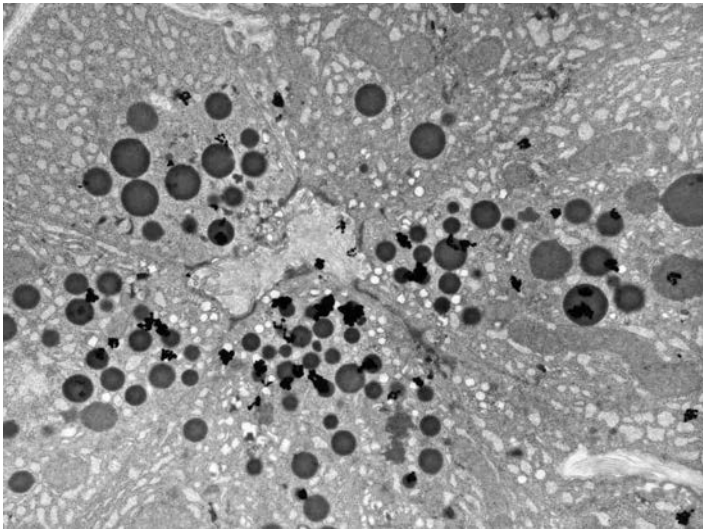


Palay and Palade Lantern Slide, Neuron, 1953

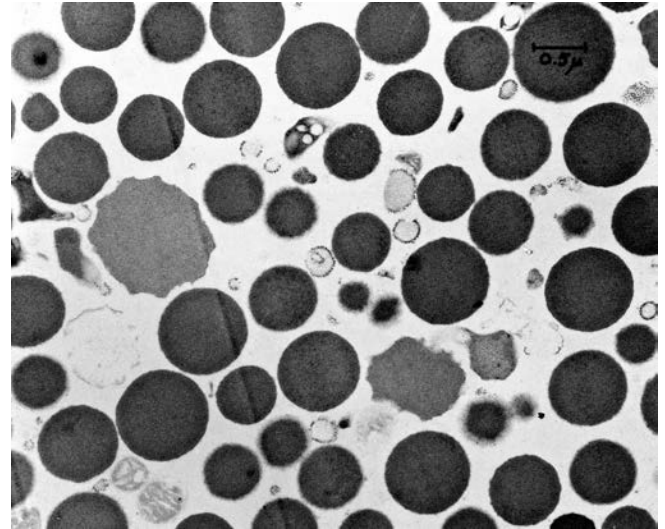
Dorsal root ganglion. Sanford Palay and George Palade took the first electron micrographs of nerve cells. Palay was a member of the Department of Anatomy at Yale from 1949 to 1956.



Lantern slides by James Jamieson (1934- ). Jamieson was chair of the Department of Cell Biology at Yale and studied components of the intracellular transport pathway in the pancreatic acinar cell as a model of a regulated secretory system.

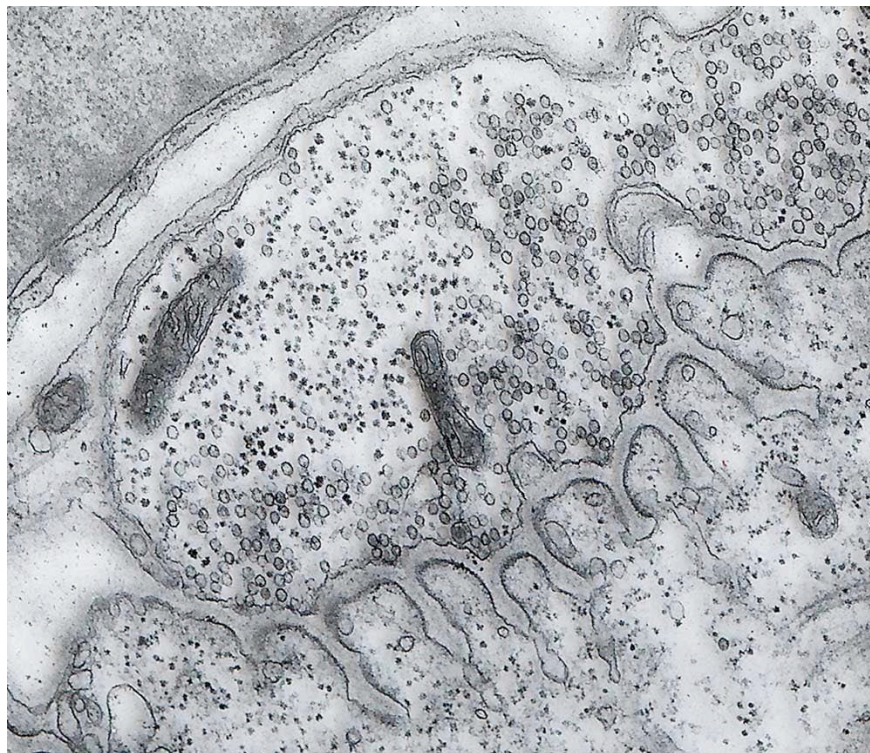


**Autoradiography of Secretory Process**



**Zymogen Granule Fraction, 1967**

Thomas L. Lentz (1939- ) was Professor of Cell Biology at Yale and studied trophic regulation by the nervous system, development of the neuromuscular junction, structure-function relationships of the nicotinic acetylcholine receptor, and cellular receptors and intra-cellular trafficking in neurons of the neurotropic rabies virus.



**Lantern Slide, Neuromuscular Junction, Thomas Lentz, 1972**

## Microscope Slides

### The Evolution of the Microscope Slide

#### Sliders

Early Microscope Sliders, c1704

Nuremberg Slider, c1770

Microscope Sliders, c1780

#### Slide Collections and Cabinets

Circular Slides, Abraham Ypelaar, 1780-1810

Set of Continental Circular Slides, c 1790

Set of French Circular Slides, c1790

Set of French Circular Slides in Drum Microscope, c1820

Early Paper-Covered Slides, c1840

John T. Quekett Slides, c1850

The Blenkins Cabinet, 1847-1870

Histology-Pathology Cabinet, fourth quarter 19<sup>th</sup> century

Nineteenth Century Cabinet with Entomological Slides

Newton-Huxley Slides, 1875

Dancer Chemical Preparations, c1870

Slides from the Challenger Expedition, 1876

Robert Koch Slides, 1886

Keeley Collection of American Slides, c1870-1940

Simon Henry Gage Serial Sections, 1894

Susanna Phelps Gage Serial Sections of Mouse Brain, 1894

Meteorite Petrographic Slides

Waksman Microscope Slides

#### Lentz Collection of Microscope Slides, c1820-2008

#### Specialized Slides

Maltwood's Finder, c1870

Stage Micrometer, c1890

Zeiss Abbe Diffraction Plate

Hemocytometer

Calibration Slide

Counting Slide for Hookworm Larvae

#### Slide Sets.

Josef Hyrtl *Texturae variae rariores* Slide Set, c1860

T. H. McAllister Slide Set, c1870

Diatom Slide Set, Arthur C. Cole, c1875

A. C. Cole Histology Slide Set, c1880

Prudden Slide Set, 1889

College of Physicians and Surgeons, Columbia University, Teaching Set

Histology Slide Set, c1900

R. Fuess Petrographic Slide Set

Botanical Slide Set, c1890

Sigmund Physiological Histology of Man and Mammalian Animals, c1920

Möller Materia Medica Slide Collection

Serial Sections of 8mm Pig Embryo, c1920

NBS Microslides Set of Spider Whole Mounts

Volcanic Ash and Sand Slide Set

Slide Set, Wait's Drugstore, Traverse City, Michigan. c1880

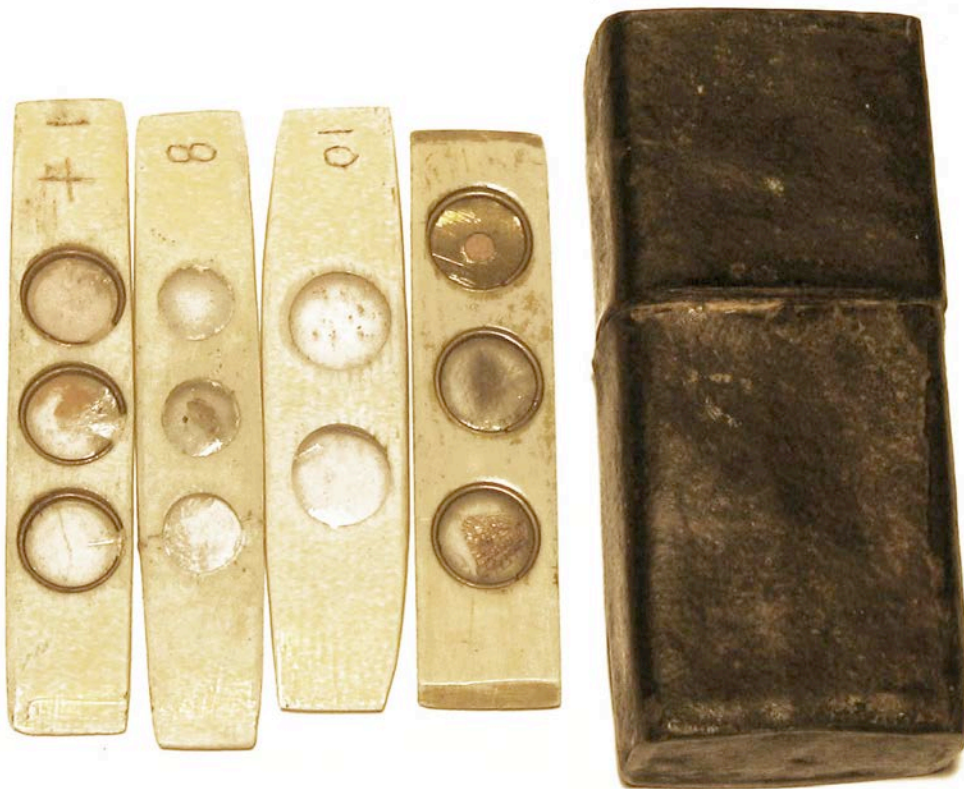


## The Evolution of the Microscope Slide

The microscope slide is a small support on which a specimen can be placed and held for viewing with a microscope. The development of slides was as important to the scientific disciplines of histology and pathology as were improvements to the compound microscope. For 250 years after the invention of the compound microscope, observations were largely limited to whole specimens held on a substrate. It was not until the advent of thin sections of specimens made by a microtome and placed on a transparent slide that the microscope became a truly useful scientific instrument. This is a brief survey of the evolution of microscope slides and their applications to different fields of science.

Sliders were the original carriers of objects for microscopical observation, described as early as 1691 by Filippo Bonanni (1658-1723), an Italian Jesuit scholar. Prior to that, specimens such as small insects were placed in live boxes or on the needle of a flea glass-type microscope for observation with a simple single lens microscope. For compound microscopes with an eye lens and an objective, objects were placed on a disc beneath the objective lens and viewed with incident light. Other objects such as tissues were dissected with knives, teased, or compressed.

Sliders are rectangular slabs, beveled at one end, usually made of bone, ivory, or ebony with round compartments cut out. Specimens were placed between two round pieces of mica called talcs and held in the compartments by brass rings. The ends were beveled so it would slip easily into a spring stage on the microscope. The early sliders are small (~ $\frac{3}{8}$ - $\frac{1}{2}$ " x 2-3") and have two or three compartments. These sliders accompanied a c1710 Culpeper screw-barrel microscope and were most likely made by Edmund Culpeper or James Wilson. A set of sliders identical in size, shape, lettering, and case is in the Museum of the History of Science, University of Oxford, and attributed to Wilson and dated c1704.



Wilson Sliders, c1704

This is a four-celled brass slider in which aquatic specimens were held between two thin sheets of glass (wet cells). The slider is  $3 \times \frac{9}{16}$  inches. It accompanied a c1710 Culpeper screw-barrel microscope. This slider is doubly stamped "EC" on one side and exhibits Culpeper's rosette pattern on the end of the other side.



**Culpeper Wet Cell Slider, c1710**

Sliders were used throughout the eighteenth century and the first part of the nineteenth century. They became larger and usually had four or five compartments that could be moved successively under the microscope objective. Most sliders are about a half inch wide and four or five inches long although there are larger ones for the solar microscope. Opaque specimens were attached to a cardboard substrate. Transparent specimens were placed between mica circles that were secured by brass circlips. The most common objects were insects, wood, feathers, butterfly wings, hair, plants, minerals, and shells.



**Ivory Slider, c1780**



**Ebony Slider, c1780**

This is an unusual bone microscope slider from the late eighteenth century. It is  $\frac{1}{2} \times 4$  inches in size and contains eight specimens rather than the configuration of four or five found in most sliders of the period. There are four entomological specimens and four fish scales, all of which are still in place. They were mounted dry between micas held in place with brass circlips. The photomicrographs of specimens illustrate the state of microscopy in the eighteenth century.



**Bone Slider, c1780**



The following slider is made of glass and paper and is transitional between the ivory, bone, or wood sliders and the glass slides that followed. In England, there was a tax on glass and windows that had been introduced in 1696. It was not until 1845 that the glass tax was repealed and the window tax six years later. This led to an unprecedented reduction in the price of glass. Prior to this, the effects of the tax resulted in a scarcity and variable quality of the material used in early glass microscope slides. There were often variations in color, thickness and size. In this slide, two glass slips have been hand cut to the contemporary shape of the bone sliders. Because the glass was hand cut, the edges are very rough. The paper spacer between the glasses was carefully cut to accommodate and hold each of the four specimens, which are dry mounted. The glass is glued to the paper. The slide is ½ x 4 inches and contains wood sections. The method of making these slides is described in Charles Gould's *The Companion to the Microscope* published by Cary in 1827. The advent of Canada balsam within a few years transformed slide preparation, superseding this method. These slides are very rare, probably because such a limited number were made between 1827 and 1832 and most were discarded when the new mounting medium was introduced.



Transitional Slide, c1830



This slide can be considered the first true slide as we know them today because of its rectangular shape, single compartment, and glass construction. It is also the earliest signed slide known. Prior to the introduction of Canada balsam, different methods for holding a specimen onto the slide were tried. The construction of this slide is the same as the transitional slide with a section of "Sasaparella" and paper spacer held between two strips of glass glued to the paper. The paper is stamped J. West. The identity of J. West is unknown but a possibility is R. J. West who was an optician in Oxford Street, London around 1820. 25 x 60 mm, c1820.

Early Slide, J. West, c1820

In this small glass slide of a humming bird feather, the specimen is placed on the glass slide and covered with a mica coverslip held on by red paper wrapped around the slide. Thin glass covers did not become available until the 1840s. The maker of the slide is Andrew Pritchard. Andrew Pritchard (1804-1882) was one of the earliest established commercial providers of microscope slides in London, being in business from the mid 1820s until the late 1850s. He was primarily known and highly respected as a skilled instrument maker, microscopist, and optician, as well as a prolific author. His popular and influential books on optics and microscopy, published beginning in 1827, are considered by many to have played a pivotal role in the further

development and commercialization of the microscope. At the same time, they encouraged the popular interest in and investigation of the natural world. His books also contained some of the first lists and descriptions of interesting microscopic objects for study, with methods for their preparation. It is believed that many of the slides retained by Pritchard were not actually made by him, but that he contracted with some of the early London slide makers to provide the inventory he advertised and sold through his shops. The cut out printed label "Feather of Indian Humming Bird" on the slide is probably cut from his book of 1832, *The Microscope Cabinet*. 20 x 52 mm, c1830.



**Pritchard Paper Covered Slide, c1830**

In this second type of slide attributed to Andrew Pritchard, the wood sections are placed between two glass slides that are sealed together at the edges with red wax. The slide is 1 x 3 inches and labeled "Eucalyptus globulus."



**Pritchard Wax Sealed Slide, c1840**

In this slide labeled "Pou Humain" (Human louse), two glass slides are held together by balsam at the edges and bound by green papers at the ends. The slide is possibly by Joseph Bourgogne who made small slides beginning around 1835 in Paris. 16 x 60 mm, c1835.



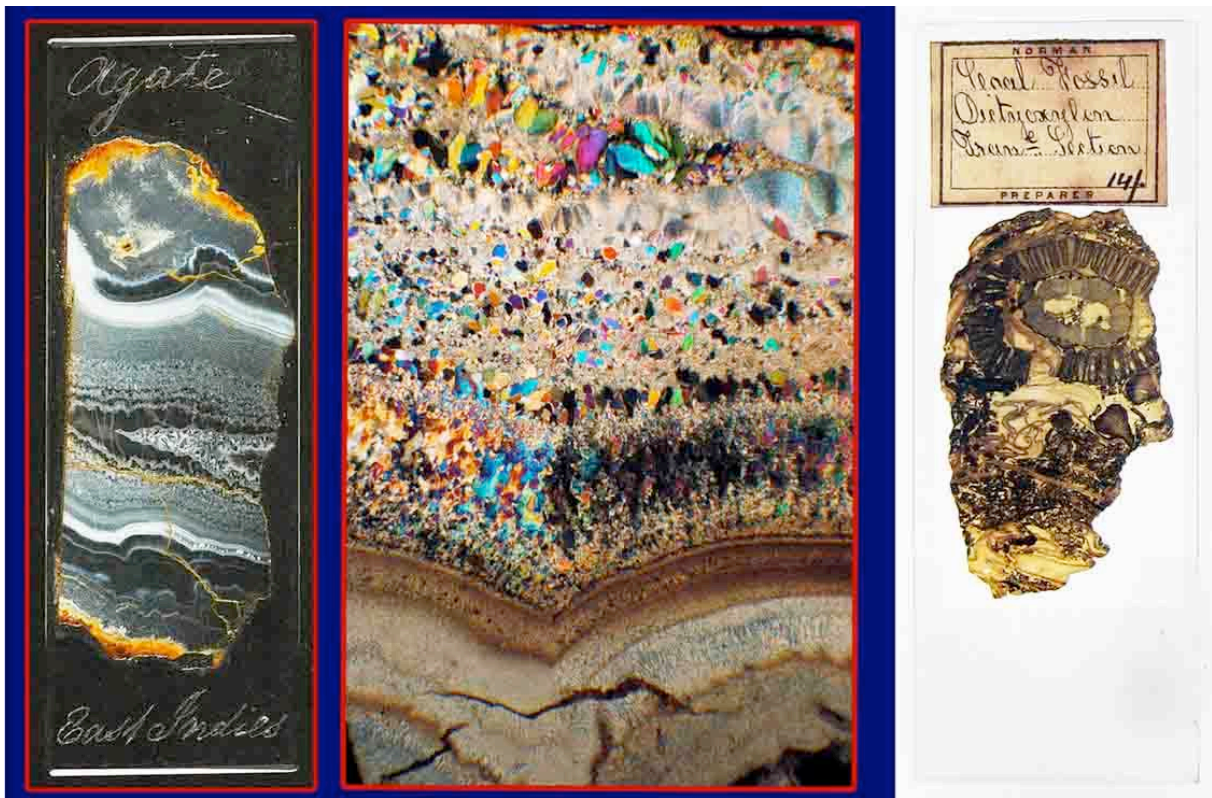
**Paper-Sealed Slide**

In the first part of the nineteenth century, a few lapidaries were engaged in preparing and mounting geological and fossil hard sections for viewing with the microscope. The difficult and laborious process consisted of obtaining a slice or fragment of a rock specimen and grinding and polishing so that one side was flat. It was then adhered to a glass slide and the other side ground down parallel to the glass without breaking the specimen or glass. Once the desired thinness that would allow transmitted light examination was obtained, the surface was polished. One of the



## Microscope Slides

first makers of these slides in London was William Hill Darker (1811-1864). Charles Morgan Topping (1800-1874) was selling sections of coal and fossils in the mid 1840s. Later, many slide makers offered slides of fossils, fossil diatoms, coal, and geological specimens. At the end of the century, reference collections of petrographic slides were used by universities for teaching mineralogy and geology.



The first slide is a section of agate from the East Indies by William Darker, c1840. It is viewed under polarized light. The second is an early fossil coal section. John T. Norman purchased a collection of early fossil coal slides and sold them under his label. c1840.



This slide is a triple section of coniferous wood fossil from Lough Neagh in Northern Ireland by William Darker. Sections were usually cut transversely, longitudinally, and tangentially. c1850.

The first paper on the microscopic structure of tissues was published by Hodgkin and Lister in 1827. In the 1830s and 40s, most scientific investigation of tissues was performed in Germany. In England, John T. Quekett made superb preparations of plant and animal histology. The first commercial mounters to prepare histology slides were C. M. Topping and Andrew Pritchard in the 1840s. When the importance of histology to medical science was realized and it was introduced into medical school curricula around 1850, the production of histological slides expanded greatly.

This is an important early histology slide by Charles Morgan Topping (1800-1874), with diamond point engraved writing. The slide, titled "Human Muscle" is one of Topping's early histology preparations, having been made in the mid 1840s. The slide is signed with the handwritten monogram "T." It also has an oval paper label in Topping's hand. The specimens are teased skeletal muscle fibers in which striations can be observed. C. M. Topping is one of the most famous mounters in history and began mounting professionally in the late 1830s. He worked closely with a number of medical professionals including John Quekett, and was renowned for his injected and corroded histology mounts.

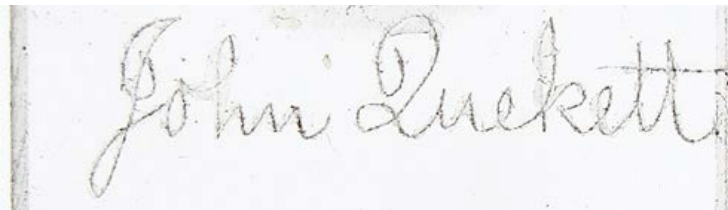


Histology Preparation by C. M. Topping, c1845

This slide was prepared by John Thomas Quekett (1815-1861) who was Conservator and Professor of Histology at the Hunterian Museum of the Royal College of Surgeons. Quekett's work was of great importance towards making the microscope a vital scientific research instrument. His histological preparations were advanced and innovative for the time and set the



standard for others. In 1848, he published a book that included detailed instructions on specimen and slide preparation. Quekett never made slides for commercial purposes. His slides remained with the Hunterian Museum and are almost unknown outside the Museum. This small glass slide is 21 x 62 mm. The glass is beveled on three sides and jagged on one. The glass coverslip is irregularly cut. The slide is labeled "Portion Choroid Frog" and bears Quekett's distinctive numbering system. It is diamond-engraved "John Quekett." The slide appears to be one of Quekett's early efforts. c1840.

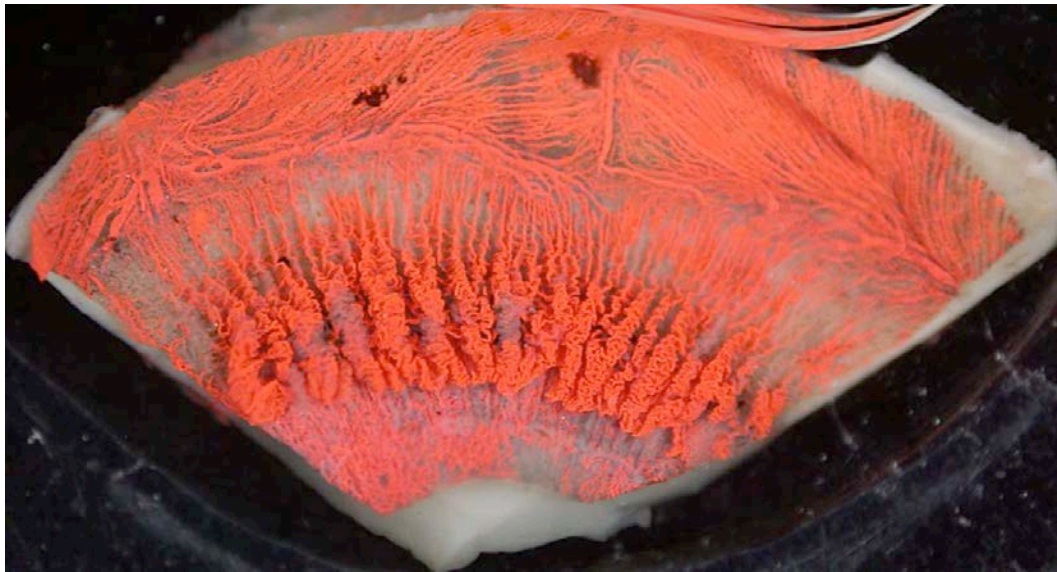


Slide by John Quekett, c1840

No standardization of slide size existed until a resolution by the committee for the members of the Microscopical Society of London was passed in 1839. It suggested slide sizes of 1 x 3 inches and 1 ½ x 3 inches. Individuals still cut the glass for their own slides and cover glasses, using a cutting-board and diamond kept by the Curator. These sizes were meant for the Society's own cabinet but they began to be used by some commercial mounters and eventually were accepted universally.

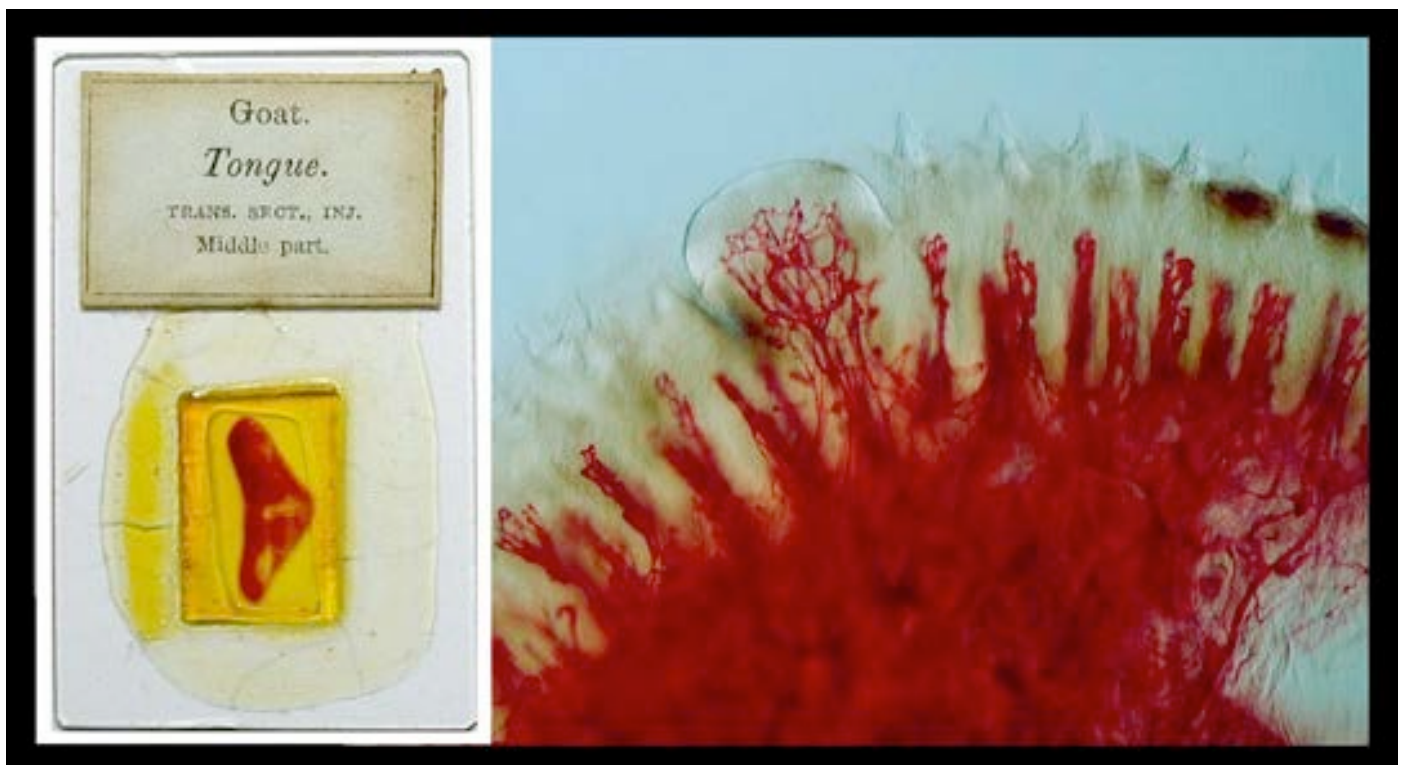
Prior to the ability to adequately section tissues, early tissue samples were often mounted in a deep cell filled with fluid, usually alcohol, formalin, or acetic acid. Many of these are still intact after 150 years. This example is the "Ciliary processes Young Pig." After injection, the surrounding tissues were corroded away, leaving a cast of the blood vessels. c1850.





**Deep Cell Fluid Mount, Ciliary Processes, c1850**

The next slide shows several advances in slide preparation. The coverslip is held on by Canada balsam. Mounting with Canada balsam was introduced around 1830 and had the advantages of being transparent and holding the coverslip on the slide. Second, the specimen is a thin section of a tissue. Microtomes at the time were used primarily for sectioning of wood. Tissues were probably sectioned with a Valentin knife or a hand microtome. The blood vessels of the tissue have been injected with a dye. Capillaries are visible in the papillae. The label reads "Goat. Tongue. Trans. Sect. Inj. Middle part." These slides were prepared by Karl Thiersch (1822-1895), a German surgeon, and imported by Smith and Beck in London in the 1850s. 34 x 55 mm.



**Transparent Injected Specimen, c1850**



Transparent specimens embedded in balsam were poorly visualized because of lack of contrast. Stains began to be employed in the 1850s and by the end of the century virtually every colored substance had been tested as a stain. One of the earliest stains, first used in the eighteenth century, was logwood which contains hematoxylin, a stain used commonly today. This slide "Parenchymatous Nephritis of Liver" by Arthur J. Doherty bears the notation "Stained Logwood." c1885.



Section Stained with Logwood

Early Medical Slide, 1857

In addition to their use in teaching histology and pathology, slides began to have a direct medical application to the treatment of patients. This is an early slide in which microscopy appears to have been used diagnostically on a living patient. The label reads "Uric acid from a

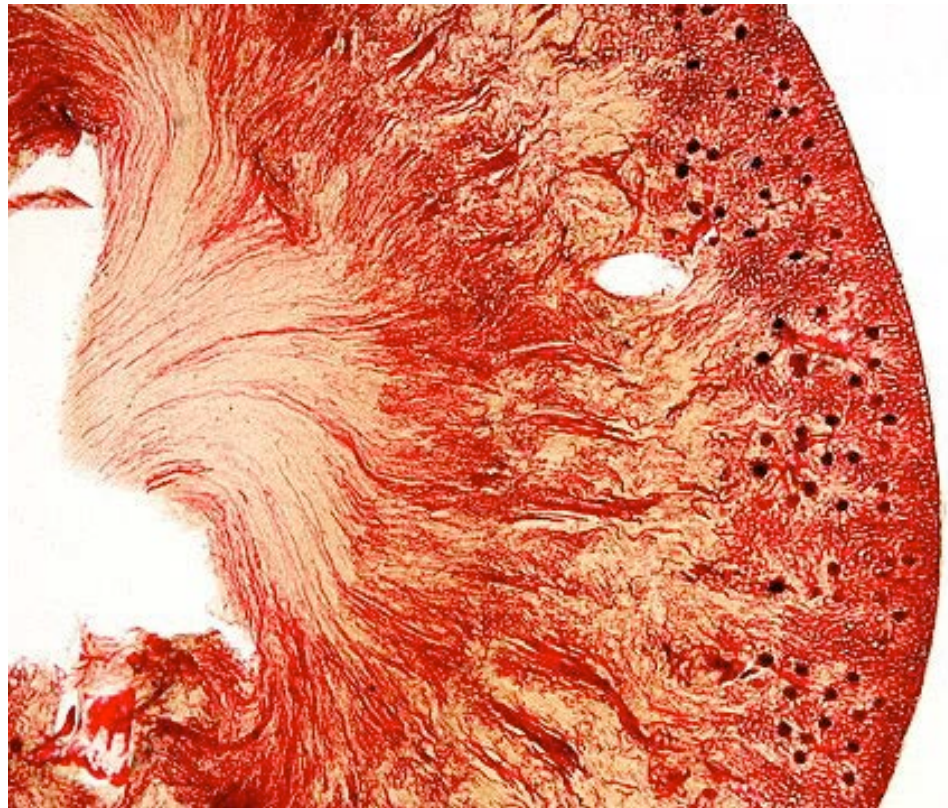
patient with Ascites. 1 ½ dram gave 6 times the quantity here shown taken before tapping no such quantity afterwards. Seen by Dr Tweedie & W Burke Ryan 28 Sept 1857." Dr. Alexander Tweedie (1794-1884) F.R.S. was an expert on fevers and wrote a book *Clinical Illustrations of Fever*. He was Physician to the London Fever Hospital. Dr. William Burke Ryan (1810-1874) F.R.C.S. received his M.D. in 1857 from the University of London. He was Surgeon to the South Middlesex Rifle Volunteers and engaged in general practice at Norfolk Terrace, Bayswater.





In 1858, Rudolph Virchow articulated what became the accepted form of the cell theory, *omnis cellula e cellula* ("every cell is derived from a [preexisting] cell") He founded the medical discipline of cellular pathology, namely, that all diseases are basically disturbances of cells. It followed that if cells comprised the organism and could grow and divide and that diseases arose in cells, cells were extremely important subjects for research and teaching. As a result, slides of normal and diseased tissues were prepared for research and teaching in medical schools.

Edmund Wheeler was a professional mounter by 1866 and prepared very fine histology and pathology slides among many other subjects. He retired in 1884 and sold his business and stock, including over 40,000 slides, to W. Watson & Sons. This is a very fine injected specimen of mouse kidney for study of normal histology.



**Injected Kidney of Mouse by Wheeler, c1870**

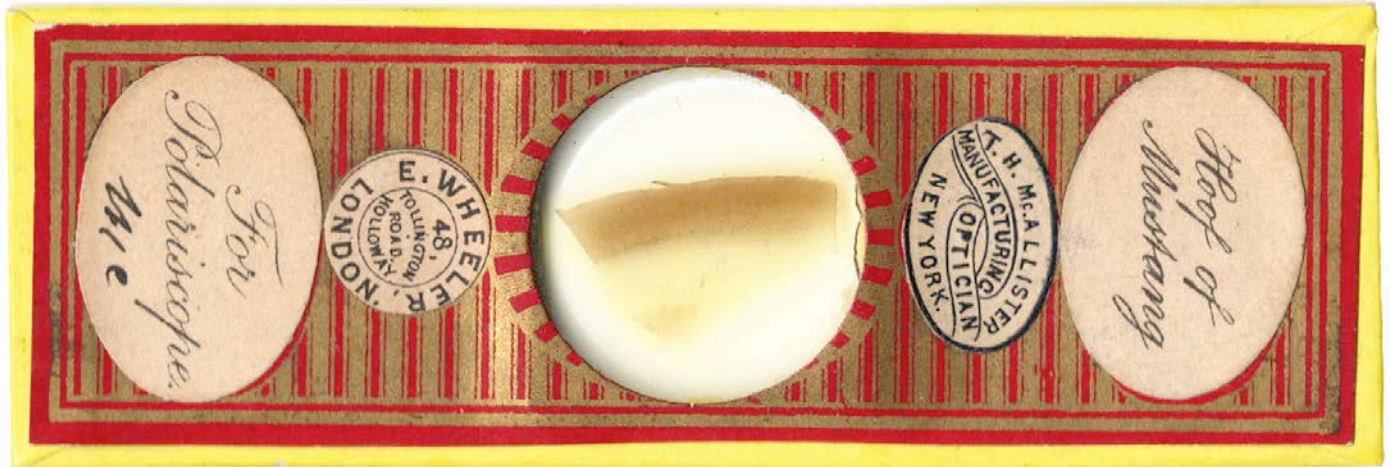
At the same time, slides of pathological specimens were prepared. This slide by Cole is a section of tubercular lung. Although several firms offered histology and pathology slides, Arthur C. Cole (1821-1900) appears to have been the first to offer them in sets.



**Tubercular Lung, c1870**



Paper covers were first used to hold the mica or glass covering slips to glass slides or to hold two pieces of glass with the specimens in between together. Although the paper covers were no longer necessary to hold the coverslip on after the introduction of Canada balsam in the 1830s, they continued to be used to cover slides. They became highly decorative, lithographed in bright colors and gilt, and sometimes included the mounter's name or monogram. During the Victorian period, microscope slides were made for education of science and medical students, but also for the entertainment of the public. This paper covered slide by Edmund Wheeler bears a secondary label for T. H. McAllister, New York. The specimen is "Hoof of Mustang" which is birefringent. The label "For Polariscope" indicates it should be viewed under a polarizing microscope. Red and gold patterned paper-covered slide, yellow border. c1875.



**Victorian Paper Covered Slide, Hoof of Mustang, c1875**

Exhibition slides of unusual objects were very popular in Victorian times. Although these "exhibition" slides were meant for entertainment and amusement in Victorian parlors, they heightened public awareness and interest in the fields of biology, botany, archeology, oceanography, paleontology, geology, and science in general. Among the most popular nineteenth century subjects were the mineral skeletons of diatoms, foraminifera, radiolarians, and polycystina.

Diatoms are a group of algae and among the most common types of phytoplankton. They are unicellular organisms with a cell wall made of silica. Diatoms were a favorite subject for mounters during the Victorian era because of the intricate patterns in their cell walls. They were also useful objects for testing the resolving power of microscope objectives. They were classified by scientists and about 100,000 species have been identified. They remain a useful tool for measuring environmental conditions presently and in the past. This is an attractive complex arrangement of diatoms in concentric circles by A. C. Cole viewed with darkfield illumination.



A. C. Cole Diatom Circle

Insects were another popular subject for slides. Frederick Enoch (1845-1916) was a mounter of whole insects prepared in a lifelike manner without pressure. His slides are of the highest quality and perhaps unequaled. This slide is labeled "Order Hymenoptera, Family Cynipidae, Genus Andricus, Species terminalis, Fred<sup>e</sup> Enock Preparer, The Oak-Apple Fly, Showing the internal and muscular structure, Polariscope or Paraboloid, 2 inch to ½ inch." The oak apple fly is one of the most striking and informative of Frederick Enoch's very small insect mounts. It is the smallest of those that he was able to clear leaving the internal and muscular structure intact.







**The Oak Apple Fly, c1885**

Although Antonie van Leeuwenhoek observed bacteria in 1674, the scientific field of bacteriology was founded in the nineteenth century as a result of the work of Ferdinand Cohn, Louis Pasteur, and Robert Koch. The germ theory of disease, namely that specific diseases were caused by specific pathogenic microorganisms, was validated. It therefore became important to observe and classify bacteria and other microorganisms. In Jena, Germany, the remarkable combination of Carl Zeiss, a machinist, Ernst Abbe, an optical theorist, and Otto Schott, an optical glass maker, resulted in the development of microscopes with unsurpassed apochromatic optics. It was now possible to clearly observe and study bacteria and even viruses with the microscope. Late nineteenth century microbiology slides include the causative agents of diseases such as tuberculosis, smallpox, anthrax, and leprosy that are absent or less commonly seen today. This is an example of a slide of “Bacillus Tuberculosis Human Lung” by W. Watson & Sons. c1890.



**Bacillus Tuberculosis, c1890**

Paper covers were used less frequently after about 1880. Coverslips were held on the slide with balsam. The edge of the coverslip was often ringed with a cement to seal and finish them. Colored ringing cements were sometimes used to give the finished mount a decorative appeal. Ringing largely died out in the first part of the twentieth century. This was unfortunate because the mounting media of unringed slides is more likely to become dried and cracked at the edges of the coverslip. This ringed slide by W. Watson & Sons is the "Junction of Retina with Ligament of Cilliary" "From the Human Eye." c1890.



Ringed Slide, c1890

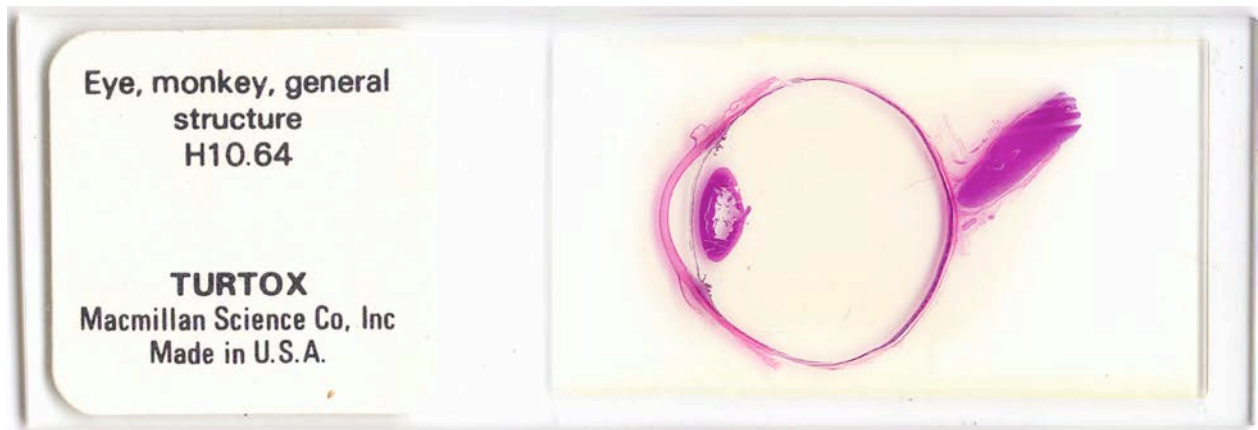
Around 1885, microtomes were developed in which the knife is fixed and the object moves to and fro past the knife. The most notable of these microtomes were the Cambridge Rocking microtome and the Minot rotary microtome. These microtomes allow for the production of serial sections of a specimen. The sections can be taken off the knife as a ribbon and mounted on a slide. Simon Henry Gage (1851-1944) published with Theobald Smith in 1883 a paper on serial sectioning that was one of the first serious discussions on the use of serial sections in histology and embryology. Gage, with his wife Susanna Phelps Gage (1857-1915), used serial sections to create three-dimensional models of the specimen. Susanna Phelps Gage was herself an independent investigator and one of the first woman histologists. This is a set of serial sections of mouse brain prepared by Susanna Gage in 1894.



Susanna Phelps Gage Serial Sections



In the twentieth century, the use of microscope slides for entertainment decreased and they became almost exclusively used for educational, scientific, and medical purposes. Firms produced large numbers of slides for educational use in courses for science and medical students. These slides, often of high quality, were practical and utilitarian. This exceptional slide of the monkey eye was prepared by Dr. James B. McCormick. McCormick founded and ran the Histoslides Company from 1945 to 1955. The company produced slides for universities and also for firms such as Turtox, Ward's Scientific, and Scientific Products. This was Histoslides No. 131 and was provided to Turtox in 1949/50.



Eye of Monkey, c1950

Around 1890, microtomes were developed that could cut sections of large specimens, some as large as whole human brains. These sections are useful because they allow structure to be visualized from the anatomical to the tissue and down to the cellular level. Shown below are slides containing sections of large structures.

The maker of this remarkable slide of a fetal hand is unknown. Fourth quarter nineteenth century.



Human Fetal Hand



**Human Heart, 1935**

This is another large slide through the entire human heart showing the right and left ventricles. It measures 3 ¼" x 4 ¼." The slide is accompanied by a note with the letterhead of Kings College, University of London, Hambleden Department of Anatomy and dated July 22<sup>nd</sup> 35. It was presented to an unnamed person and prepared by Edmund J. Westin, FRMS. The nerves are stained black in the slide.

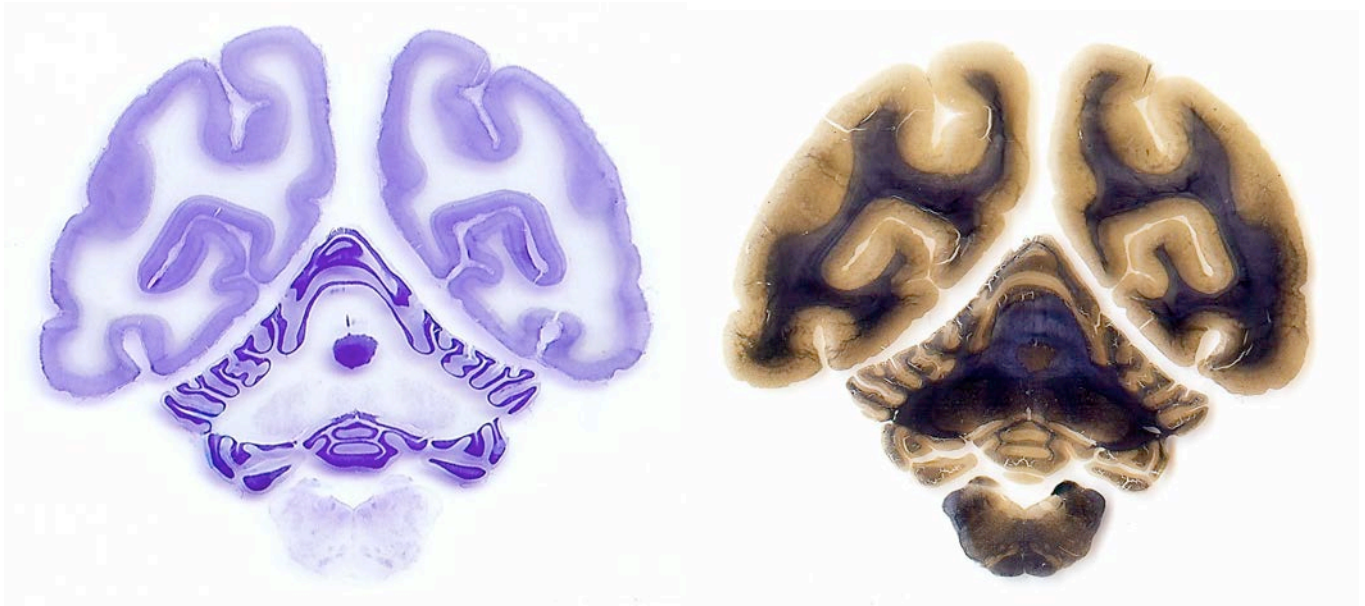
This slide is a sagittal section of a three month human embryo. The slide is 1 ½ x 3 inches. Slides of whole human embryos are rare.



**Human Embryo Slide, c1960**

These slides are coronal serial sections through the occipital region of the cerebrum and the cerebellum of a monkey. One slide is stained with cresyl violet for cells and the other with Weigert's stain for myelin. 38 x 76 mm. Yale University, c1970.





Monkey Brain

Beginning in the 1970s, the Carolina Biological Supply Company began producing slides of tissues fixed and embedded in the same manner as for electron microscopy. Tissues are fixed with osmium tetroxide and embedded in epoxy resin. This allows for better preservation of tissues and the ability to make thin sections with an ultramicrotome. The sections are  $1.5\ \mu\text{m}$  thick whereas conventional paraffin sections are about  $7\ \mu\text{m}$  thick. As a result, these slides are probably the finest ever made for observing fine detail of tissues at the light microscopic level.



1.5  $\mu\text{m}$  Section of Monkey Skin, c1980

The future of the microscope slide is uncertain. Medical schools are increasingly turning to the virtual microscope in which a very high resolution scan of a slide is viewed and manipulated on a computer screen. It is no longer necessary, as in the past, to supply each student with a set of slides in histology, neuroanatomy, pathology, and microbiology courses. Slides will still be needed to perform scans for the virtual microscope, in research laboratories, and diagnostically in clinical medicine. However, the large scale production of teaching slides is probably over. It is, therefore, all the more important that microscope slides depicting one of the most important eras in the history of science and medicine be preserved.

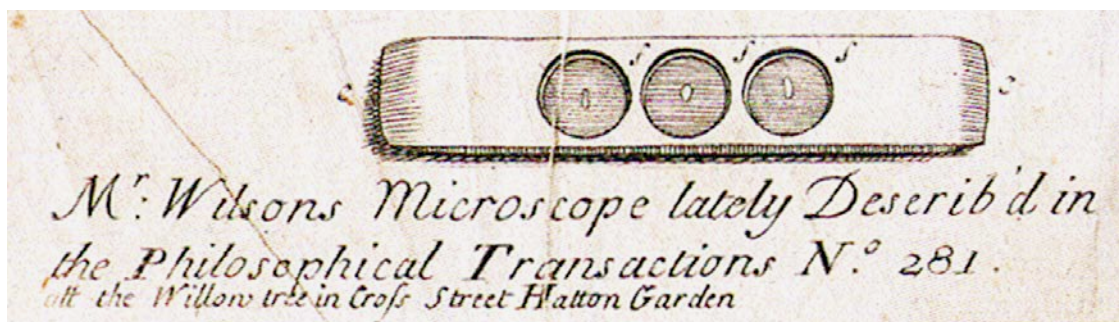
## Sliders

### Early Sliders, c1704

Sliders were the original carriers of objects for microscopical observation, described as early as 1691 by Filippo Bonanni (1658-1723), an Italian Jesuit scholar. Sliders are rectangular slabs, beveled at one end, usually made of bone, ivory, or ebony with round compartments cut out. Specimens were placed between two round pieces of mica and held in the compartments by brass rings. These sliders are small (~3/8" x 2"), have two or three compartments, and fit into a fish skin case. They accompanied the Culpeper screw-barrel microscope and were most likely made by Edmund Culpeper or James Wilson. A set of sliders identical in size, shape, lettering, and case is in the Museum of the History of Science, University of Oxford, and attributed to Wilson and dated c1704. The date is plausible because the sliders are the same as one illustrated in Wilson's 1706 pamphlet describing his pocket microscopes.



Early Sliders, c1704



Sliders pictured in Wilson's 1706 Pamphlet



### Nuremberg Slider, c1770



This is a wooden Nuremberg slider for use with the Nuremberg toy microscopes. It is 6 ¼ inches long, ¾ inches wide, and ¼ inch thick. The ends are beveled. There are six cells with the specimens held between micas and secured with steel rings. The wood appears to be walnut.

### Sliders, c1780



This is a set of seven ivory and eight ebony sliders in a case, eighteenth century. These sliders are larger and have more compartments than the earlier sliders. The sliders have four compartments which can be moved successively under the objective. The specimens in the ebony sliders are attached to a substrate. Those in the ivory sliders are secured by micas and brass clips. There are a variety of objects: insects, wood, feathers, butterfly wings, hair, plants, minerals, shells, etc. All specimens are intact.

## Slide Collections and Cabinets

### Circular "slides" 1780-1810, Abraham Ypelaar

What can be considered the first slides are round bone or ivory rings of various sizes. Some are hexagonal. Within the circle, transparent objects were held in place between two micas by a brass or gilded ring. Opaque objects like pieces of shell, stone or small seeds could be glued on carton. These can be considered slides because they could be placed on a stage and moved around. They were made from about 1780 to 1820 when rectangular slides began to be made.

These are 12 circular and two hexagonal slides. The six cells with thin walls were made by Abraham Ypelaar in Amsterdam. Some of the others are French. The first round slides were made by Abraham Ypelaar. At a young age, Ypelaar (1736-1811) developed a fascination for microscopy and the writings of Antoni van Leeuwenhoek and Jan Swammerdam, the great Dutch microscopists of the seventeenth century. A diamond setter by origin, Ypelaar later turned his hobby of preparing zoological, botanical and inorganic microscopical specimens into an important business. With the help of his cousin, Ypelaar started a "factory" for the commercial production in ready-made microscopical preparations. They picked up on the growing awareness of scientific culture by the middle classes. Instrument makers usually would provide most commercial microscopes with an amount of ready-made preparations in long bone-sliders. Ypelaar, however, produced round bone rings. The preparations produced by Ypelaar drew on both aesthetics and natural history. The opaque specimens in particular were arranged in attractive geometric patterns or formed as flowers. Ypelaar himself even referred to his specimens as "artistic objects" and he wrote about his own artistic ability as being appreciated by competent art experts. He produced specimens in sets and cabinets ranging in size from 20 to 1,600. In 1808 he was awarded a silver medal at the Holland Industry Exhibition. Ypelaar's slides are extremely rare outside of museums.



#### Set of Continental Circular Slides, c1790



This is a numbered set of 11 (of 12) circular ivory cells,  $\frac{5}{8}$  inches (16mm) in diameter, set with botanic specimens between transparent disks of mica and held in place by brass spring rings. Many objects are as-collected; some are thin sections. One or two specimens seem lacking; otherwise the set is in very fine condition, complete with its little cylindrical paper and leather-bound card case.

#### Set of French Circular Slides, c1790

This is a very rare complete set of twenty circular, ivory slides. The varied specimens are set between two micas and held by a brass circlip. All of the cells are labeled in French. Some of the cells have the letter "T" on the reverse, perhaps the sign of the maker. The cells are 15 mm in



## Microscope Slides

diameter. The cells are held in a mahogany case 88 mm x 77 mm with a sliding lid. All of the slides are in excellent condition with clear writing and no loss to micas and specimens.



Set of French Circular Slides

Set of French Circular Slides with Microscope, c1820



This is a set of circular slides probably made in France. These specimens are held in a plate screwed into the bottom of a small drum microscope. The brass microscope focuses by rack and pinion and has a mirror below the stage. It is missing the eyepiece and glass circle for the stage.

The specimens are listed (in French) on paper on the inside of the baseplate:

1. aphid wing
2. wood of red gooseberry
3. bedbug
4. wing of collibelle
5. egret ?
6. flea

### Early Paper-covered Slides

This is a group of papered cardboard slides dating to the period 1835-1850. The slides are of plants: Nasturtian, Sea Weed, Godetia, Mallow, Evening Primrose, Begonia Seed, Hop, Campanula, Oriental Mallow, Holyoake. The slides are made of cardboard, have a piece of thick glass over the object, and are wrapped in paper. The different sizes, types and patterns of the papers used, and the use of a thick irregular piece of glass for a cover illustrate developments in the preparation of slides at this time. In England, there was a tax on glass and windows that had been introduced in 1696. It was not until 1845 that the glass tax was repealed and the window tax six years later. This led to an unprecedented reduction in the price of glass. Prior to this, the effects of the tax resulted in a scarcity and variable quality of the material used in early glass microscope slides. There were often variations in color, thickness and size. These slides are of cardboard, probably to conserve glass, and have a smaller glass cover. The slides are of different sizes. No standardization of slide size existed until a resolution by the committee for the members of the Microscopical Society of London was passed in 1839. It suggested slide sizes of 1" x 3" and 1 ½" x 3". The blue slide to the left is standard size. Individuals still cut the glass for their own slides and cover glasses, using a cutting-board and diamond kept by the Curator. Eventually, these sizes were accepted universally.





Regarding the papers, the Rotary press printing machine invented by Richard March Hoe, in New York City in 1843, speeded up the printing process for chromolithography and reduced the price of printed papers of all kinds. It is therefore possible to date the introduction of patterned printed papers suitable for microscope slides to the early years of the 1840s. Paper as a covering for glass slides came into use in the 1830s. These slides show a number of different types of paper, the earliest of which is the plain and marbled papers (upper right). There are various printed patterns of the 1840s one of which is the Star pattern.

John T. Quekett Slides, c1850



These important slides in were prepared by John Thomas Quekett (1815-1861) who was Conservator and Professor of Histology at the Hunterian Museum of the Royal College of Surgeons. Quekett's work was of great importance towards making the microscope a vital scientific research instrument. His histological preparations were advanced and innovative for the time and set the standard for others. There are 11,000 of his slides in the Hunterian Museum. These slides are examples of the two main types that he made, one with a diamond-engraved description "Part of the lung of the Boa constrictor lower end" in Quekett's own hand; and the other with a handwritten description "Muc Memb. Crop Fowl" and numbering system for his slides. Quekett never made slides for commercial purposes. His slides remained with the Hunterian Museum and are almost unknown outside the Museum .

Born in England in 1815, John Thomas Quekett was the youngest of four brothers, each with a predilection for natural history. He developed an interest in microscopes early in life and at the age of sixteen built his own microscope with a roasting-jack, parasol, and some fragments of brass. Quekett chose the field of medicine as a career and entered King's College and the London Hospital Medical College as an apprentice to his brother Edwin. In 1840, Quekett was awarded his Diploma of Membership in the Royal College of Surgeons and gained a three-year studentship there in Human and Comparative Anatomy. He was involved in the repair and maintenance of specimens in the Hunterian Museum. At the end of his three year term, his ability in making and arranging microscopical preparations was recognized and he was appointed Assistant Conservator of the Museum. He prepared a series of microscope slides closely related to and illustrative of the finer structure of many of the preparations in the Physiological Series of the Hunterian collection. Many of these are fine injected specimens. The slides, numbering nearly 3,000, were purchased by the College in 1846. He gave lectures on histology that were published in two volumes in 1852 and 1854 as "Lectures on Histology." In 1848, he wrote "A Practical Treatise on the Use of the Microscope," an important work leading to rapid growth in the popularity and scientific potential of microscopy. It was also the first work to address specimen preparation techniques for the newly effective achromatic compound microscopes. In 1852, he was rewarded with a professorship in Histology at the Royal College of Surgeons. He was appointed Resident Conservator of the Hunterian Museum, succeeding Sir Richard Owen in 1856.

In 1839, Quekett and his brother Edwin were among the seventeen founding members of The Microscopical Society of London, the world's first microscopical organization, renamed the Royal Microscopical Society in 1866. He was made honorary secretary of the Microscopical Society in 1841, a position he retained for 18 years. In 1857, he was made a Fellow of the Linnaean Society, and in 1860, a Fellow of the Royal Society. He was elected president of the Royal Society in 1861. He held office for only a brief period, however, dying only six months later of Bright's disease at the age of 46.

### The Blenkins Cabinet



**George Eliezer Blenkins**

George Eliezer Blenkins, F.R.C.S. (1815-1894), was one of the earliest members of the London Microscopical Society, joining in 1848. The London Microscopical Society became the Royal Microscopical Society in 1866. Blenkins was Surgeon to the Grenadier Guards serving in the Crimean campaign and a Lecturer in Anatomy at St. George's School of Medicine in London. Beginning in 1851, he was one of the first to introduce histology into a medical school curriculum and taught a course of practical histology in which every student was provided with a microscope and taught how to make their own preparations. He was Secretary of the Royal Microscopical Society from 1858 to 1867.

Blenkins life is described in his obituary which appeared in the British Medical Journal No. 1762, October 6, 1894, p 789.

DEPUTY INSPECTOR-GENERAL G. E. BLENKINS,  
F.R.C.S.



We have to announce with regret the death of Deputy Inspector-General G. E. Blenkins, F.R.C.S., late Grenadier Guards. He entered the regiment in April, 1838, and served in the Crimean campaign including the fall of Sebastopol, receiving the gold medal with clasp, the 5th Class of Medjidie, and the Turkish medal. After serving more than thirty years in the regiment he retired, in December, 1868. Mr. Blenkins has so long retired from active work that the younger generation will hardly recognize his name as one of the most active and valued workers some thirty years ago. He was one of that distinguished class of army surgeons, then by no means too numerous, who to a thorough knowledge of his profession and departmental duties, added a great love of scientific research in the active study of its most difficult departments. He was a practical and skilful histologist, when to be so was a rare distinction even in the schools in civil life.

We incline to believe that he was the first amongst the teachers of histology in the metropolitan medical schools who instituted classes of practical microscopic work and demonstration. He lectured and taught at Lane's School of Anatomy and Medicine adjoining St. George's Hospital, and as far back as 1851 he carried on there a class of practical histology, in which every student was provided with a microscope, and was taught himself to make, prepare, and put up the specimens. This class Mr. Blenkins conducted while a surgeon in the Guards, and it had, at that time at least, few if any parallels in this country, for what is now an every day rule of teaching was then a rare and brilliant exception.

This brief tribute is due to the memory of one of the most lovable and accomplished surgeons of his day, for to a handsome presence, great dignity and refinement of manner, of which the only fault perhaps was a somewhat marked reserve, Mr. Blenkins Blenkins joined singular modesty, unflinching kindness of heart, and an interest in the personal welfare of his pupils which lasted throughout his and their lives.



Blenkins' slides are housed in a very fine mahogany cabinet of the 1850 period measuring 22 ½ inches in height, 14 ½ inches deep, and 12 inches wide. It weighs 50 pounds with slides. This cabinet is of great historical significance because the owner and maker of most of the slides is identified, its date is established, and it was undertaken at a time when the making of glass slides, especially of a histological nature, was in its infancy.

Some of the drawers contain blank slides, mounting papers, specimens wrapped in paper, and an envelope with Blenkins name on it. All of this material that was used in mounting has been left intact and its presence suggests that this was a working cabinet that has been untouched since the time it was in use. The cabinet could justifiably be described as a time capsule of the histology slide collection of a surgeon of the mid 19th century.



The cabinet was purchased from Brian Davidson in England. He is a scholar of early microscopy and holder of probably the largest and best collection of microscope slides in private hands. It was his wish that this cabinet be preserved intact. The provenance of the cabinet is unknown. Davidson purchased it at auction in London about 30 years ago. It had been in the hands of a dealer for a short while, and possibly sold to the dealer by a descendant of Blenkins.

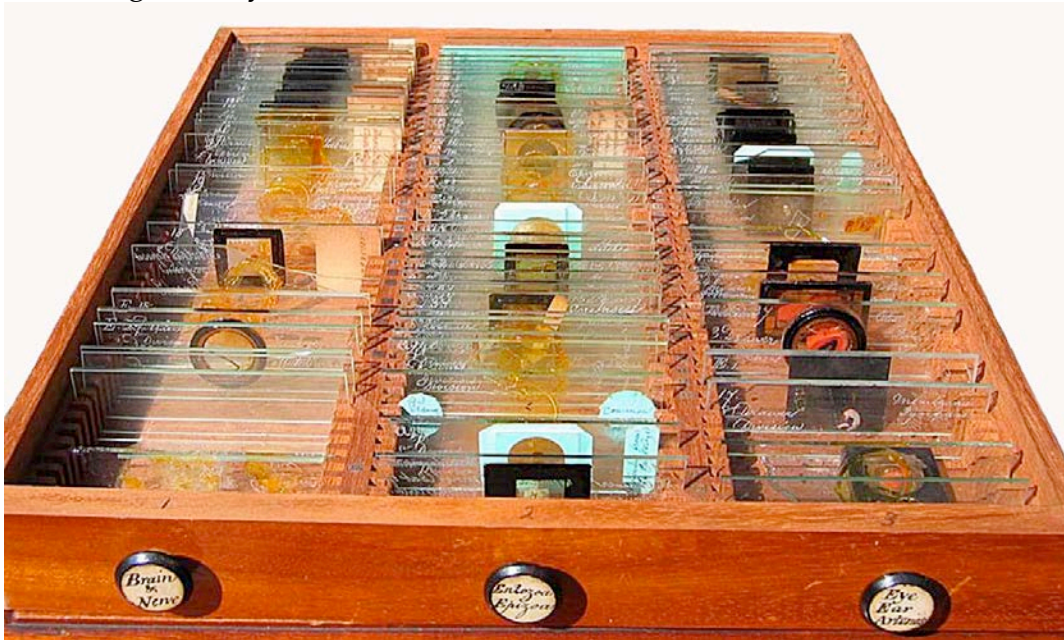


Drawer knobs with paper labels



## Microscope Slides

There are fourteen drawers each with three knobs. Each knob has a paper label identifying the contents of drawer. The knobs on the drawers are labeled Diatoma; Diatoma; Spicula of Spong; Shell; Bone; Bone; Skin, Fat; Epithelium, Spermatozoa; Fibrous Tissue, Fat; Teeth; Cartilage; Quill, Hair, Feather; Muscle; Tongue, Mouth; Pharynx, Stomach, Oesophagus; Nose, Lung, Air Tubes; Liver; Eye; Spleen, Pancreas; Urine; Intestine; Brain, Nerve; Entozoa, Epizoa; Eye, Ear, Arteries; Knob missing (Scales); Limbs, Antennae, Insects; Ovipositor, Spiracles, Stings; Vegetable Cells, Hairs; Scales, Cuticle, Spiral Vess; Nuts, Woody Tissue; Scalaus Tissue, Spiral Vess; Photographs, Metal; Algae, Seaweed; Polariscope; Seeds, Vegetables; Anthozoa; Skin; Intestine; Liver; Lung; Kidney; Uterus.



**Drawer with diamond engraved slides**



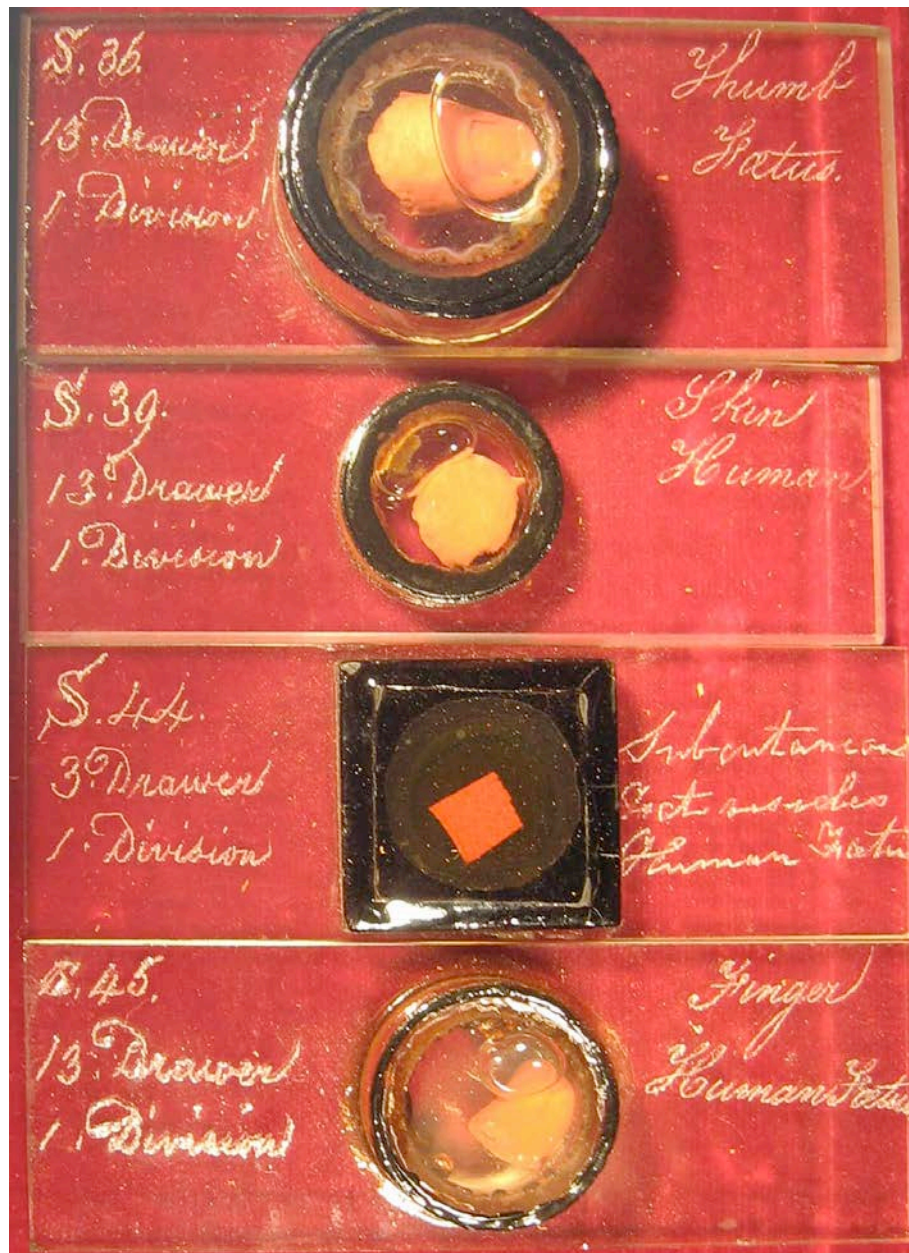
**Drawers with deep cell fluid mounts.**

All except the bottom two drawers have the slides upright in slots. The lower ones contain a number of deep cell fluid mounts which are horizontal and held in place by two removable mahogany strips. There are about 950 slides in the collection and about half of them are histological in nature. The majority of the slides are diamond engraved, undoubtedly in Blenkins' own hand. Each slide is engraved with a description and its number, drawer, and division (row in the drawer). A few have Blenkins' initials and some are dated, the earliest being 1847. Most of the slides are likely the work of Blenkins himself and were made between 1850 and 1865. There are also a few microphotographs of Blenkins.





Diamond-engraved writing, microphotograph of Blenkins.



Fluid mounts of human skin



Blenkins' collection contains two fluid mount slides with the following notations: "Villi of Chorion, Human Ovum, Described & Figured, Microscopl Transact, June 10th, 1857"; and "Human Ovum, Described & Figured, Microscopl Transactions, June 10, 1857". These slides were the basis of his note entitled "On an early Human Ovum" published in the Society's Transactions in 1858. This is one of the first microscopic accounts of an early human embryo. The embryo can be identified as about Stage 13, 32 days.



Human Ovum

Described & figured  
Microscop<sup>l</sup>-Transactions  
June 10 - 1857

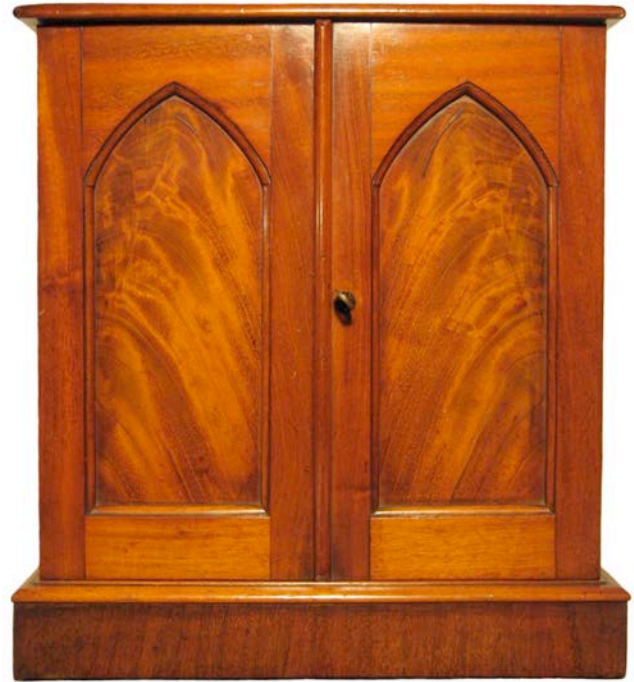


Drawing of the "Ovum" from Blenkins' paper

Blenkins' fluid mount slide of a human embryo ("Ovum"), description published in the Transactions of The Microscopical Society of London, N. S., 6: 5-9, 1858, one of the first microscopical accounts of an early human embryo.

### Histology – Pathology Cabinet

This is a very fine cabinet of histology and pathology slides. They appear to have been the collection of one man, probably the maker of the slides. They may have been the teaching slides of a professor. The histology slides cover all the tissues of the body with only one or two exceptions and represent a set sufficient to teach a course. Similarly, the pathology slides cover the diseases most prevalent at the time. The cabinet is 15 inches wide at the base and 19 ½ inches high. There are 50 large 1½ x 3 inch slides and 109 slides of normal size. The slides appear to date from the latter part of the 19<sup>th</sup> century. The cabinet is of very fine quality with mahogany double doors and a handle on each side. The ten drawers are inlaid at the front with a contrasting light-colored wood and have a pair of turned bone knobs. Each of the slides has its own compartment separated from the next one by a wooden partition. This cabinet with individual cells would have been expensive to make and indicates the importance the owner attached to the collection. The cabinet was obtained from Brian Davidson in 2008.







Drawer 3

Nineteenth Century Cabinet with Entomological Slides



This is an 11 x 10 x 11½ inch cabinet containing 500 slides. The first 128 slides are butterfly and moth wings with about 70 being British butterflies and the rest from around the world. The labels show the Latin and common names of the butterflies. These may be amateur preparations by an entomologist but the slides are of high quality. The remaining slides are professional mounts by makers including Smith, Beck & Beck, Enock, Russell, Wheeler, Topping, Norman,

Bourgogne, Cole, and Dancer. Most are colored paper-covered slides and others are diamond-engraved. Many of the latter are signed "T" [Topping]. These slides are representative of the subjects, including diatoms, polycistina, foraminifera, insects, plants, objects for polariscope, etc., most popular for viewing with the microscope in Victorian England. A few slides are dated between 1872 and 1875.

### Newton-Huxley Slides

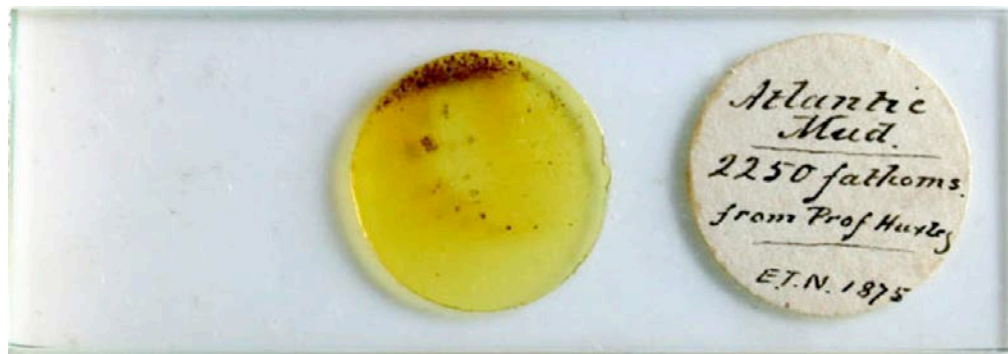
This collection of eight slides has a close connection with Professor Thomas Henry Huxley (1825-1895). Huxley was a champion of Charles Darwin. His keen and vocal support, and his public debate with William Wilberforce, did much to convert many to Darwinism. Huxley was a comparative anatomist, interested in fossils, geology and evolution. After spending time in the Navy as a Surgeon, he was elected Fellow of The Royal Society in 1850. In July 1854, he became Professor of Natural History at the Royal School of Mines and naturalist to the Geological Survey in 1855.

These slides were made by Professor Huxley's assistant, Edwin Tulley Newton, (1840-1930). In 1868 Newton was appointed assistant to Huxley who was at that time naturalist to the Geological Survey. These slides were made in this period. In 1882 he was promoted to be paleontologist to the Geological Survey, a position which he occupied until his retirement in 1905. One of Newton's earliest successes was his preparation of the first satisfactory microscopic sections of coal, which were used by Huxley in a lecture at Leeds in 1870 and they were described and discussed by Newton himself in his first scientific paper, which was contributed to the "Geological Magazine" in 1875. His chief official duty as paleontologist to the Geological Survey was the naming of the fossils collected and the preparation of lists of these fossils for the memoirs that accompanied the maps.

These slides, labeled in Newton's own meticulous hand, are all dated 1875. Three slides of Atlantic sea bed mud from 2250 fathoms, mention Professor Huxley by name. Other slides are of Norfolk Island Pine. Two of these are from the Thames Embankment at the Houses of Parliament. Finally there is a slide of sections through a sea urchin's spines. The slides are in a nineteenth century wooden box labeled on the inside of the lid "E. G. Howard, F. R. M. S." There is a lantern slide of Professor Huxley in the lantern slide collection.







Atlantic Mud, 2250 fathoms, from Prof. Huxley, E. T. N. 1875



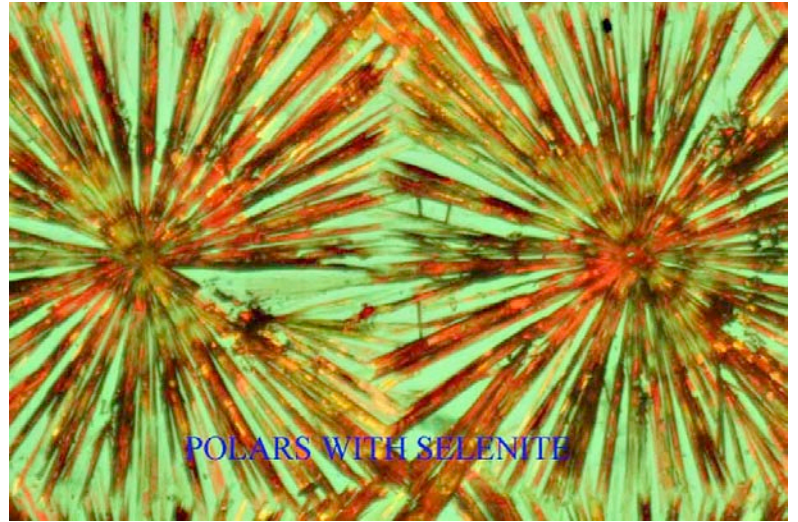
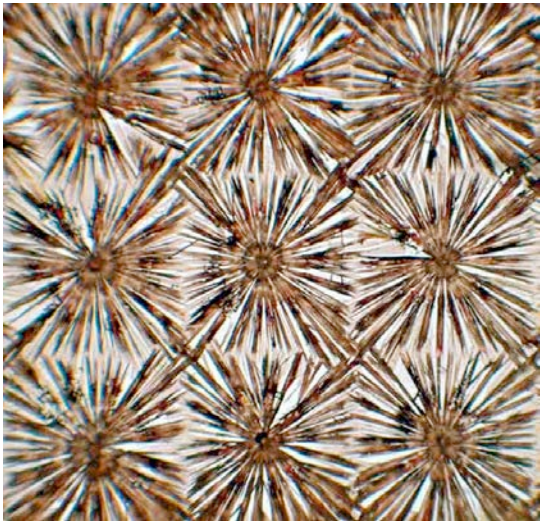
Norfolk Island Pine, Thames Embankment, House of Parliament, 1875, ET. Newton

### Dancer Chemical Preparations, c1870

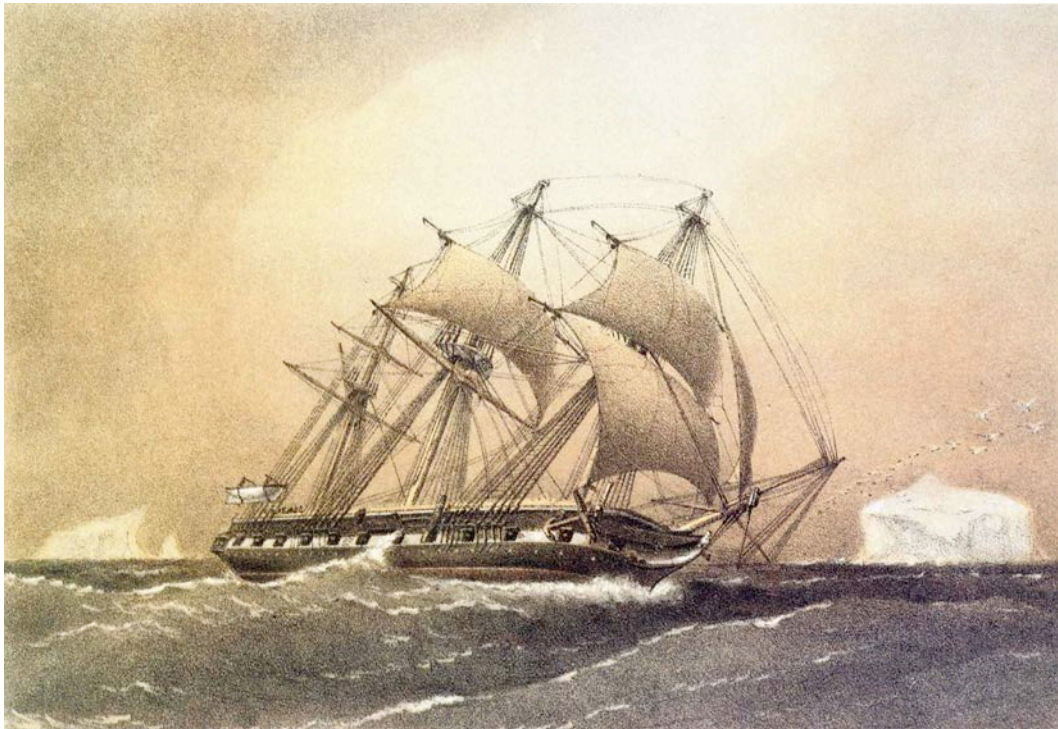
This is a set of ten chemical preparations by John Benjamin Dancer (1812-1887). Dancer sold a wide range of scientific equipment, but he is best known as the originator of microphotographs. He produced a long series of microphotographic slides on many subjects (see The Lord's Prayer in the Lentz Collection of slides). He also produced chemical preparations that are extremely rare. The slides bear two printed labels marked with "J.B.D." and the number. The left hand label gives the chemical name, molecular formula, and microscope viewing instructions. The right hand label provides information about the chemical. The slides are suberic acid, benzoic acid, azelaic acid, phthalic acid, palmitic acid, margaric acid, diazoamidotoluol, binitrobenzol, aniline, and hematoxylin. Hematoxylin, derived from logwood, is widely used as a stain for tissue sections. It is not uncommon to see nineteenth century slides with the stain listed as "logwood."







### Slides from the Challenger Expedition



Modern oceanography began with the Challenger Expedition that took place between 1872 and 1876. It was the first expedition organized specifically to gather data on a wide range of ocean features, including ocean temperatures, seawater chemistry, currents, marine life, and the geology of the seafloor. For the expedition, HMS Challenger, a British Navy corvette (a small warship) was converted into the first dedicated oceanographic ship with its own laboratories, microscopes, and other scientific equipment onboard. The expedition was led by British naturalist John Murray and Scottish naturalist Charles Wyville Thompson. Thompson had previously dredged some curious creatures from the ocean depths in the North Atlantic and the Mediterranean Sea, and these discoveries persuaded the British government to launch a worldwide expedition to explore the ocean depths. The Challenger Expedition left Portsmouth, England, just before Christmas in 1872.



The ship had many different types of samplers to grab rocks or mud from the ocean floor, and nets to capture animals from different levels in the ocean. Challenger also had different winches, mechanical engines used to lower and hoist sounding lines to measure how deep the ocean was. At each sampling station, the crew lowered trawls, nets and other samplers to different depths, from the surface to the seafloor, and then pulled them back on board loaded with animals or rocks.

Challenger first traveled south from England to the South Atlantic, and then around the Cape of Good Hope at the southern tip of Africa. It then headed across the wide and very rough seas of the southern Indian Ocean, crossing the Antarctic Circle, and then to Australia and New Zealand. After that, Challenger headed north to the Hawaiian Islands, and then south again around Cape Horn, at the southern tip of South America where the Pacific and Atlantic Oceans meet. After more exploration in the Atlantic, Challenger returned to England in May of 1876.

On her 68,890-nautical-mile (127,580 km) journey, 492 deep sea soundings, 133 bottom dredges, 151 open water trawls, and 263 serial water temperature observations were taken. About 4,700 new species of marine life were discovered. Among the Challenger Expedition's discoveries was one of the deepest parts of the ocean, the Marianas Trench in the western Pacific, where the seafloor is 26,850 feet, or more than 4 miles deep (8,200 meters). This is a set of six slides by different mounters of soundings from the Challenger Expedition.



Soundings from the Challenger Expedition by different mounters

### Microbiology Slides from the Laboratory of Robert Koch

Heinrich Herman Robert Koch (1843-1910) was a pioneer bacteriologist and the first to prove definitively that specific microorganisms cause specific diseases. He discovered the microorganisms causing anthrax (1876), wound infections (1878), tuberculosis (1882), conjunctivitis (1883), cholera (1884), and other diseases. He was professor at the University of Berlin from 1885 to 1891 and head of the Institute for Infectious Diseases (founded for him) from 1891 to 1904. He was awarded the Nobel Prize in Physiology or Medicine for his findings on tuberculosis in 1905. He is considered one of the founders of microbiology. This is a group of ten

## Microscope Slides

slides most of which bear "Koch's Lab" or "Koch's Lab Berlin" on the label. The slides are of M. Tetragonus, B. Comma Miller's Tooth, Staph. cocci Pyogenes Alba, Staphylococcus Pyogenes Aureus, Bacilli Anthrax, Bacillus Megaterium, Aspergillus Niger, Saccharomyces Rosaceus, Bac. Comma Asiatic Koch's, and Micrococcus Prodigiosus. They are dated between 3-4-86 and 3-29-86 and were prepared not long after the discovery of these bacteria. They appear to be "working" slides prepared in the laboratory for scientific purposes. The slides were obtained from a descendant of a Polish physician who worked in Koch's lab and emigrated to the United States around 1900.



## Keeley Collection of American Slides



Frank Keeley (1868-1949)

In the nineteenth century, there were a large number of commercial mounters in England, and many of these produced a large number of slides. There were fewer mounters in the United States and many of these had a relatively small production. However, at least 180 American makers have been identified. Some companies, like Queen & Co., sold English slides under the American label. In the twentieth century, American firms increasingly made slides for use in education. Medical schools often had laboratories for producing histology, pathology, microbiology, and neurobiology slides for medical students.

This is a rare collection of 72 microscope slides by American slide makers, from the late 19th century to the early 20th century. Most of these slides are from the collection of Frank J. Keeley (1868-1949). Keeley was a naturalist and microscopist who studied and contributed papers on diatoms and other biological objects and on optical mineralogy. He was initially a conservator at the Academy of Natural Sciences in Philadelphia, later the Curator of the Vaux



## Microscope Slides

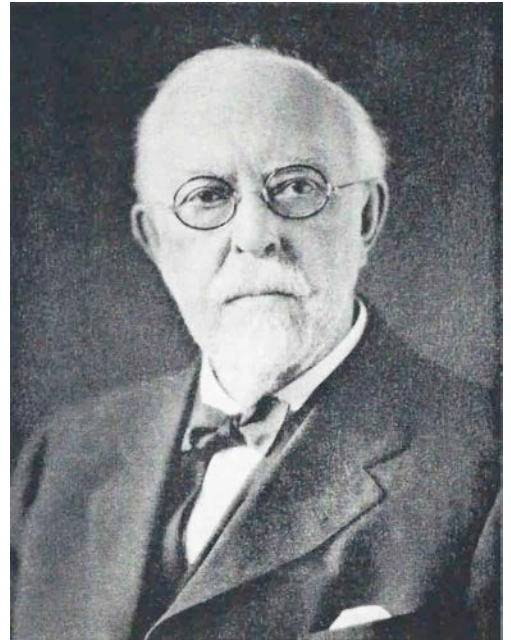
Collection of minerals at the Academy. When he died, most of his extensive collection of microscope slides was left to the Leidy Microscopy Society in Philadelphia. His slide collection was the basis for the best database of American slide makers through his lifetime. Many of these American slides are extremely rare. The slides are contained in a boxwood case with a hinged lid and front retained by brass catches.



Keeley Collection

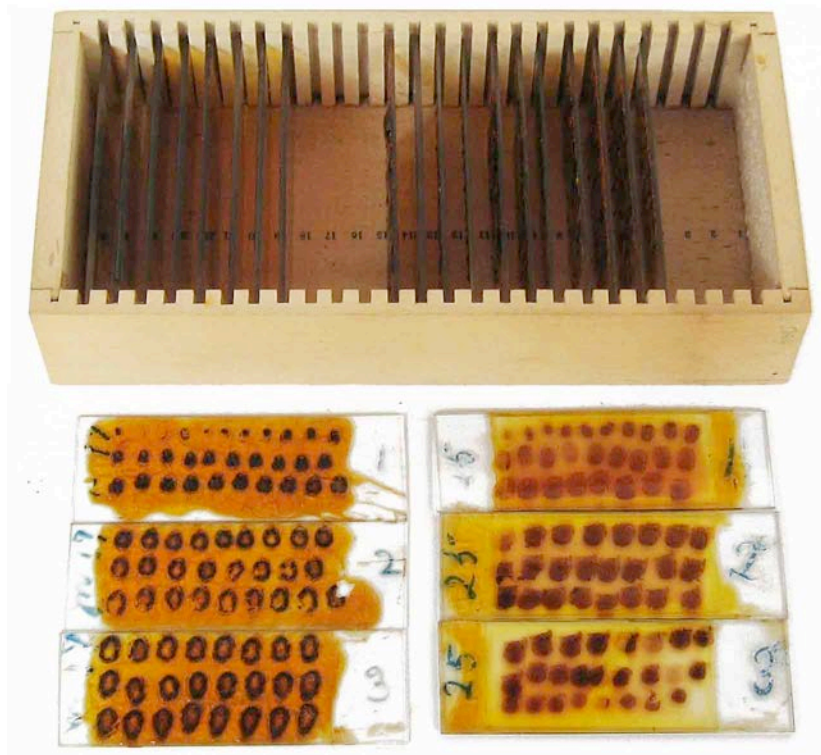
### Simon Henry Gage Serial Sections, 1894

Simon Henry Gage (1851-1944) was one of the most important figures in the history of American microscopy. He was a Professor of Histology and Embryology at Cornell University. His book *The Microscope*, originally written for his students, went through seventeen editions from 1881 to 1941. In 1883, he published with Theobald Smith a paper on serial sectioning that was one of the first serious discussions of serial sections in histology and embryology. Gage, with his wife Susanna Phelps Gage, used serial sections to create three dimensional models of the specimen. He was a President of the American Microscopical Society. He was a founder and editor of the *American Journal of Anatomy*. He wrote numerous research papers on microtechnique, the newt, toad, lamprey, fat digestion, and comparative anatomy of the pancreas. Gage retired in 1908 but remained active for the rest of his life in teaching and research. His manuscript on *Microscopy in America (1830-1945)* was published in 1964.



Simon Henry Gage

This is a set of 25 slides with serial sections of several different specimens. On 14 slides, the sections are covered in a thick uneven layer of balsam. The other eleven slides have coverslips. There are handwritten notes in the box dated June 94. The notes indicate the specimens are of white mice and describe the sections and stains used. The slide box is lightly initialed in pencil "SPG" for Susanna Phelps Gage. The set was originally obtained from a descendant of Simon Gage.



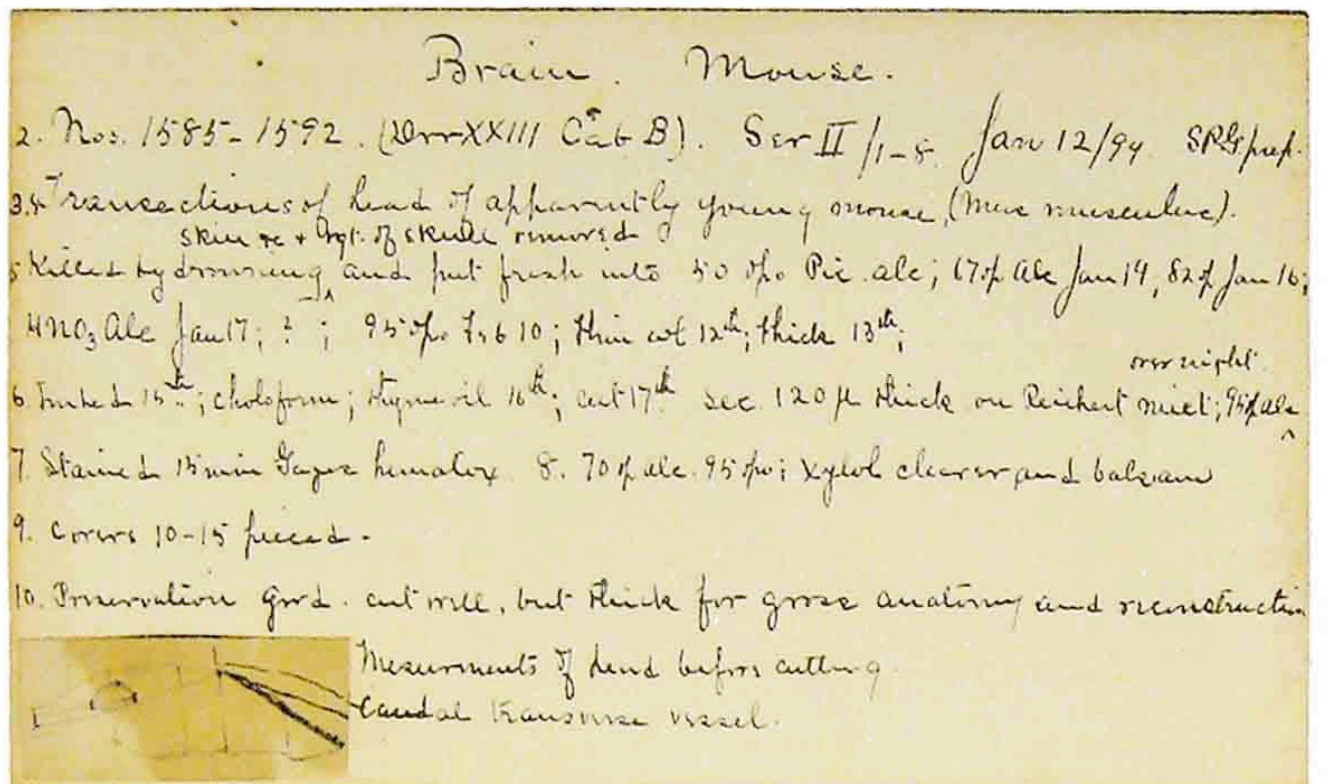
Simon Henry Gage Serial Sections

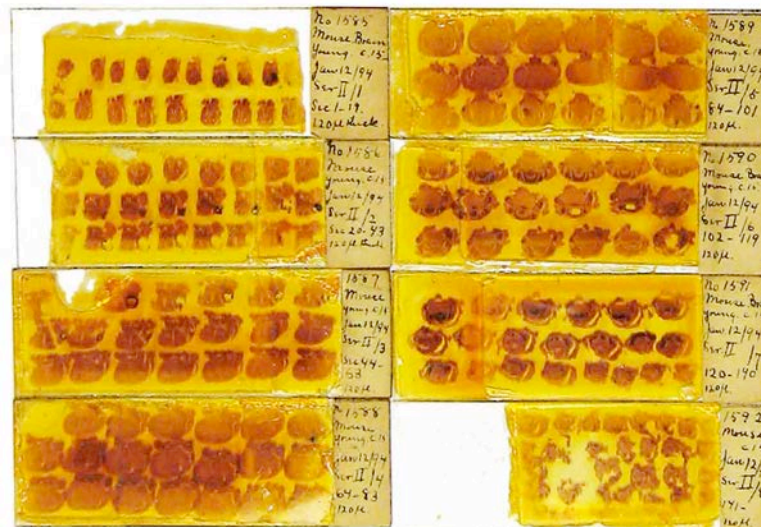


## Susanna Phelps Gage Serial Sections of Mouse Brain, 1894

Susanna Phelps Gage (1857-1915) attended Cornell University where she earned a PhD degree in 1880. While at Cornell, she earned the distinction of being the first woman in the history of the university to take a laboratory course in physics. In 1881, she married Simon Henry Gage, a professor of histology and embryology at Cornell. After graduating from Cornell, she became a respected embryologist and comparative anatomist. However, like most other women scientists of the late 19th and early 20th centuries who were married to scientists, Gage's research was often viewed as a mere adjunct to her husband's projects. In 1904, she joined the research team at the Bermuda Biological Station. The following year, she began to study neurology, first at Johns Hopkins Medical School and, in 1905, at Harvard University. She incorporated her education in neurology into her research on the comparative morphology of the brain. She also explored the development of the human brain, the comparative anatomy of the nervous system, and the structure of muscle. She published several papers on these topics. An adept artist, Gage illustrated her papers, as well as those of her husband, with meticulous detail. She was elected a fellow of the American Association for the Advancement of Science and was also a member of the Association of American Anatomists. She was one of only 25 women to be highlighted as particularly significant contributors to their fields in the 1910 edition of *American Men and Women of Science*.

This is a collection of 25 slides of serial sections of mouse brain. The slides are accompanied by three cards, dated January 12 and 13, 1894, that list the steps taken in the preparation of the slides: fixation, embedding, sectioning, staining (Gage's hematoxylin), and mounting. The preparer is "SPG" (Susanna Phelps Gage) and "SPGage." The cards are significant in describing the steps taken in the preparation of histological slides at the end of the nineteenth century. Serial sections like this were used by the Gages in preparing three dimensional models of the brain. They also confirm the status of Susanna Phelps Gage as an independent investigator and one of the first woman histologists.





Susanna Phelps Gage Serial Sections of Mouse Brain

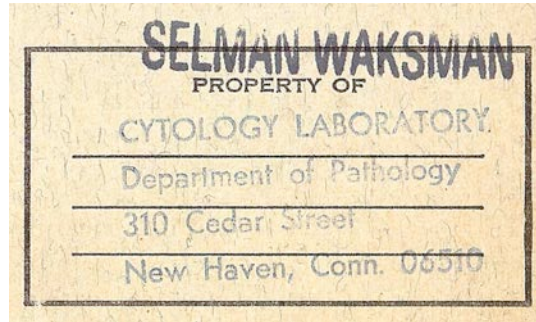
### Meteorite Petrographic Slides

This is a collection of 15 1" x 2" thin section, petrographic microscope slides of meteorites. They were made in the A.P. Karpinsky All-Russian Institute of Geological Research (VSEGEI) thin section workshop.





## Waksman Collection of Microscope Slides



This collection was purchased on eBay in 2009 for \$999. The seller said he purchased them from members of Byron Waksman's family. The collection consists of eight folders each holding 20 slides. All of the folders are stamped with the name Selman Waksman. Some also bear a stamp for the Cytology Laboratory at Yale. The subjects of most of the slides are histology, pathology, and microbiology. The slides bear various labels: Neuropathology Department; Mass. Gen. Hosp. Boston; Dept. of Pathology, Yale University; and others.

Selman A. Waksman (1888-1973) received the Nobel Prize in Physiology or Medicine in 1952. He isolated a number of antibiotics, most notably streptomycin in 1943 and neomycin in 1948. Selman's son, Byron, was a Professor of Microbiology at Yale. In my opinion, most of the slides were Byron's and that he used Selman's slide folders. A few microbiology slides in storage in the Yale TAC building are the same as in this collection. It is possible some of the older slides were Selman's.

## Lentz Collection of Microscope Slides, c1820-2008

The collection of 1000 slides contains examples of the types of microscopic preparations from the early nineteenth century to the present time. There are two main groups of slides. The first are exhibition preparations, diatoms, insects, zoology, botany, and mineralogy. Many, especially the exhibition slides, were made for the entertainment and enjoyment of those able to afford them and others were made commercially for educational purposes. Most of these slides were made in the Victorian age that is considered to be the golden age of microscopy. The second group are medically-related slides, particularly histology, and including embryology, neuroanatomy, pathology, microbiology, and materia medica. The collection is housed in two Victorian mahogany cabinets, each holding 504 slides. Representative examples of slides in the different categories are shown below.

### Collection of Slides

#### Cabinet 1

Early slides  
Exhibition slides  
Test slides  
Diatoms and protozoa  
Insects and spiders  
Zoology  
Botany  
Pathology  
Microbiology  
Materia medica  
Petrography  
American slides

#### Cabinet 2

Early histology slides  
The Cell  
Epithelium  
Skin and derivatives  
Connective tissue  
Bone and cartilage  
Blood and bone marrow  
Muscle  
Blood vessels  
Lymphoid organs  
Respiratory system  
Urinary System  
Teeth  
Digestive system  
Liver and pancreas  
Nervous system  
Eye  
Other Sensory organs  
Endocrine glands  
Male reproductive system  
Female reproductive system  
Embryology  
Neuroanatomy  
Evolution of microscope slides



Lentz Collection Slide Cabinets



## Early Slides – 1830-1857



In the first part of the nineteenth century, the slider evolved into small glass slides of various sizes that fit the smaller stands of the period. Because thin glass was scarce and expensive, micas continued to be used for coverslips and were held on to the slide by covering papers. In some cases, the specimen was held between two glass slides held together by paper. In 1839, a committee of the Microscopical Society of London recommended two sizes for slides: 1 x 3 and 1 ½ x 3 inches. The 1 x 3 inch size was adopted by commercial preparers and soon became the most widely used standard. Some examples of early slides are shown here.

The slides are as follows:

- Crab shell. 13 x 46mm, mica cover held on by green paper, possibly by James W. Bond, from the collection of Brian Stevenson. c1830.
- Pou Humain. Human louse, 16 x 60mm, two slides held together by balsam and bound by green papers at the ends, possibly Joseph Bourgogne, from the collection of Brian Stevenson. c1830.
- Wing of moth. 19 x 51mm, mica cover, red paper-covered cardboard slide, yellow border. Probably Andrew Pritchard. c1830.
- Feather of Indian Humming Bird. 20 x 52mm, cut out printed label, mica cover, red paper-covered glass slide. Andrew Pritchard. c1835.
- Pinus insignis. Andrew Pritchard. Specimens between two slides sealed at the edges with red wax. Printed label that may be cut from his book of 1832, *The Microscope Cabinet*. c1835.
- Guaiacum. Andrew Pritchard. Specimen under coverglass sealed onto slide, red paper edging. c1840.
- Goat, Small Intestine, Tr. Vert. Sect., INJ. and IMB, Shewing the Peyer's glands, the epithelial cells, and the Lieberkuhn's glands. This is a transparent injected specimen prepared by Karl Thiersch (1822-1895), a German surgeon. Smith and Beck imported the slides from Germany in the 1850s. The slides are unnecessarily large for the size of the section and have a bluish tint. The labels are often informative as in this case where Peyer's patches and glands of Lieberkuhn are mentioned. There are several more of these slides among the histology slides. 35 x 72mm. c1850.
- Superior Surface of Child's Tongue, Surface of Child's Tongue, 1857, B C. Opaque whole mount, diamond-inscribed, injected and corroded, showing blood vessels on surface. From the collection of Brian Davidson.



Child's tongue. In the top image, the slide has been placed on black paper to reveal the diamond engraving. 1857.





**The preparation of tongue has been injected and corroded to reveal the surface blood vessels.**

Human Bone Femur, Trans Sec. Diamond-engraved label, black paper over cover held on by typical Pritchard sealing wax, c1840.

Spermatozoa of the Dog, 1847. Mica sealed onto the slide with green paper. 24 x 64mm, from the Blenkins cabinet.

Ciliary processes & Iris of the Eye of the young Ox, 1850. Alexander Hett first advertised his slides in 1852. The slides are opaque injections having a large and deep glass cavity filled with fluid and cemented to a slide. There is a set of Hett slides in the collection.

Small slides, about 16 X 60mm, were made beginning around 1835 by Joseph Bourgogne in Paris and continued by his sons Charles and Eugene for many years. These "Continental" sized slides were made in great numbers for the small French drum microscopes.



**Proboscis of Butterfly**

## Victorian Paper-Covered Slides



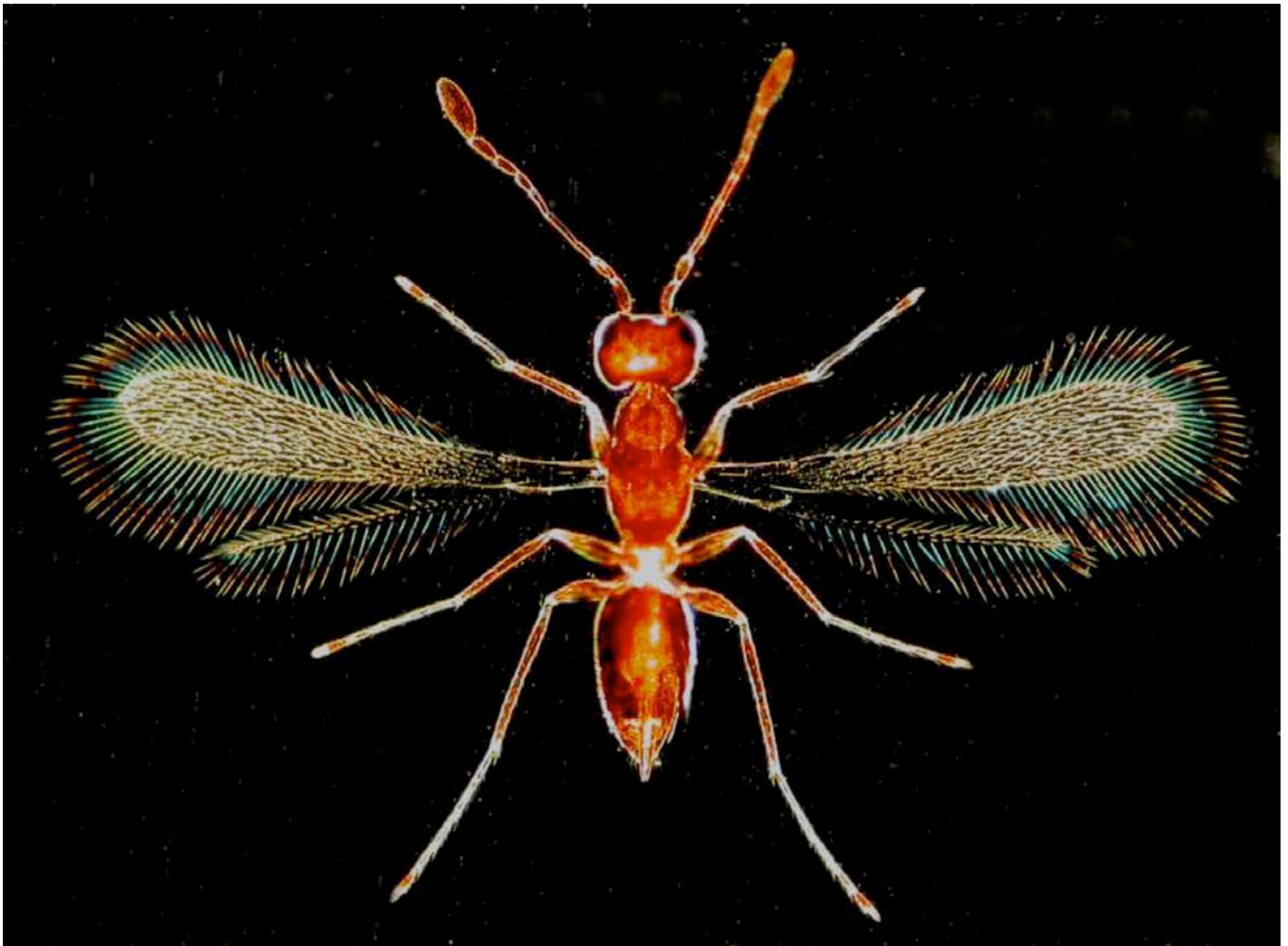
Paper covers were first used to attach the mica covering slips to glass slides or to hold two slides together. Although they were not necessary after the introduction of Canada balsam in the 1830s, they continued to be used to cover slides. They became highly decorative, lithographed in bright color and gilt, and sometimes included the mounter's name or monogram. They were used less frequently after about 1880. Another type of decoration used by some mounters was polychrome ringing, in this example a gold colored shamrock cover.

## Exhibition Slides

Exhibition slides of unusual objects were very popular in Victorian times. Although the "exhibition" slides were meant for entertainment and amusement in Victorian parlors, they heightened public awareness and interest in the fields of biology, botany, archeology, oceanography, paleontology, geology, and science in general.

The fairy fly by Frederick Enock is perhaps the most famous slide ever made. Frederick Enock (1845-1916) was a mounter of whole insects prepared in a lifelike manner without pressure. His slides are of the highest quality and perhaps unequaled. One of the most famous and sought after slides is Enock's fairy fly. He bred the flies himself from parasitized aphids. Around 1870 he worked for his uncle Edmund Wheeler and set up business on his own in 1878. The slide is from the collection of Brian Davidson.





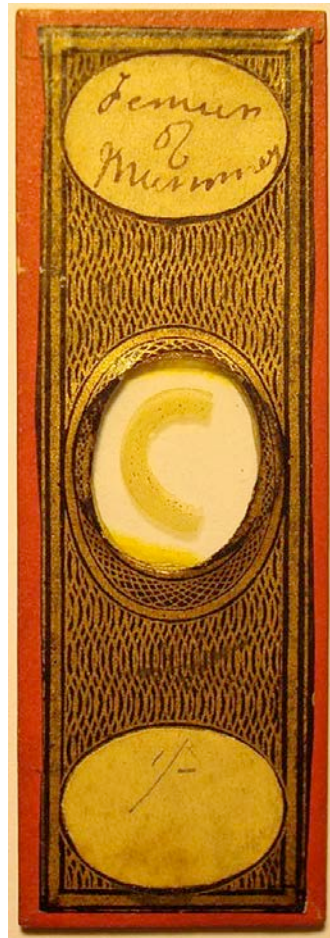
**Cosmocoma, the Fairy Fly by Enock**



**Silkworm Skin by R. & J. Beck**



Mummy Cloth

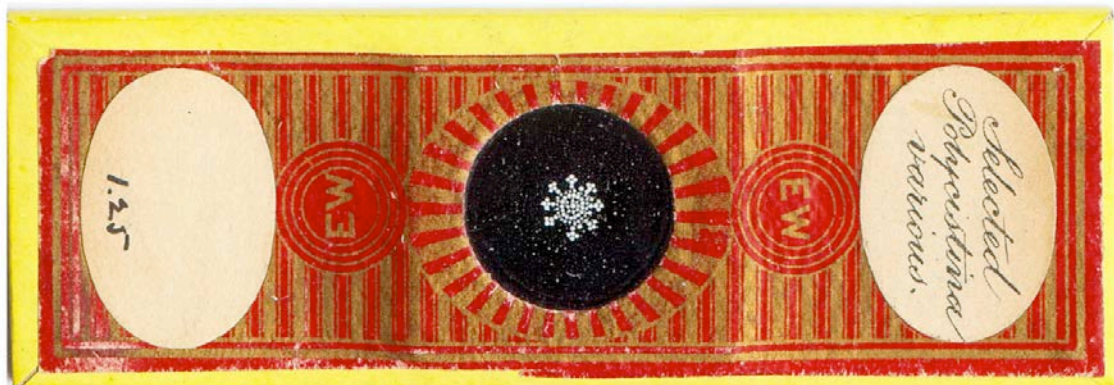


Femur of Mummy



Both slides c1880, the Mummy Cloth slide with later labels and showing the provenance.

Among the most popular nineteenth century subjects were the mineral skeletons of diatoms, foraminifera, radiolarians, and polycystina. They were often arranged in intricate patterns. This is an example of "Selected Polycystina Various" arranged in a rosette pattern by Edmund Wheeler. c1875. The slide is also an example of an opaque preparation in which the specimen was mounted on a substrate and viewed with incident light from above, usually focused onto the specimen with a condenser lens on a stand. This type of preparation was useful for visualization of surface details.

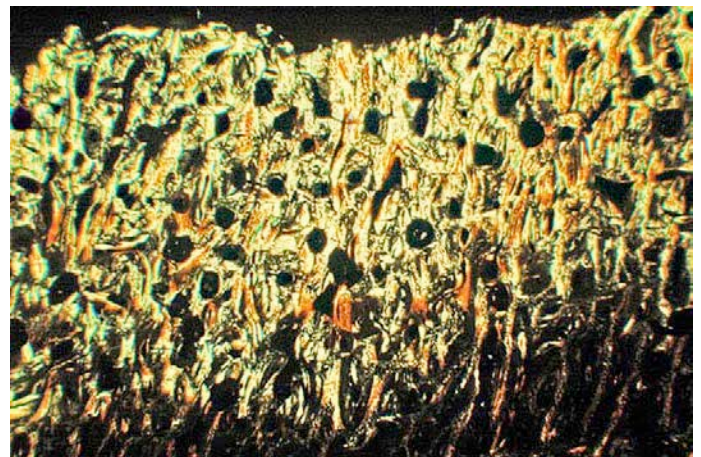
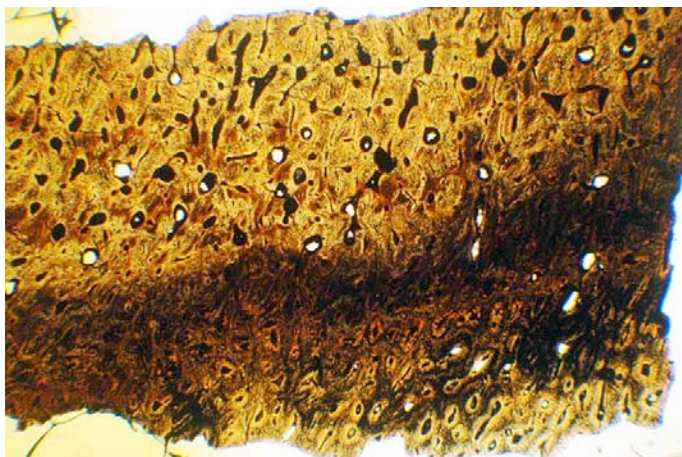


Arranged Polycystina, c1875





Butterfly wing, 1876



Mastodon Bone

This is a section of mastodon bone by C. M. Topping viewed under transmitted and polarized light. Haversian canals are evident. The fact that it is birefringent shows that collagen is still present.





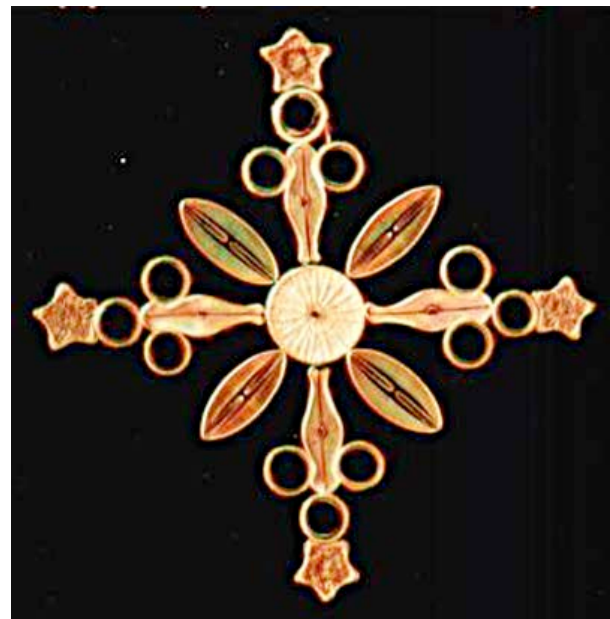
**Cedar from Solomon's Temple**

Cedar of Lebanon was brought back to England from the Palestine Exploration of 1869 and said to have come from the ruins of Solomon's Temple which had an altar made of cedar wood. The authenticity of the wood is doubtful as the location of the Temple is unknown. Nonetheless, the slide is of interest as a Judaica relic.



**Soundings, 1869**

Sounding from the deep-sea dredging expedition of HMS Porcupine in the North Atlantic in 1869. These soundings represented the beginnings of the science of oceanography. They revealed the presence of life in the deep sea and were popular subjects for microscope slides.

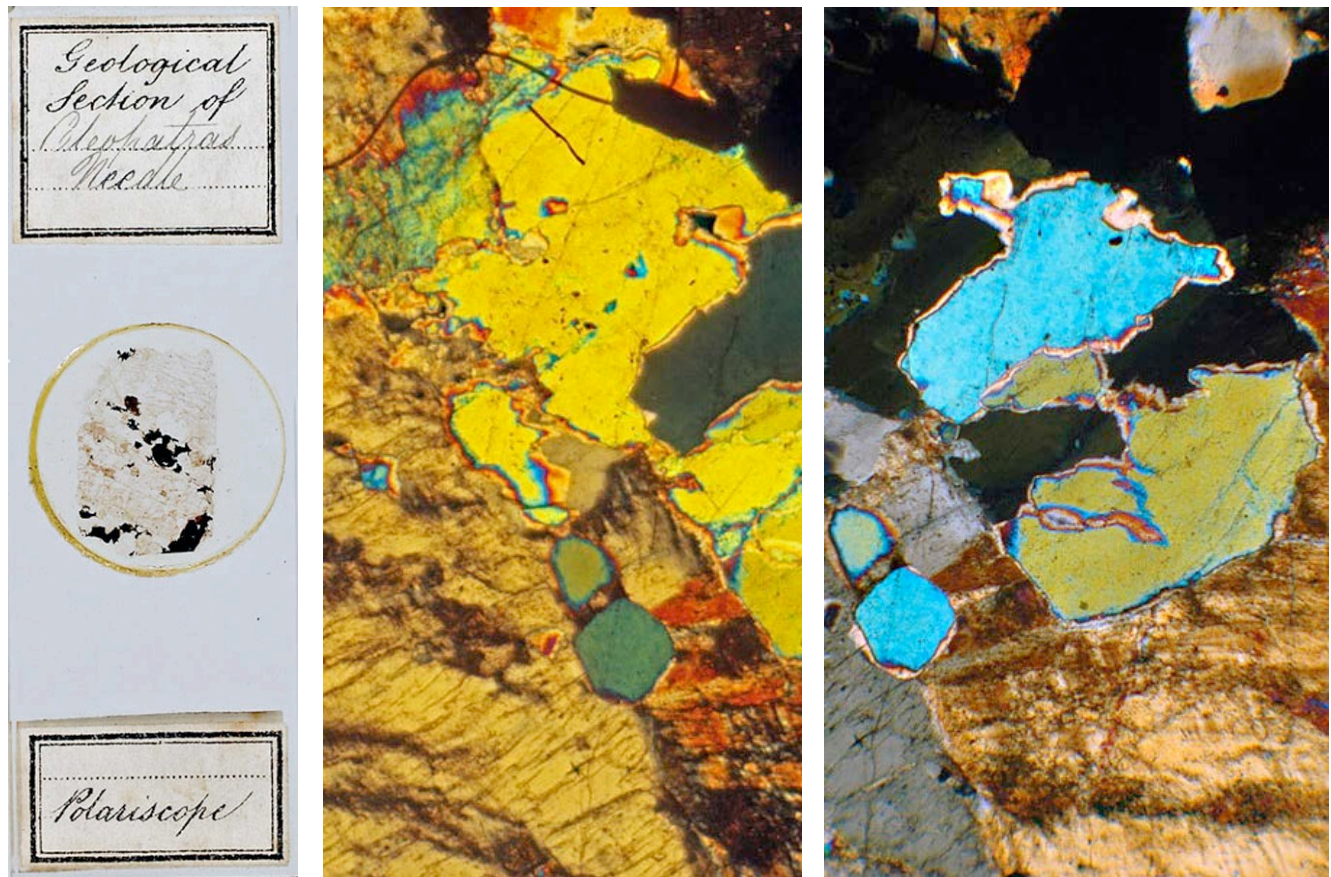




## Microscope Slides

Arranged butterfly scales were another popular type of exhibition slide. This beautiful slide by K. D. Kemp is a flower arrangement of butterfly scales, 50 forms (left). Klaus D. Kemp (1937-) originally joined the staff of Flatters & Garnett Ltd. in 1953. When they went bankrupt in 1967, he worked for other firms before setting up on his own in 1993. He made arranged mounts of diatoms, such as this 25 form star pattern (right), and butterfly scales, equal to the best ever made.

Petrography is a section of petrology that deals with the microscopic details of rocks and minerals. A thin sliver of rock is cut from the sample and ground optically flat. It is then mounted on a glass slide and then ground smooth using progressively finer abrasive grit until the sample is only 30  $\mu\text{m}$  thick. This is a slide of red granite from Cleopatra's Needle viewed under polarized light. Cleopatra's needle is an ancient Egyptian obelisk that was moved to London in 1878. Although this is an exhibition slide, reference collections of petrographic slides are used by universities for teaching mineralogy and geology.



**Red Granite from Cleopatra's Needle**



**Radium Scintillation Slide**

This is a microscope slide designed to allow one to view the streaks of light given off when the alpha particles produced by the radioactive decay of radium, discovered by Marie and Pierre Curie in 1898, strike a zinc sulfide phosphor screen. The Scientific Shop sold scientific equipment in Chicago in the early part of the twentieth century.

### Microphotographs



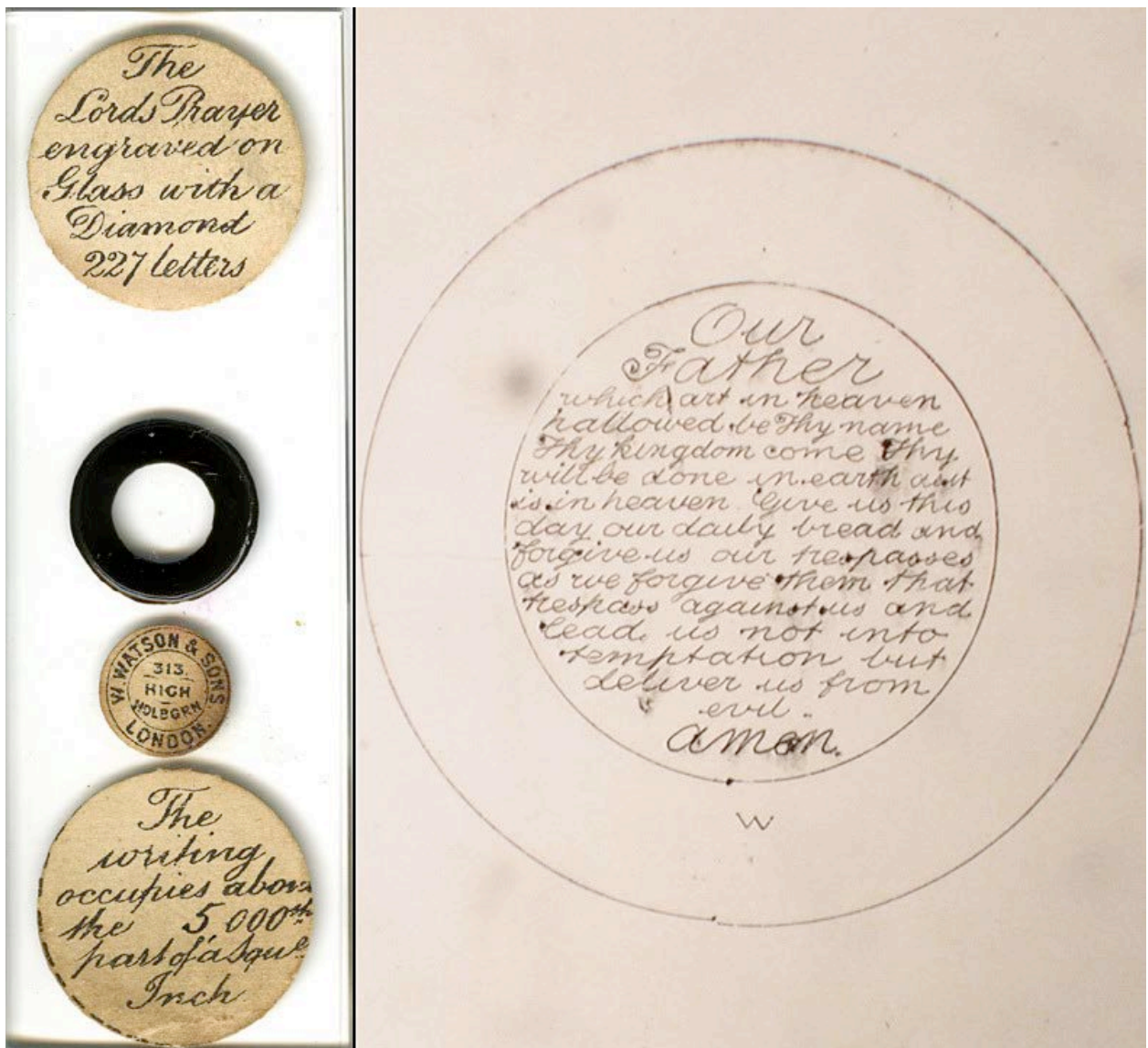
Photomicrographs were prepared of a variety of subjects including famous persons, bible passages, celestial bodies, buildings, paintings, nudes, etc. This photograph shows two gentlemen using a microscope and an oil lamp on a rotating microscope table. The man on the left is Richard Beck, a cofounder of one of the most important British microscope manufacturers. An important microphotograph in the collection is "The Lord's Prayer, Illuminated," by J. B. Dancer

### Webb Microengraving

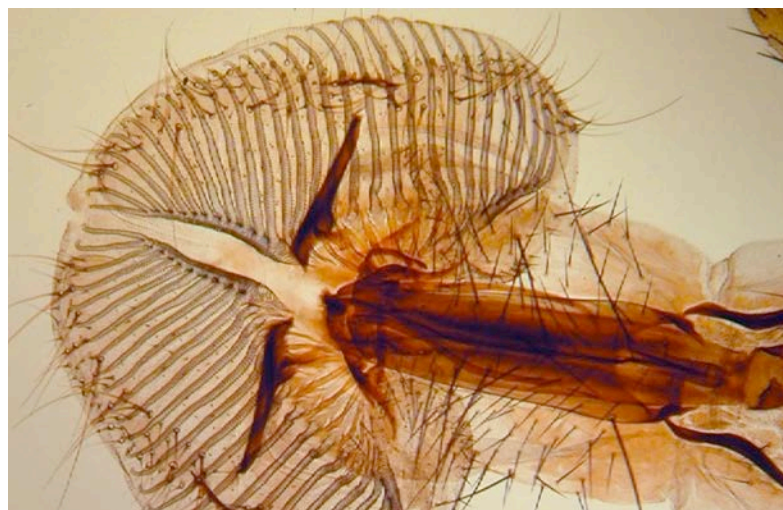
William Webb (1815-1888) used fine diamonds to etch words and pictures onto glass. He was a Law Courts shorthand reporter who developed a machine for making minute writing on glass. The machine consisted of levers and gears that reduced the movements of a hand-operated stylus to extremely small dimensions. His texts were written at a scale of "bibles per square inch," that is, the entire text of how many bibles that could be written in a square inch, varying from one to 59. Webb engraved upon the underside of the cover slip, not on the actual 1x3 slide, reporting that this permitted their use as tests of higher-powered objective lenses. He first demonstrated his machine at the London International Exhibition in 1862 where it made an impressive showing. He sold his writings direct and through the trade and continued to at least 1887.

Webb was especially well known for his microscopic writing of the Lord's Prayer which cost between £1 and £10 depending on fineness. A brief article *Webb's Lord's Prayer*, appeared in the *Journal of the Royal Microscopical Society*, Series 2, Vol. 6, pages 147-148 (1886). Edmund Wheeler was the sole proprietor of the "Microscopic Engravings by W. Webb, Esq." until 1884 when he sold his business and slides to the Watsons. This slide bears the label of the Watsons and the notations "The Lords Prayer engraved on glass with a Diamond 227 letters" and "The writing occupies above the 5,000<sup>th</sup> part of a Squ Inch." Thus, this slide dates between 1884 and 1887, unless it is an earlier slide from Wheeler's stock with Watson's label. The slide is signed with a "W."





Test Slides

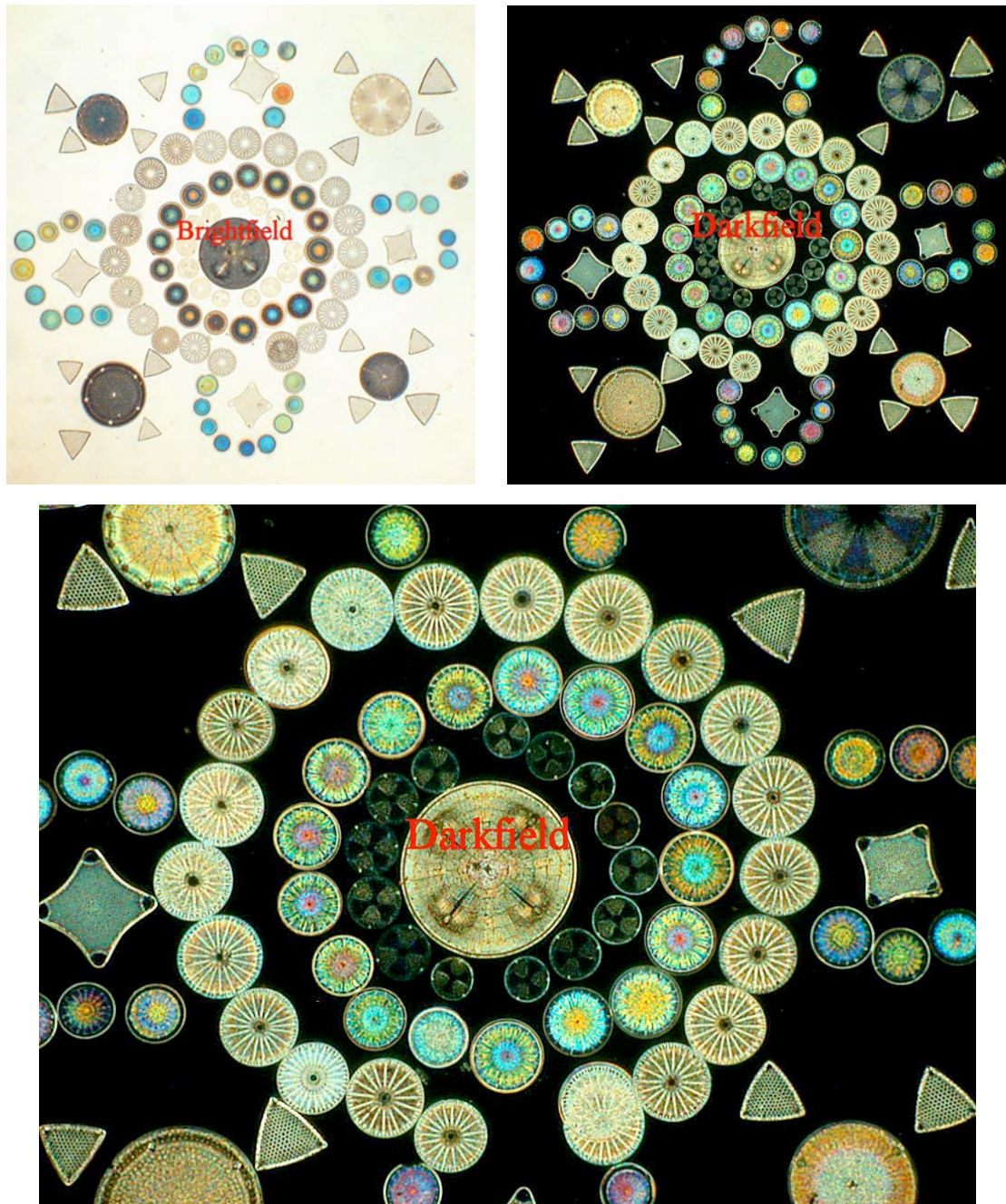


Blowfly Proboscis

Test objects were used to test and compare the quality of microscope objectives. Insect scales were early test objects and diatoms of various species were widely used. The blowfly proboscis was also used. Diamond rulings of increasing fineness were developed. These test objects were of considerable importance to microscopy as makers used them to improve the resolution of their instruments. The blowfly proboscis was prepared by C. M. Topping.

### Diatoms, Protozoa

Among the most popular nineteenth century subjects were the mineral skeletons of diatoms, foraminifera, radiolarians, and polycystina. These were often arranged on slides in intricate patterns.



A. C. Cole Diatom Circle



A most attractive complex arrangement of diatoms in concentric circles by A. C. Cole. The diatoms have mainly been chosen to give a diffraction effect under either transmitted or darkfield illumination. Diatoms are a major group of algae, among the most common types of phytoplankton, with intricate cell walls made of silica.



Foraminifera, British Isles, Dry Mounted, B. Darnton. Foraminifera are amoeboid protists with a test or shell made of calcium carbonate. Brian Darnton (1935-) is well-known for his mounts of Foraminifera, usually in dry cells and on grids. This is a type slide of the tests of recent Nearshore Foraminifera from around the British Isles. The tests in the circle are actually from an antique source of planktonic species collected by the now famous HMS Porcupine in the mid nineteenth century.



This is an antique microscope slide by Watson & Sons, London. The slide is of "Polycystina, From Cambridge Estate [Barbados]." Polycystina belong to a group of amoeboid protozoa that produce a siliceous skeleton. The intricate detail and variety of these forms have long attracted microscopists. These specimens have been dry mounted in a deep cell on black opaque background for viewing using incident lighting techniques. The image shows the slide and a photomicrograph taken from the mount imaged using incident (top) lighting.





Marine algae by J. Bourgogne

Insects



Parasite of Goat by Topping



Yellow Ant by Darlaston

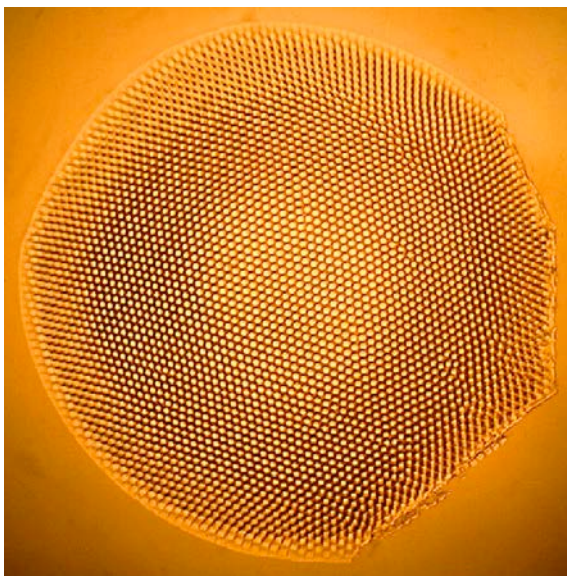


Parasite of the Hessian Fly by Enock

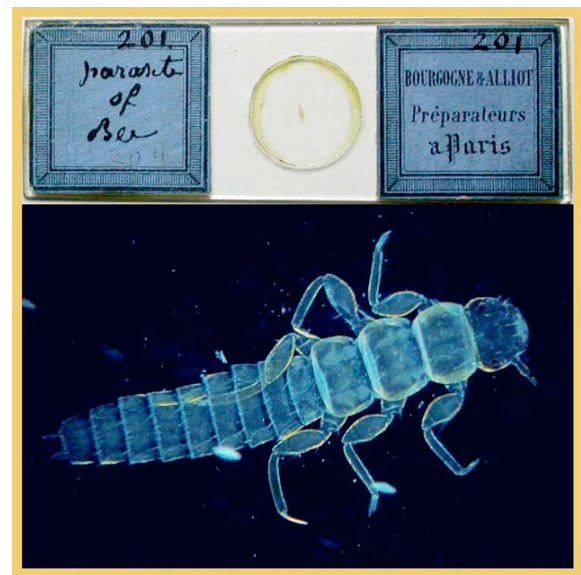




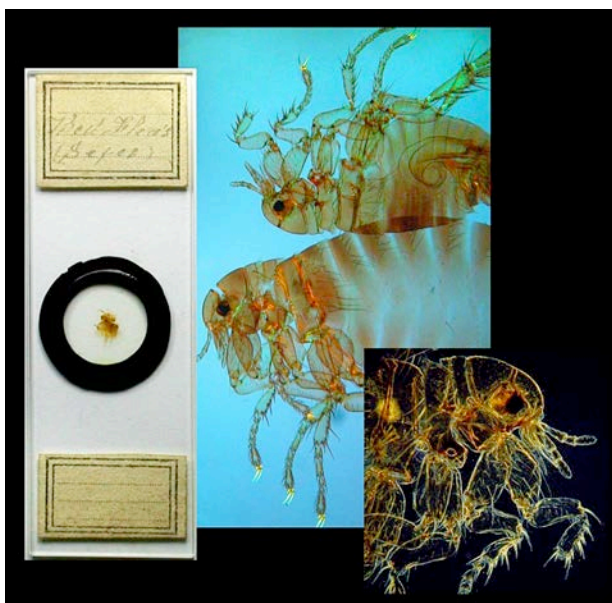
House Spider by Enock



Eye of beetle by W. Watson & Sons



Parasite of Bee by Bourgoine & Alliot

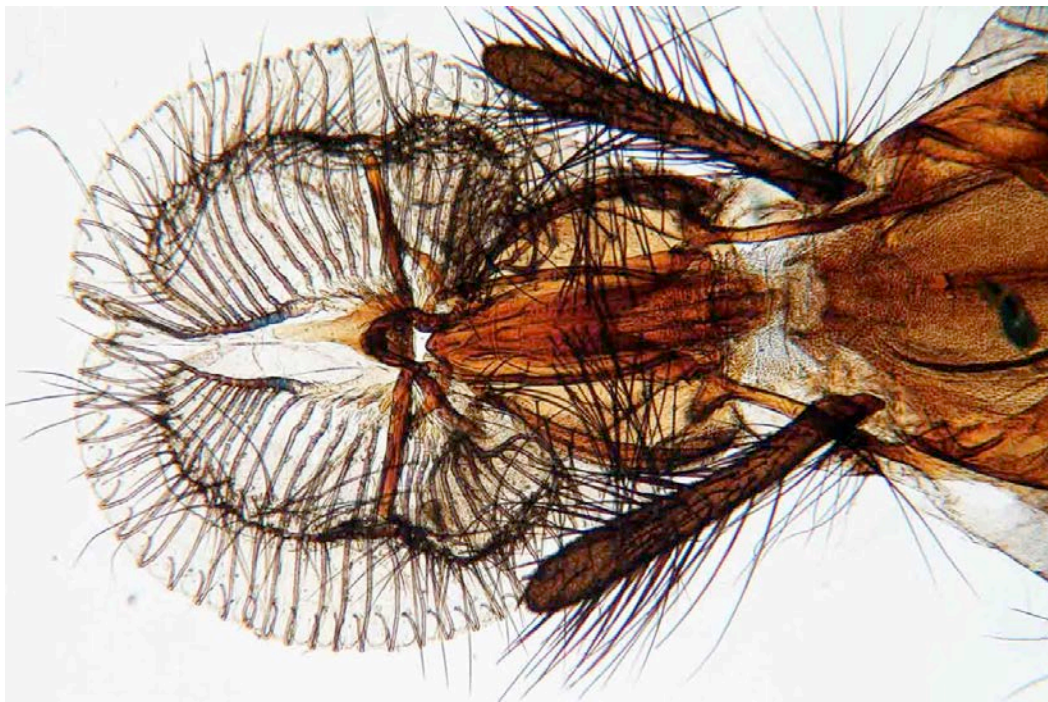


This is an antique microscope slide of "Bed Fleas (Sexes)," by Amos Topping, c1880. Both a male and female flea have been carefully prepared and expertly mounted for viewing. Although unsigned, the handwriting is unquestionably that of Amos. The image shows the slide, and includes two photomicrographs taken from the mount, using polarizing and darkfield lighting.





Female flea, Victorian paper-covered slide



Tongue of *Mesembrina meridiana*, the noon fly, by Richard Suter who began making slides by at least 1887.



## Zoology



Fluid mount of a fish by Wheeler

Edmund Wheeler was a professional mounter by 1866. He retired in 1884 and sold his business and stock, including over 40,000 slides, to the Watsons.



Zoophytes, early paper-covered slides

Zoophyte is an obsolete term for invertebrate animals such as corals, sponges, and sea anemones that attach to surfaces and superficially resemble plants in appearance. One slide is labeled "from Yarmouth."





Scale of Boar Fish



Gill Plates of Dogfish

These are two slides of fish scales by Charles Collins Jr. who worked from about 1885 to 1895. He worked using the title "Micro-Naturalist" and some of his slides carry this distinctive label on the rear of the slide. The bottom front label indicates a mount for use with polarizing filters, and includes the hand written suggestion of use of a selenite filter for enhanced viewing. The "Scale of Boar Fish" was imaged using crossed polars with a selenite filter.

This is an antique microscope slide of "Gill plates of Dogfish Trans sect" by W. Watson & Sons Ltd, London which operated after 1908. One photomicrograph is imaged using transmitted light in darkfield, while the inset is a higher magnification in brightfield.

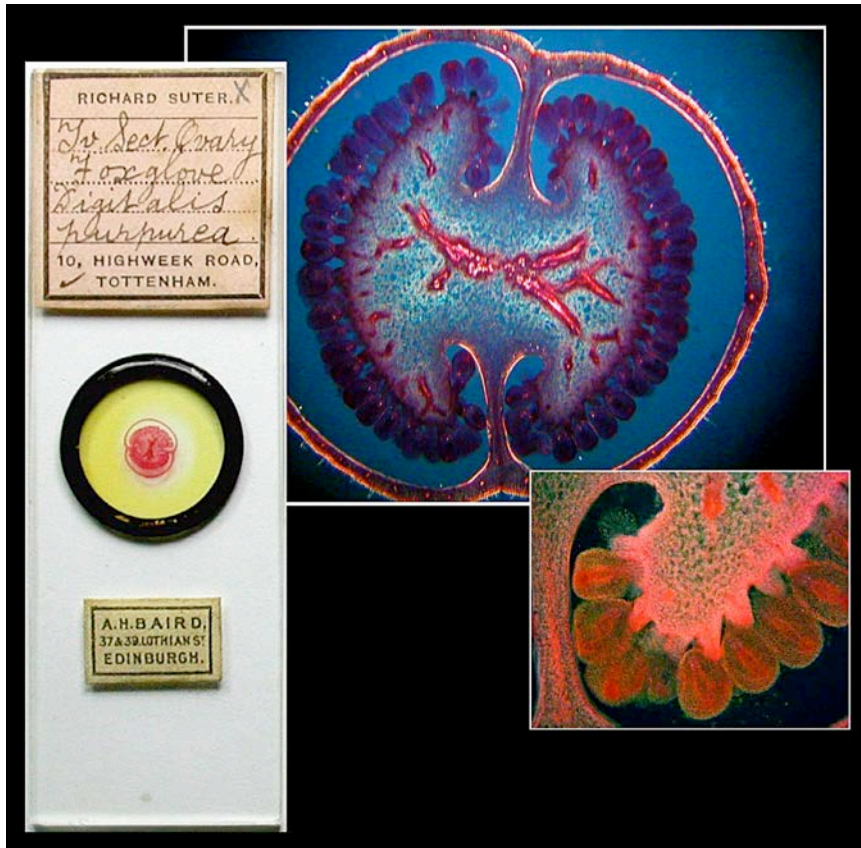


Hoof of Mustang, For Polariscopes, E. Wheeler, London, T. H. McAllister, New York

Objects such as hooves, horns, hair, bone, and minerals that are birefringent were very popular during Victorian times and were viewed with a polarizing microscope ("polariscopes").

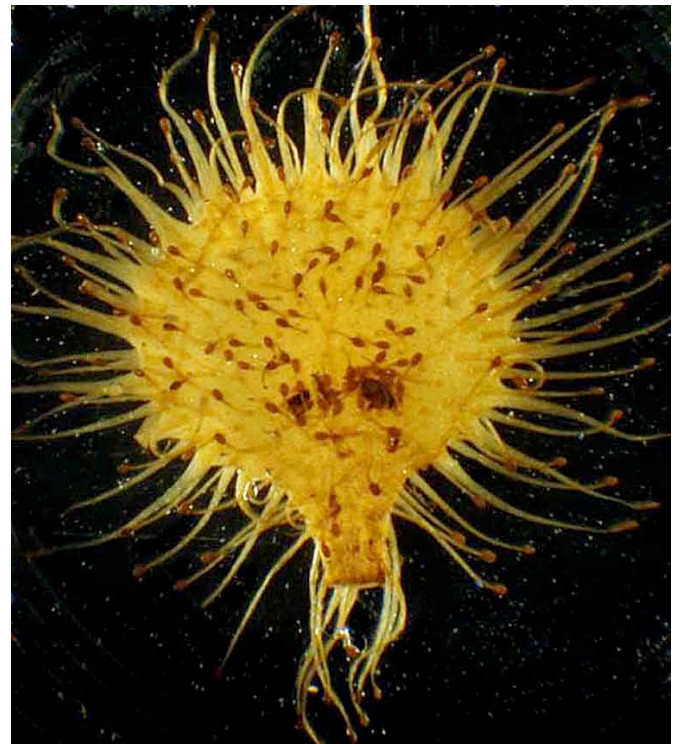
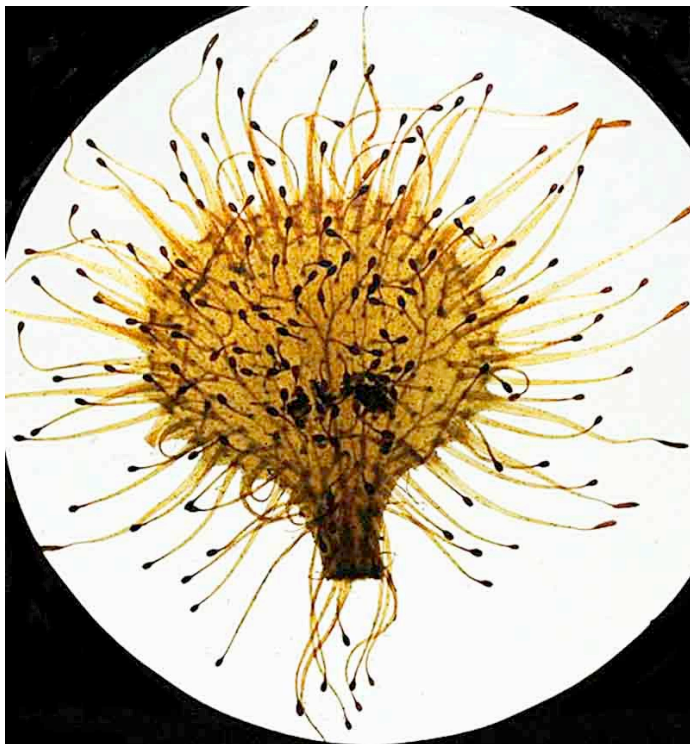


## Botany



This is a microscope slide of slide of "Tr. Sect. Ovary Foxglove *Digitalis purpurea*" by Richard Suter. Richard Suter (1864-1955) began making slides by at least 1887 and offered slides on all subjects subjects for over 50 years. It also carries a rare secondary label from the optical shop of A. A. H. Baird in Edinburgh. The slide and includes two photomicrographs taken from from the actual mount, imaged imaged using transmitted light light with crossed polarizing filters and a selenite and darkfield lighting. *Digitalis* is a cardiac glycoside that increases cardiac contractility and acts as an antiarrhythmic agent. Its use for heart ailments ailments was first described by William Withering in 1785

which is considered the beginning of modern therapeutics.

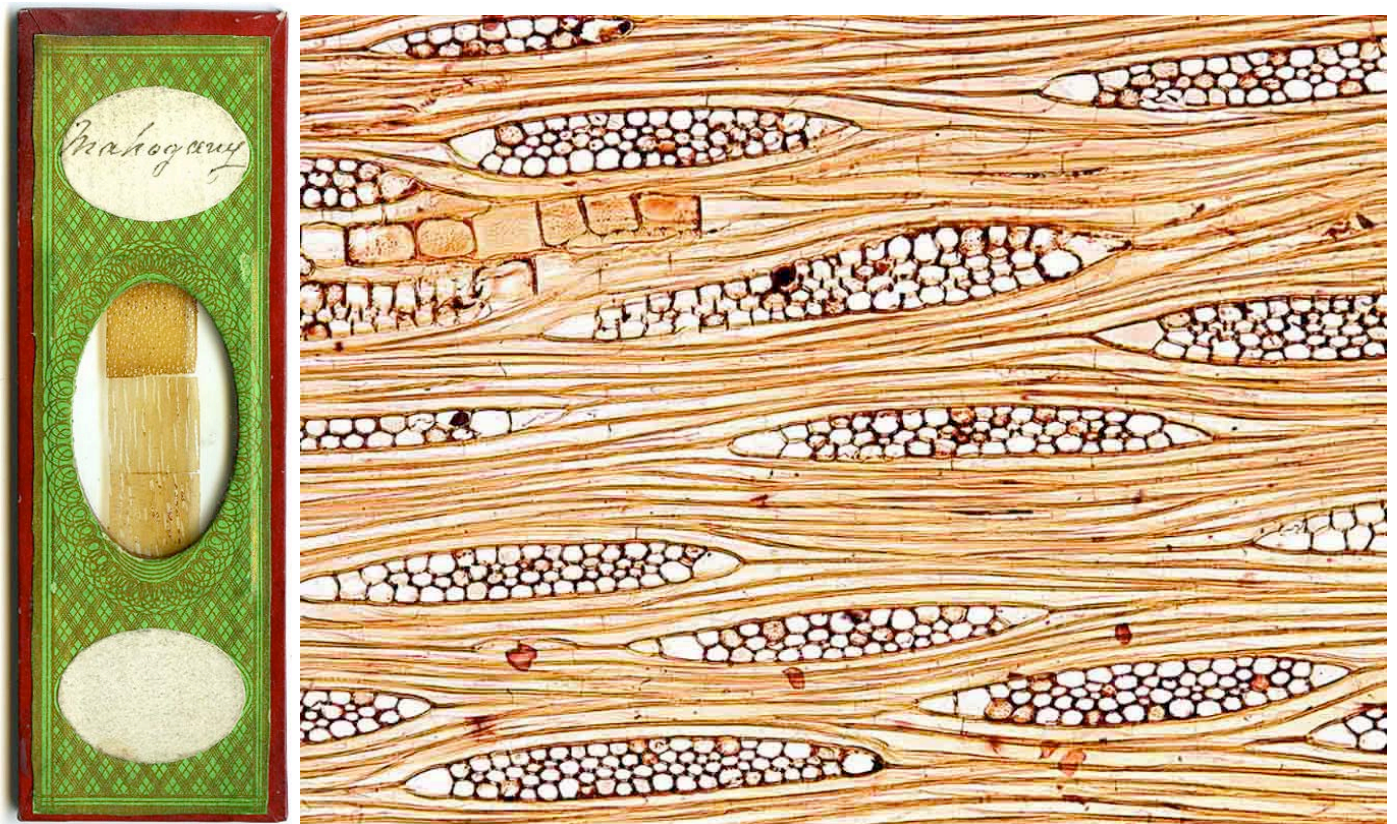


*Drosera*, an insectivorous plant, brightfield and darkfield





Double mount by J. C. Tempère. Leaf rust. The lower specimen shows the underside of the leaf structure. The top specimen shows the characteristic red-orange pustules that erupt from the upper epidermis of the leaf. Jean-Clodius Tempère (1847-1926) came to England from Paris in 1871 and advertised slides in 1878. He returned to Paris in 1883 and offered a vast range of mounts. In his early years in England and Paris, many of his slides were marked S. L., for "S. Louis," in a diamond or circle. He also used a shield-shape label with distinctive handwriting.

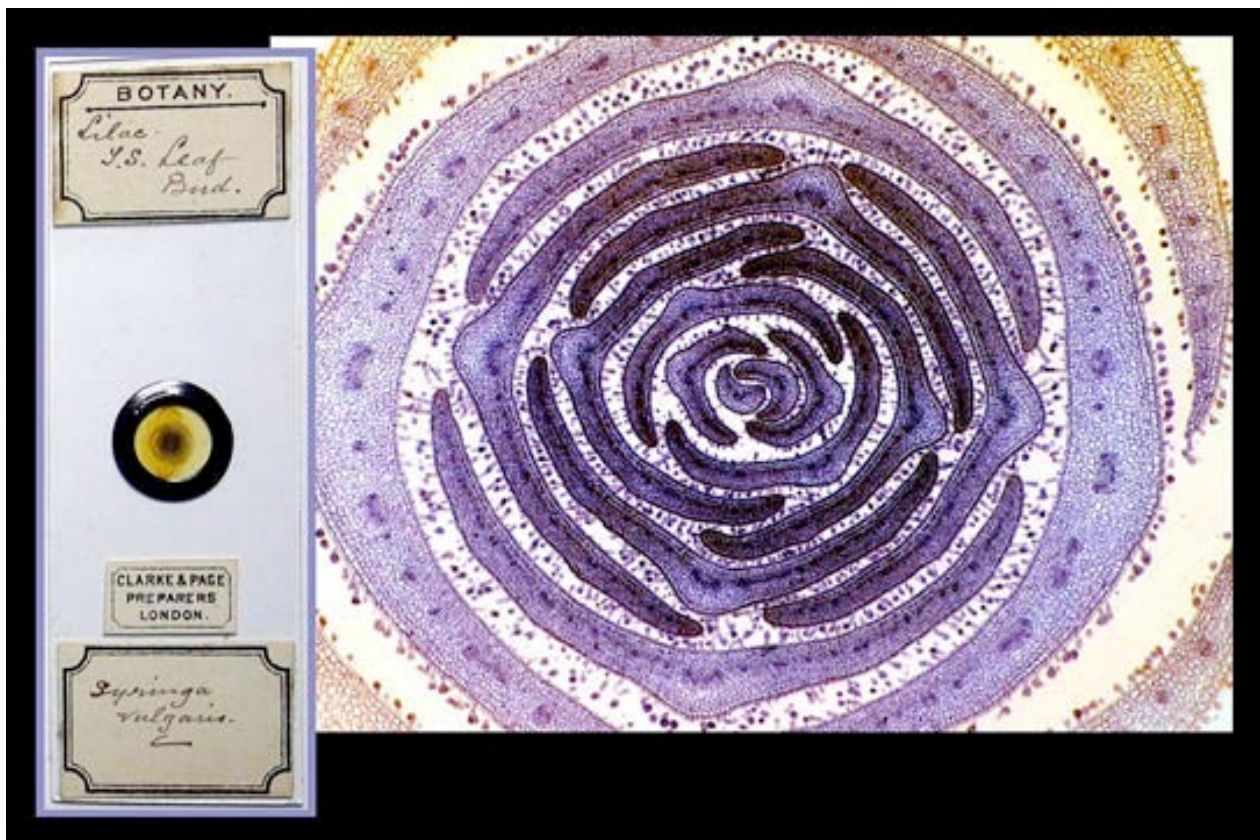


Sections of timber were some of the earliest sections ever made and remained popular throughout the nineteenth century. This Victorian era slide displays three samples of mahogany. The handwriting indicates this slide was prepared by John Barnett.





This is a slide of "Seed of Eccremocarpus" (Chilean glory flower), c1870, by Edmund Wheeler viewed with the polarizing microscope.



Transverse section through the leaf bud of lilac. Clarke & Page, "Specialists in Microscopy," operated in London in the early 1900s.

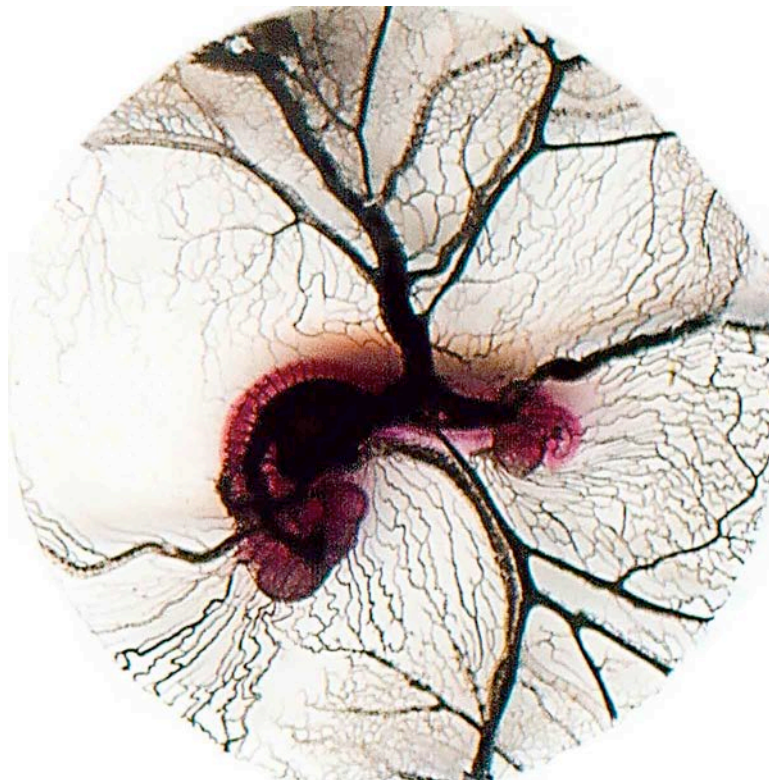


**Embryology**



**10 mm Rabbit Embryo, T. Gerrard & Co., London**

Gerrard & Co. was founded in 1850 and produced a wide range of plant and animal histological preparations. Around 1950 the firm was T. Gerrard & Co.



**Chick embryo, injected, 72 hours, Carolina Biological Supply Co.**



Carolina Biological Supply Company was founded in 1927 by Thomas E. Powell in Burlington, NC, USA. It is now run by his son. They offer very fine slides on a variety of subjects. Beginning in the 1970s, they produced thin ( $1.5\mu$ ) sections of epoxy-embedded tissues that are probably the finest slides ever made for fine detail. A complete set of these slides, most of which are no longer made, was purchased in 1980 and is a part of this collection.

This is a rare slide of a longitudinal section of a whole human embryo. It bears the label of W. Watson & Sons Ltd, 313 High Holborn, London. After 1908.



Longitudinal section of whole human embryo by Watson & Sons, Ltd.

Pathology

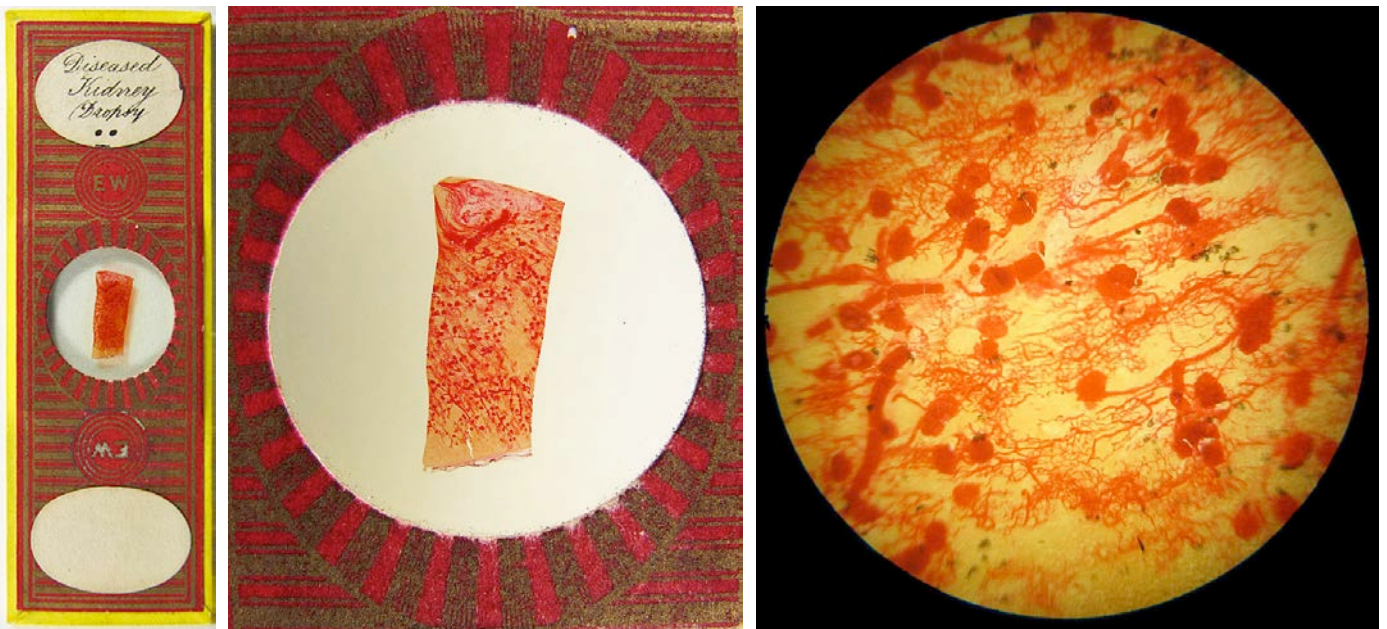


Pathology Slides, 1892



Wheeler and Watson Urinary Series, 1880-1910





This is a fine slide of "Dropsy" by Edmund Wheeler, c1875. The kidney is injected showing the glomeruli and blood vessels.

### Microbiology



Late nineteenth century microbiology slides include the causative agents of diseases such as tuberculosis, smallpox, anthrax, and leprosy that are absent or less commonly seen today.

This is a microscope slide by the shop of John Thomas Norman (c1814-1893), although it doesn't carry the firm's label. The label bears Norman's ornate and distinctive handwriting. Norman was in business professionally by 1845 and worked until 1892 when the firm was turned over to his sons. His slides are of the highest quality. Many of his slides were sold by other professional mounters under their own labels, as in this slide that bears the label of Newton & Co. The specimen is an interesting mount of "Trichyzed in Pork." The specimen has been carefully prepared and mounted for viewing with transmitted lighting. The image shows the slide, and includes photomicrographs taken from the actual mount, imaged using oblique transmitted lighting and partially crossed polarizing filters. The slide shows the larva of *Trichinella spiralis* within cysts of skeletal muscle. Trichinosis was a major public health problem in the nineteenth and early twentieth century.

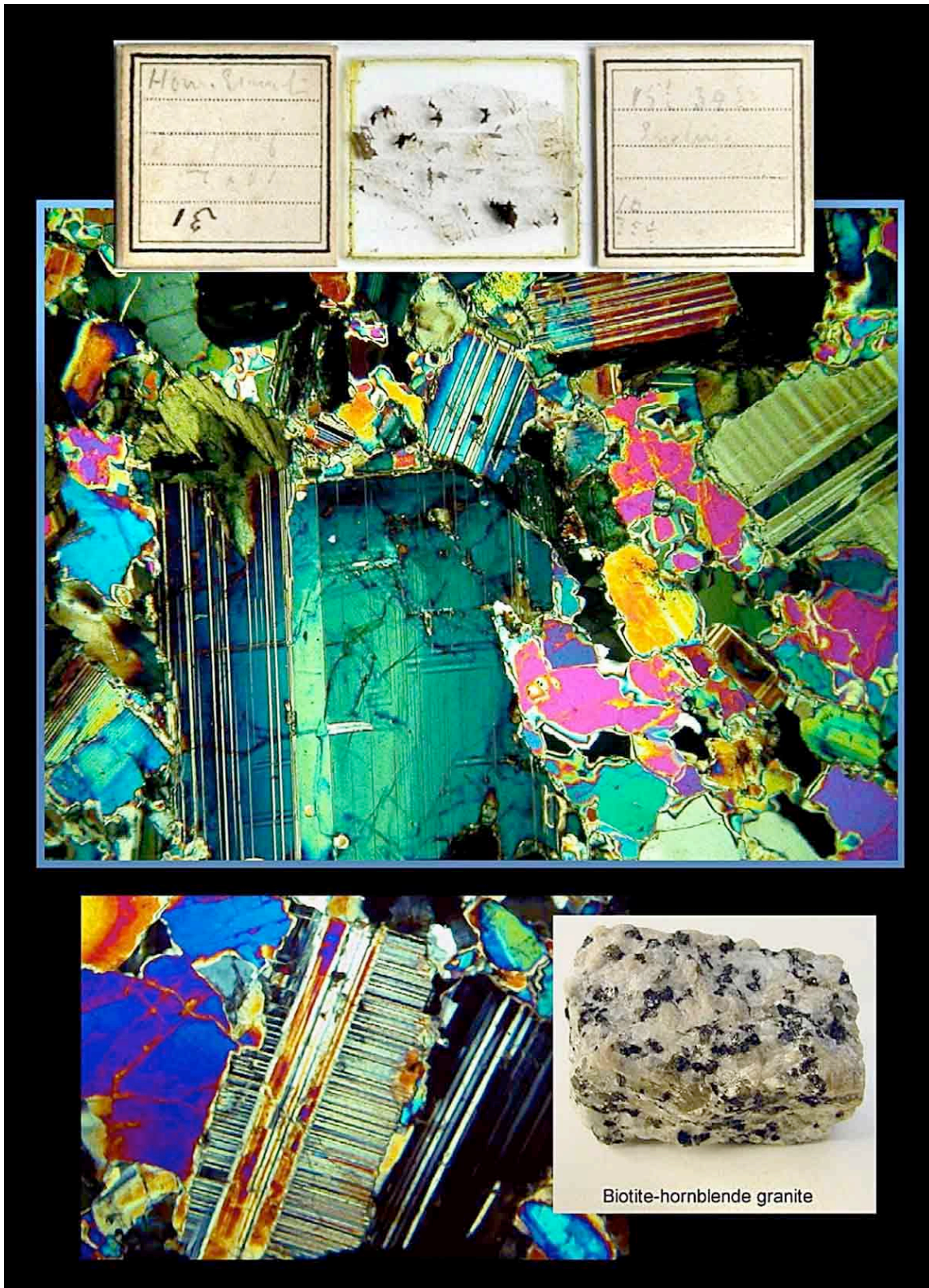


### Petrography

Minerals and thin sections of rocks were popular objects in the Victorian era. Some are especially attractive under polarized light. They also had important scientific and educational uses. Reference collections were used by universities for teaching mineralogy and geology. Preparation of thin sections of rocks is a difficult process requiring great skill. First, a rock is sliced with a diamond saw and the slice is trimmed to fit on the glass slide. One side of the slice is ground flat and the slice cemented to the glass slide. All but one mm of the cemented piece is sliced off. Then the cemented piece is ground smooth by hand using progressively finer abrasive



grit until the sample is only 30  $\mu\text{m}$  thick. This slide is a thin section of hornblende granite viewed with polarized light. The slide is unsigned but was most likely made by Scottish geologist Matthew Forster Heddle (1828-1897).



Hornblende granite viewed with polarized light





Crystals

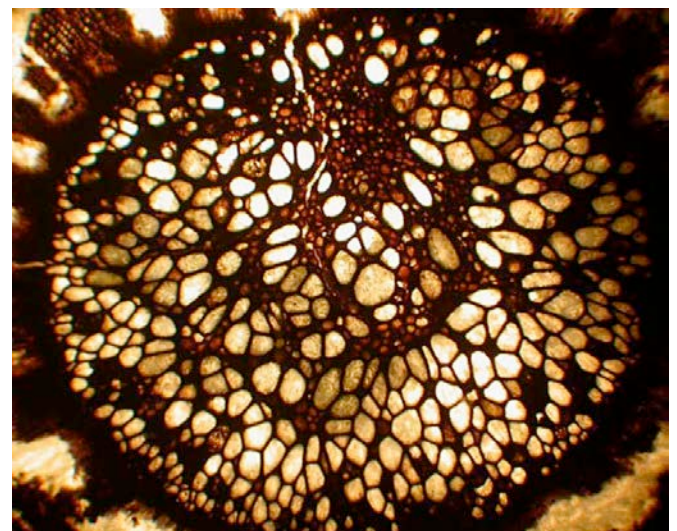
Crystals, back

Early paper-covered slides of crystals, c1850



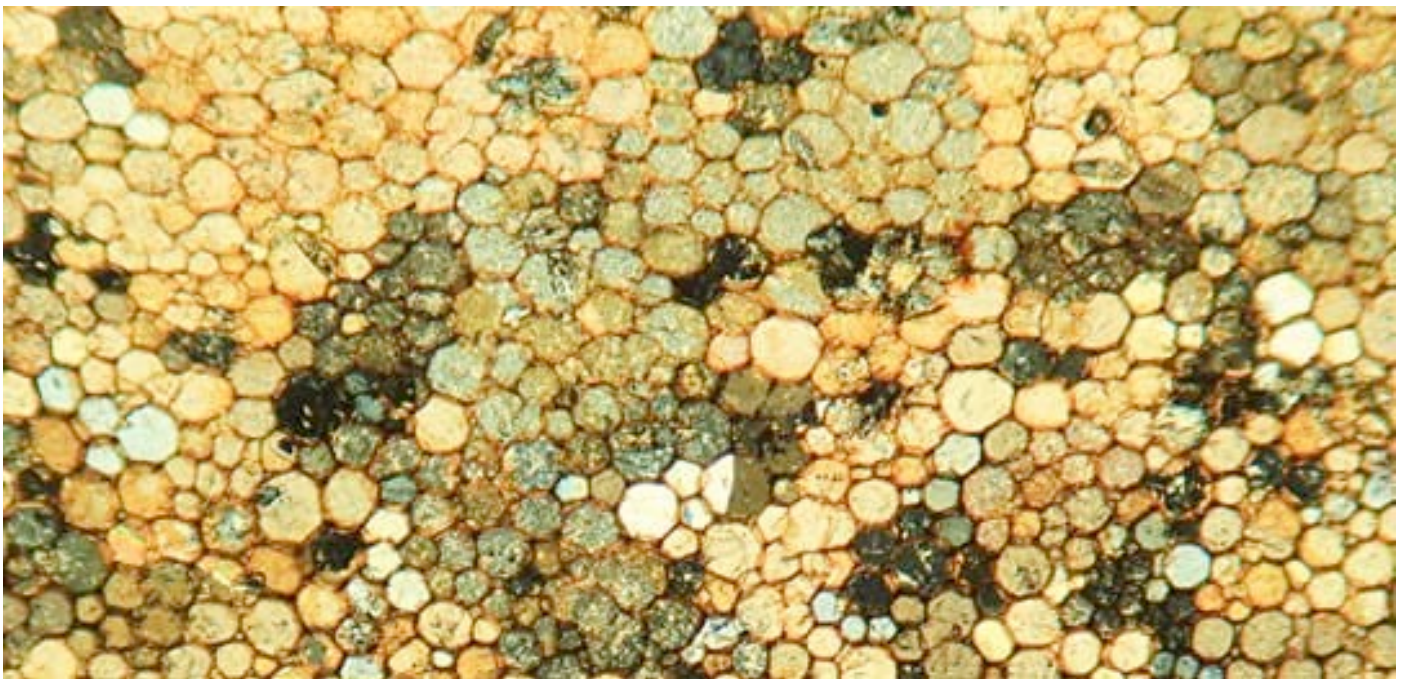
Coprolite

Coprolite, Maws Creek, Texas. From a dinosaur. By examining coprolites, paleontologists are able to learn about the diet of the animal, such as whether it was a carnivore or herbivore.



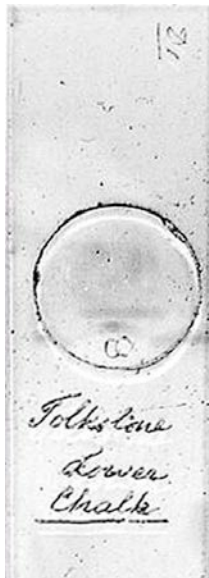
Section of *Lepidodendron harcourtii*, a fossil tree in which cells can be seen





Thin section of *Metaclepsydropsis duplex*, a fossil fern of the Carboniferous period.





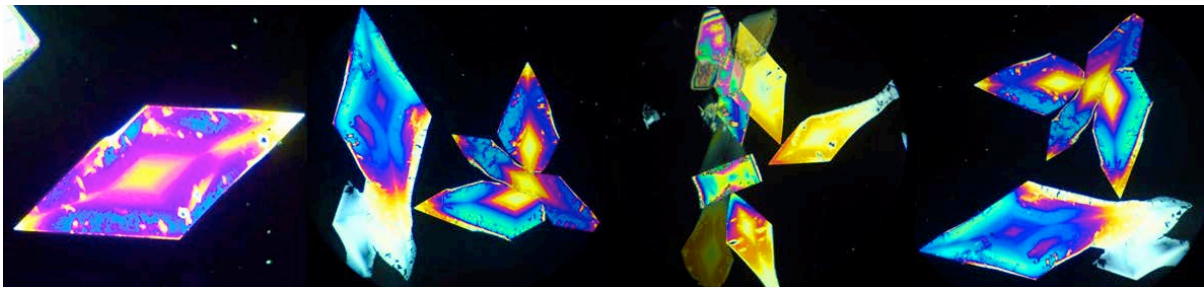
**MICROSCOPICAL SOCIETY.**

June 18, 1845.—Thomas Bell, Esq., F.R.S., President, in the Chair.

Also a paper by H. Deane, Esq., "On the Existence of Fossil *Xanthidia* in the Chalk," was read.

After mentioning that the occurrence of *Xanthidia* in a fossil state had not hitherto been observed in any other situation than in the flint-nodules of the chalk, and consequently that great doubt existed whether these fossils were really independent animal existences or only parts of some other creature, Mr. Deane stated that there is a grayish kind of chalk having no flints, but containing quantities of nodules of iron pyrites, which juts into the sea between Dover and Folkstone, forming the beach for some distance. Upon exposing a portion of this to the action of hydrochloric acid, and examining microscopically the insoluble sediment, bodies similar to, if not identical with, the *Xanthidia* in flints were exposed to view; several species were clearly to be recognised, together with casts of *Polythalamia* and other bodies frequently found in flints.

This slide is a rare engraved slide titled "Folkstone Lower Chalk" and dates from around 1845. Folkstone is located at the extreme southeast tip of England and contains chalk dating from approximately 120 to 80 million years ago. While unsigned, this particular slide is nearly identical in handwriting, with similar subject matter and mounting detail to several others bearing the engraved signature of H. Deane, an early researcher of diatoms and fossil material. The slide is beautifully finished, with chamfered and polished edges all around. The discovery in the late 1830s that many rocks and minerals were comprised of the remains of living organisms was just being investigated during this period. The slide is from a collection originally assembled by J. Rand Capron, FRS, during the 1840s and early 1850s.



Crystals of aspartic acid by Watson & Sons viewed under polarized light

### Early Histology Slides

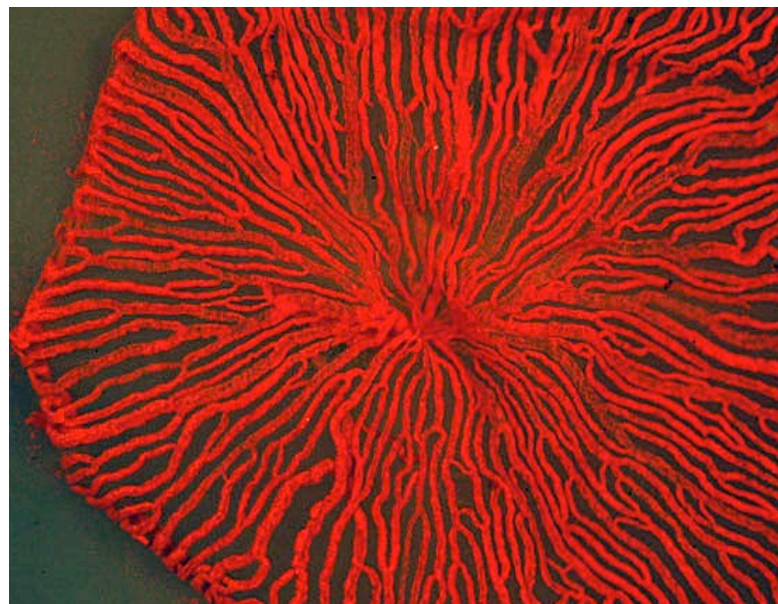
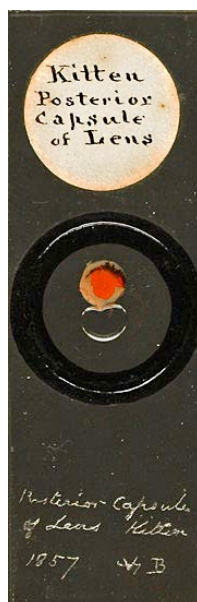
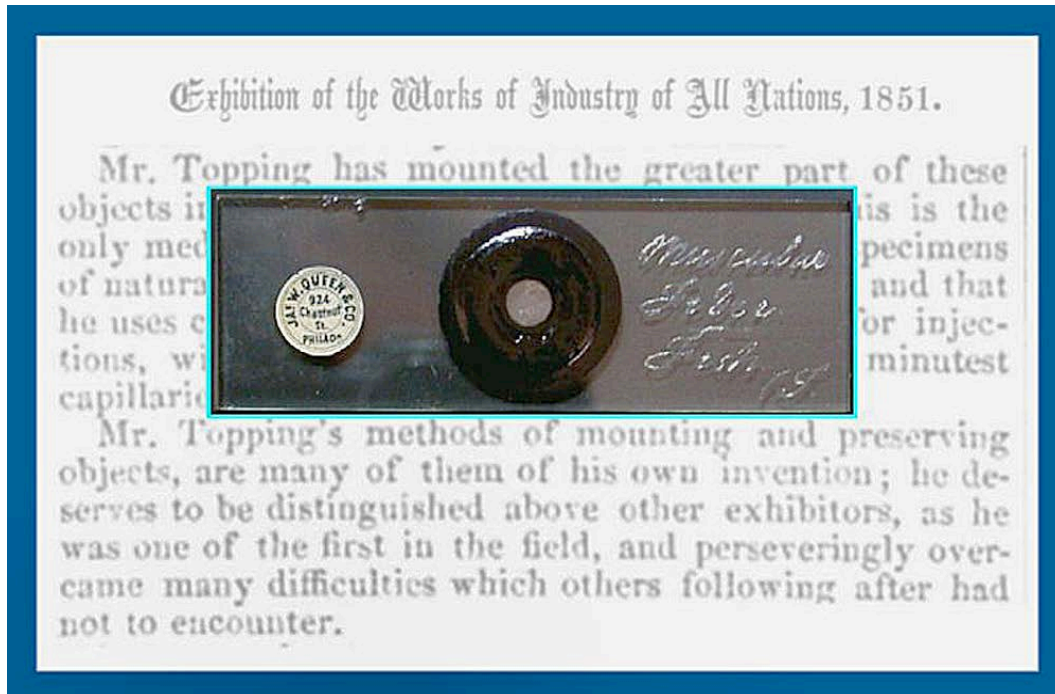
The first paper on the microscopic structure of tissues was published by Hodgkin and Lister in 1827. In the 1830s and 40s, most scientific investigation of tissues was performed in Germany. In England, John T. Quekett made superb preparations of plant and animal histology. The first commercial mounters to prepare histology slides were C. M. Topping and Andrew Pritchard in the 1840s. When the importance of histology to medical science was realized and it was introduced into medical school curricula around 1850, the production of histological slides expanded greatly.

### Muscular Fibre Fish



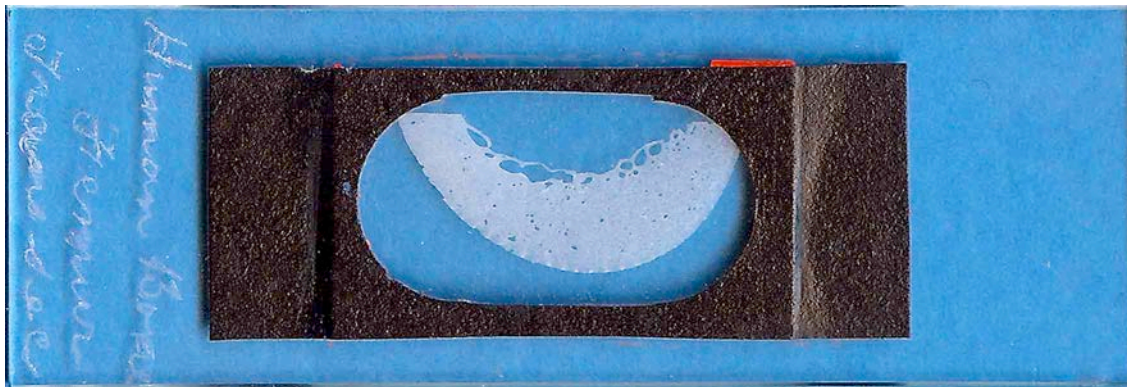
## Microscope Slides

This is an important early histology slide by Charles Morgan Topping (1800-1874), with diamond point engraved label and signed "T". The slide, titled "Muscular Fibre Fish" is one of Topping's early histology preparations, having been made in the mid to late 1840s. In Bracegirdle's *Microscopical Mounts and Mounters* for the entry on Topping, these slides are described: "Very occasionally his slides are named and signed only with a diamond point, using a handwritten monogram." The slide is shown superimposed over text from the comments in the report of the Jury at the 1851 Great Exhibition. This event would have been several years after this slide was probably made, but indicates the esteem in which he and his work were viewed. C. M. Topping is one of the most famous mounters in history and began mounting professionally in the late 1830s. The slide bears a secondary label of James W. Queen & Co. which sold scientific supplies in Philadelphia from 1853 to 1908.



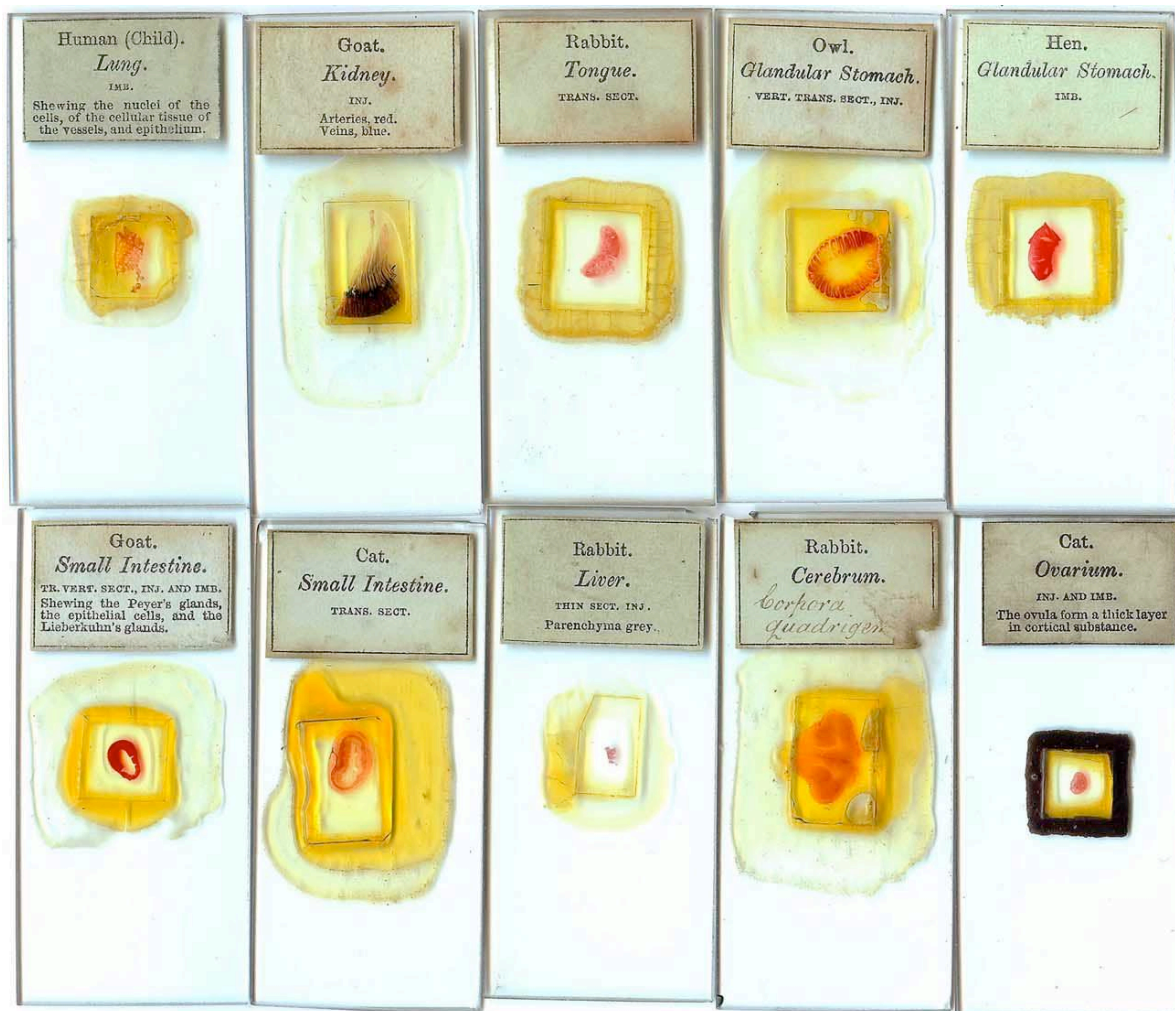
Posterior capsule of lens Kitten

This slide is dated 1857 and labeled "B." It is a deep cell fluid mount of the developing lens of the eye with the blood vessels injected.



Pritchard, Human femur, c1840

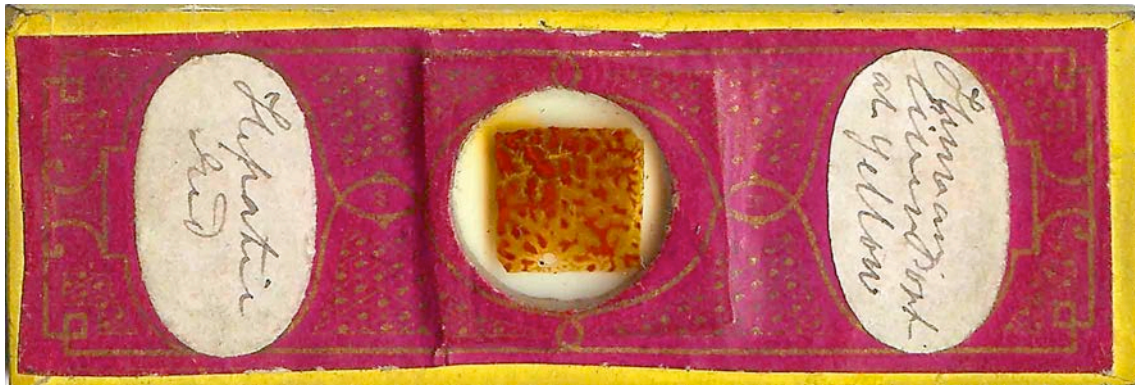
Andrew Pritchard (1804-1882) was one of the first commercial mounters beginning in 1827 in London. His specimens were typically mounted between two slides sealed together at the edges with red wax or, as in this case, with black paper over the cover held on by sealing wax, c1840.



German transparent injected histology slides imported by Smith & Beck in London, 1850s



These injected specimens were imported from Germany by Smith and Beck in London in the 1850s. The slides are unnecessarily large for the size of the section and have a bluish tint. They represented an advance in histological preparations in that the specimens are thin sections for transparent viewing. They were prepared by Karl Thiersch (1822-1895), a German surgeon born in Munich. Thiersch received his doctorate from the University of Munich in 1843, where from 1848 to 1854 he served as a prosector of pathological anatomy. It is most likely that he prepared slides during this period. Afterwards he became a professor of surgery at the Universities of Erlangen (from 1854) and Leipzig (from 1867). His contributions to medical science included demonstrating the epithelial origin of carcinoma, modifying Lister's technique of antiseptic sterilization by substituting salicylic acid for carbolic acid, studies on wound healing, and developing a method of split-skin grafting.



Liver, doubly injected. Portal yellow; Hepatic red, c1860

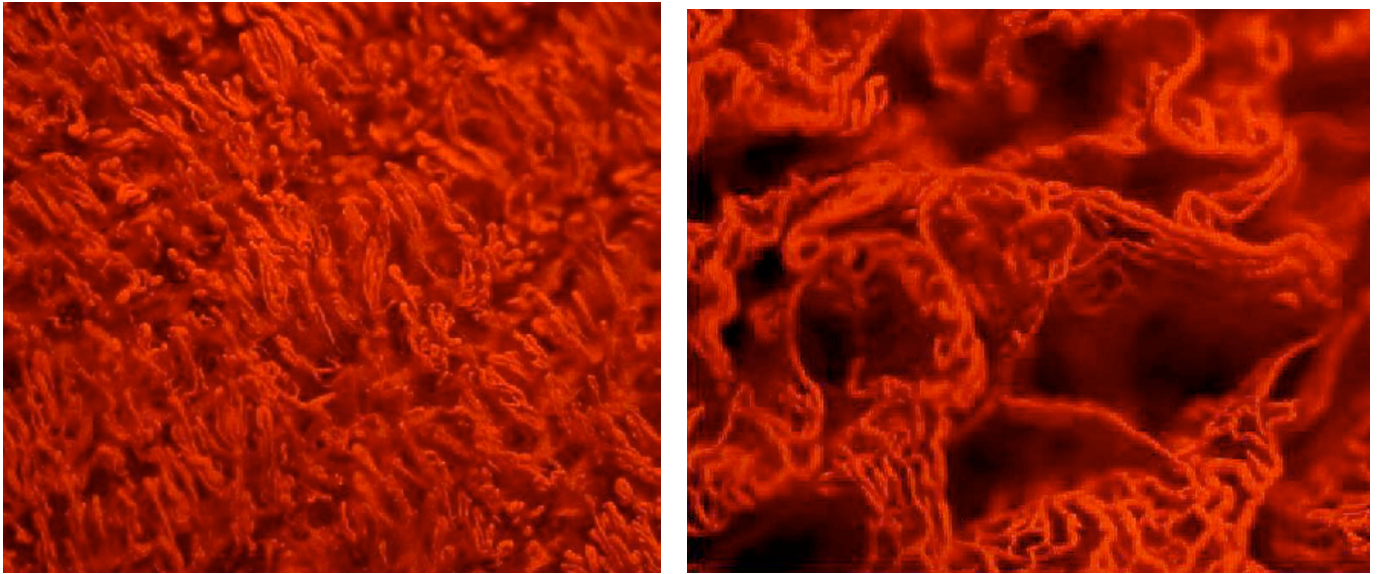
The maker of the doubly injected liver slide is unknown.



Whalebone

## Microscope Slides

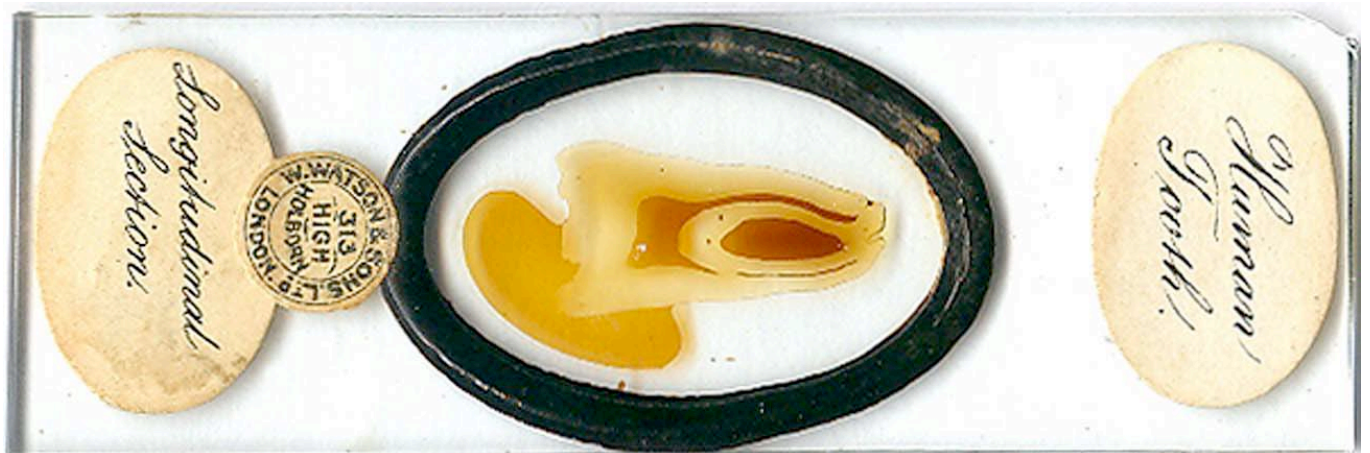
This is an early microscope slide, probably c1850, with engraved label entitled "Section of Whale Bone." The maker of this interesting slide has not been identified. The photomicrographs taken from the slide are imaged with a polarizing microscope using crossed polars with selenite filters and clearly show the Haversian systems of compact bone.



**Skin (left) and Lung (right), injected and corroded, showing blood vessels, c1860**

Charles Morgan Topping (1800-1874) was renowned for his injected and corroded histology mounts. After injecting the blood vessels, the surrounding tissues were corroded away. Although this technique reveals the capillaries, it yields relatively little histological information.

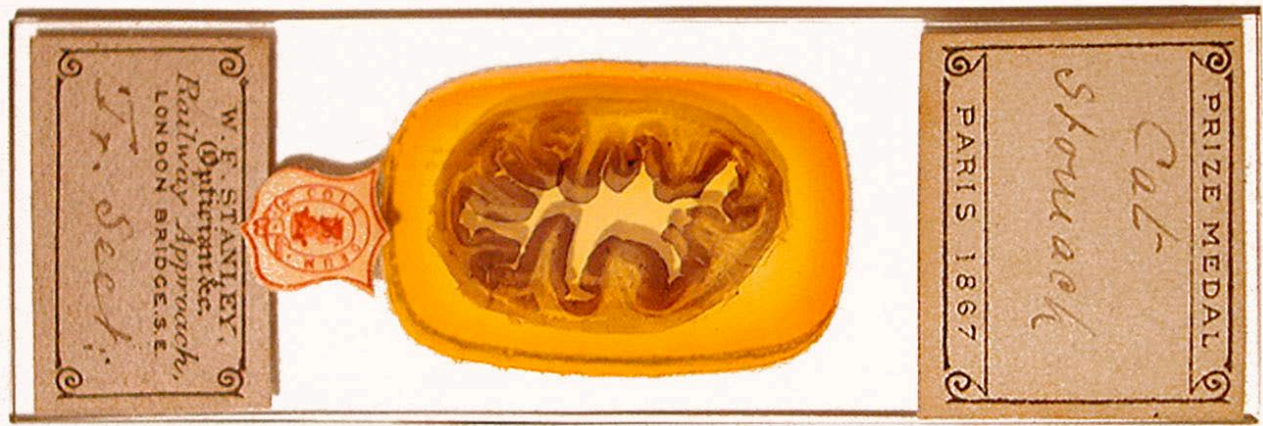
## Histology Slides



**Human tooth by Watson**

William Watson set up an opticians firm in London in 1837. The name was W. Watson & Son 1867-1882, W. Watson & Sons 1882-1908, and W. Watson & Sons Ltd 1908-1957. They began supplying preparations in 1884, when they took over the business of Edmund Wheeler. They offered very fine slides on all subjects.





Stomach of cat by A. C. Cole with secondary label of W. F. Stanley

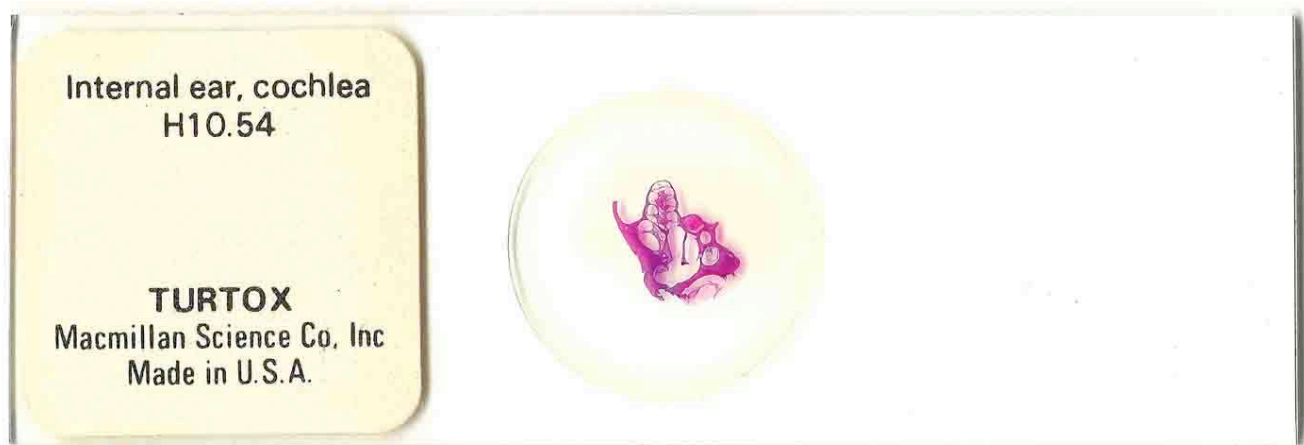


Blood Disks, C. M. Topping

Charles Morgan Topping (1800-1874) is one of the most famous mounters, perhaps best known for his mounts of the blowfly proboscis. He began mounting professionally in 1840 and is known for his red paper-covered slides with their gilt lithographed designs. He developed the injection-corrosion method of preparing histological specimens. This revealed the veins, arteries, and capillaries more clearly than before.



Human Eye by W. Watson & Sons

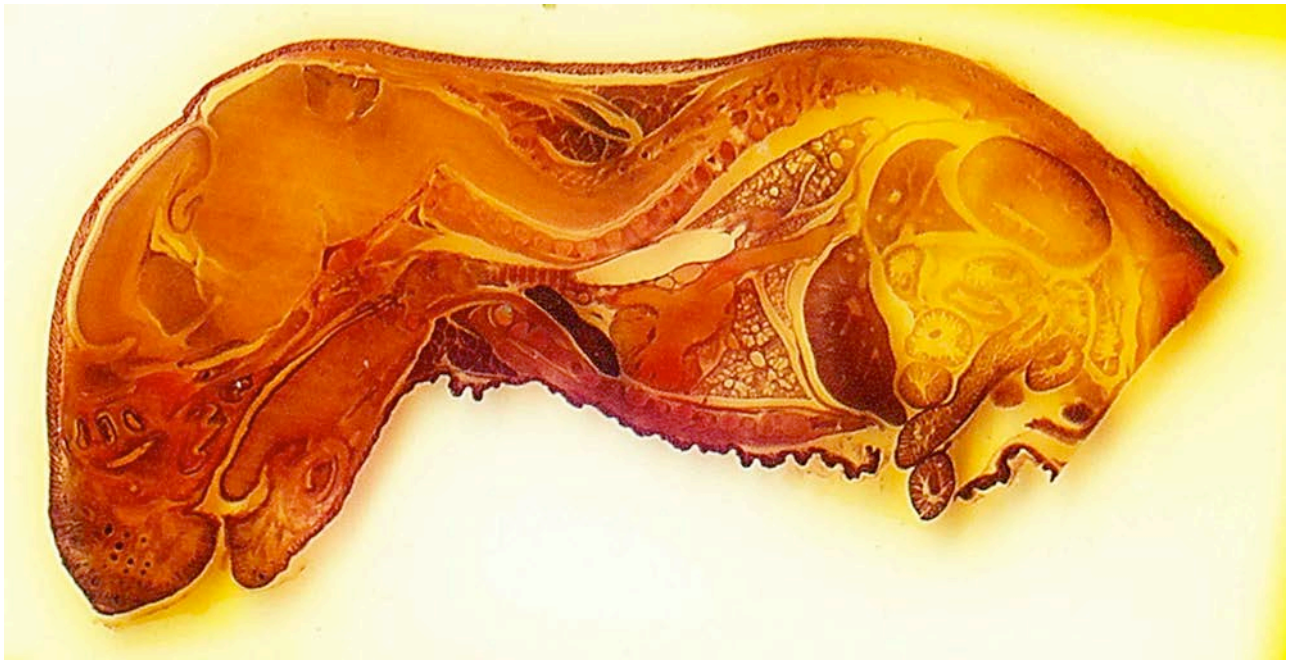


Cochlea by James B. McCormick

This slide of the cochlea was prepared by Dr. James B. McCormick. McCormick founded and ran the Histoslides Company from 1945 to 1955. The company produced slides for universities and also for firms such as Turtox, Ward's Scientific, and Scientific Products. This was Histoslides No. 129 and was provided to Turtox in 1949/50. General Biological Supply House in Chicago, founded in 1918, supplied slides under the name Turtox until 1980. They became Turtox, Inc., which was taken over by Ward's in 1992.

Flatters & Garnett was formed in 1901. The company continued after the departure of Flatters in 1909 and became the largest producer of slides in England, perhaps in the world, ceasing operations in 1967. This is an exceptionally fine sagittal section of a whole mouse. Detailed tissue structure is visible under the microscope.

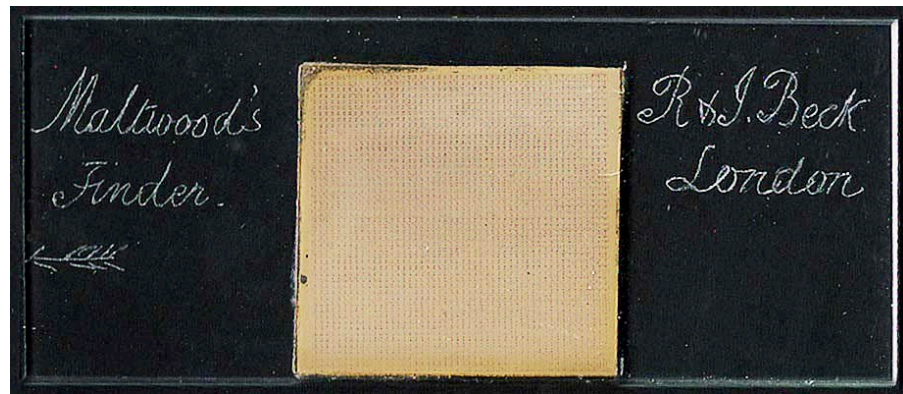




Whole Mouse by Flatters & Garnett

### Specialized Slides

#### Maltwood's Finder



24	25	26	27	28	29	30
24	24	24	24	24	24	24
24	25	26	27	28	29	30
25	25	25	25	25	25	25
24	25	26	27	28	29	30
26	26	26	26	26	26	26
24	25	26	27	28	29	30
27	27	27	27	27	27	27
24	25	26	27	28	29	30
28	28	28	28	28	28	28

Maltwood's finder is a slide that allows a point of interest in an object microscope slide to be located in subsequent observations of the slide. It was described by Thomas Maltwood in 1858. The finder consists of a reference grid divided into 2,500 squares. Each square contains two numbers, one of which indicates its position from left to right while the other marks the position from top to bottom. A point of interest is located in an object slide. Then the finder is substituted in place of the object slide and a reading on the grid is taken. If at some time in the

future, one wishes to locate the point of interest in the object slide, the finder is placed on the stage and the grid reading located. Then the object slide is substituted for the finder and the point of interest will be in view. This slide is diamond engraved "Maltwood's Finder" and "R & J Beck London." There is a slipcase for the slide. The glass slide is a little wider than an ordinary slide

and the edges are beveled. A photograph of the grid occupies a space of one square inch and is covered by a coverslip.

### Stage Micrometer



A stage micrometer is a microscope slide with a scale etched on the surface. It is used for measuring the size of an object, calibrating an eyepiece micrometer, and testing the resolution of objectives. The first reported measurements performed with an optical microscope were undertaken in the late 1600s by the Dutch scientist Antonie van Leeuwenhoek, who used fine grains of sand as a gauge to determine the size of human erythrocytes. This is a very fine brass stage micrometer labeled "Micrometer 1/1000" by W. Watson & Son in a silk and velvet-lined case. c1890.

### Zeiss Abbe Diffraction Plate

Abbe diffraction plate, German, c1900, signed on the original case "Carl Zeiss, Jena, Diffractionsplatte Nach Abbe." The diffraction plate consists of a glass slip with three cover glasses cemented side by side. The lower surfaces of the latter are silvered and have groups of lines ruled upon them so as to form simple and crossed gratings. The slide demonstrates the effects of diffraction in the formation of images in the microscope.



### Hemocytometer

A hemocytometer (haemocytometer) consists of a thick glass microscope slide with a rectangular indentation that creates a chamber. This chamber is engraved with a grid of lines. The device is crafted so that the area bounded by the lines is known, and the depth of the chamber is also known. It is therefore possible to count the number of cells or particles in a specific volume of fluid and thereby calculate the concentration of cells in the fluid overall. In an improved Neubauer hemocytometer, the total number of cells per ml can be determined by simply multiplying the total number of cells found in the hemocytometer grid by  $10^4$  (10,000).



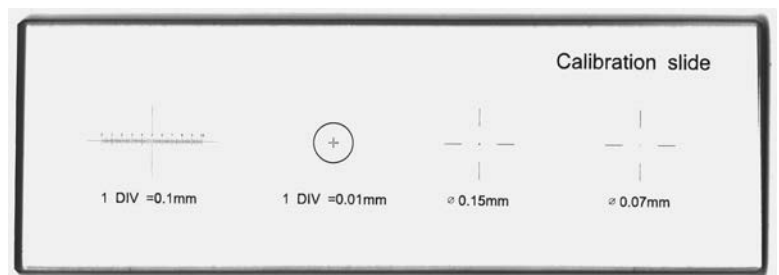
The counting chamber of this hemocytometer is a beveled glass slide divided by four parallel trenches and one short transverse center trench creating an "H" pattern. The slide is  $2 \frac{7}{8} \times 1 \frac{1}{4}$  inches and marked "Improved NEUBAUER, 1/400 sq mm, 1/10 mm deep, Pat May 24 1927, Nov



1 1927, MAX LEVY USA PHILADELPHIA, and N°." The firm of Max Levy had improved the hemocytometer by fashioning it out of one piece of glass. The center cover glass support is cut with improved Neubauer ruling. There is a cover glass that is held 0.1mm off the marked grid. There are two slender glass diluting pipettes, each with a bulb just above the center that contains a small mixing bead. The pipettes fit to rubber tubes that connect to small plastic mouthpieces. Included in the set is a manual on the Levy counting chamber (Patented Jan. 30, 1917) and another on "An Improved Technique for the Counting of Blood Corpuscles, Blood Platelets, Cells in Cerebro-Spinal Fluid and Pus Cells in Urine prepared especially for use with Levy and Levy-Hausser counting chambers" published and copyright, 1940. The set is housed in a felt-lined, leather-covered maroon case 7 1/8 inches long, 4 inches wide, and 1 1/4 inches high. The case is marked "AMERICAN STANDARD HAEMACYTOMETER WITH LEVY COUNTING CHAMBER ARTHUR H. THOMAS COMPANY PHILADELPHIA." This slide illustrates the stages in the development of the hemocytometer and is complete and, except for some scuffing of the case, is in extremely fine condition.

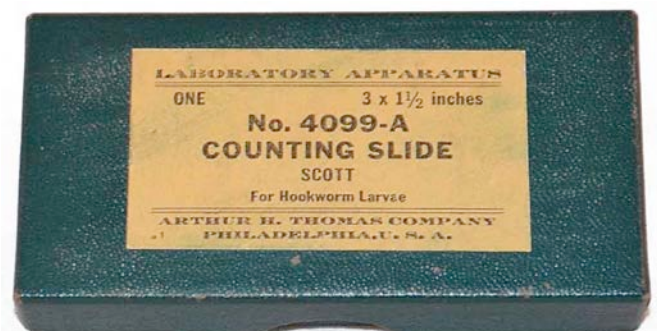
### Calibration Slide

This is a modern microscope calibration slide that is used to calibrate microscope eyepieces and microscope digital cameras. The slide has four different calibration patterns. The first of pattern is the 0.01 mm or 10 micron gradient lines with 100 division in total. The second pattern on the calibration slide is the crossed reticule with 0.01 mm or 10 micron each division on both the X and Y axis. The third calibration pattern is a 0.15 mm diameter dot and the fourth one is a 0.07 mm diameter dot. The slide is housed in a plastic case.



### Counting Slide for Hookworm Larvae

This is a microscope slide used for counting hookworm larvae in soil samples. It is in its original box labeled "Laboratory Apparatus. One 3 x 1 1/2 inches. No 4099-A Counting Slide. Scott. For Hookworm Larvae. Arthur H Thomas Company Philadelphia, U.S.A." The slide is a piece of rectangular clear glass with a groove running down its length. The slide is moved laterally with a mechanical stage to count the larvae in the groove. 1930-1960.



## Slide Sets

### Set of Small Continental Slides, c1850

Small slides, about 16 x 50-60mm, were made beginning around 1835 by Joseph Bourgogne in Paris and continued by his sons Charles and Eugene for many years. These "Continental" sized slides were made in great numbers for the small French drum microscopes. This is a set of small slides, probably French and prepared for the English market, c1850. The 7 ½ inch (19 cm) wide mahogany carrying case contains 45 slides with three empty slots. Each slide is glass, 15 x 50 mm in size, covered in decorative colored paper, with a prepared specimen mounted under a mica cover "glass" and with a printed identification label. Subjects include seeds, hairs, feathers, scales, wood, and insect parts.





### Alexander Hett Slide Set, c1850

Alexander Hett (1807-1870) FRCS was a surgeon and inventor who prepared microscope slides beginning in the late 1840s. His distinctive slides were highly regarded. The specimens were thick sections of human and animal tissues injected with a red dye and held in a thick, fluid-filled cell. The identity of the specimen and Hett's name were diamond engraved on the slide. Hett first advertised his slides in 1848 in John Quekett's *A Practical Treatise on the Microscope*. He was elected to the Microscopical Society of London in 1850 and won a Prize Medal at the Great Exhibition in London in 1851.

This is a complete set of 12 microscope slides by Alexander Hett contained in a wood box. The slides are opaque injections held in large and deep, fluid filled glass cells. The slides are diamond engraved with the name of the sample and signed "Hett." The specimens are: Gill of the Eel; Small Intestine human, shewing the Villi, Ileum, adult; Mucous membrane of the nose of the human foetus; Ciliary processes Iris, and portions of the vessels of the membrana papillaris Pia foetal; Small Intestine of the Pig, shewing villi and Peyers glands; Section of the Kidney of the Pig, shewing Malpighian bodies; Tongue of the Dog shewing the papilla; Buccal membrane of the Lamb; Small Intestine of the Frog; External surface of the Lung of the sheep; Skin from the Palmar surface of the finger shewing the papilla; Human Lung shewing Air cells. All of the cells retain their fluid.

The slots in the box are set further apart than usual to accommodate the thick cells on Hett's slides. Hett's advertisements included the following: "Parties residing at a distance from London may have a box of preparations sent for inspection, on giving a respectable town reference and paying carriage *both ways*; by this means they are enabled to examine the objects before purchasing, and to select such specimens *only* as they may require." It is possible this set of slides is one of those Hett sent out for approval. This set previously belonged to Gerard L'E. Turner.



Alexander Hett Slide Set

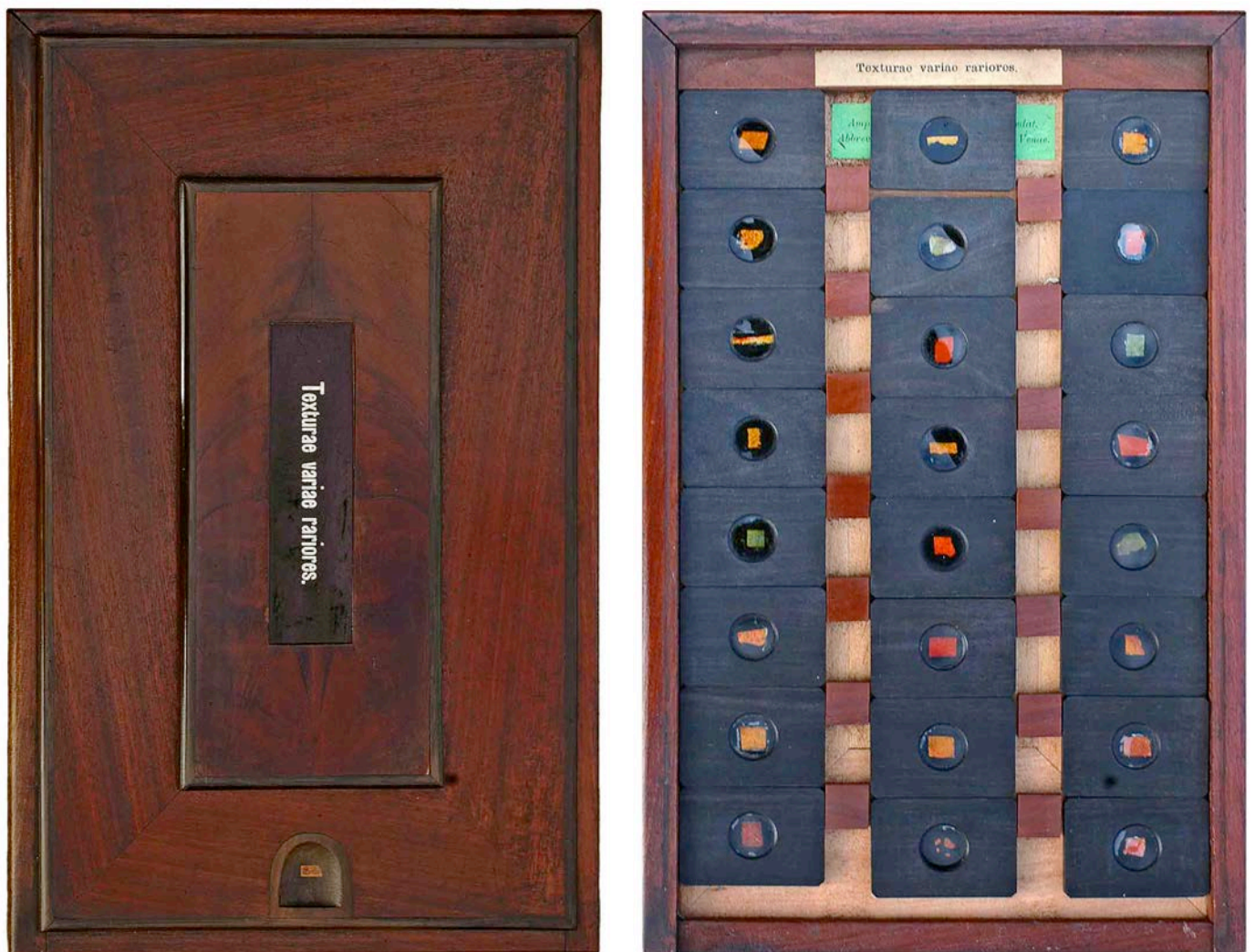
### Josef Hyrtl *Texturae variae rariores* Slide Set, c1860

This is an extremely rare cased set of 24 histology injection/corrosion slides prepared by Josef Hyrtl entitled "*Texturae variae rariores*." Each specimen is mounted on a paper-backed ebony tablet measuring 1 ¾ x 1 ¼ inches. Each mount consists of the prepared specimen in Canada balsam between two glass covers. They are mounted for reflected light investigation only. In some slides, the arterial and venous systems are injected with different colors. The description of each slide is on green paper on the back of the slide, printed in Latin. The superb polished case

## Microscope Slides

is made of mahogany and measures 11 ½ x 7 ½ inches. The case and slides are in almost mint condition.

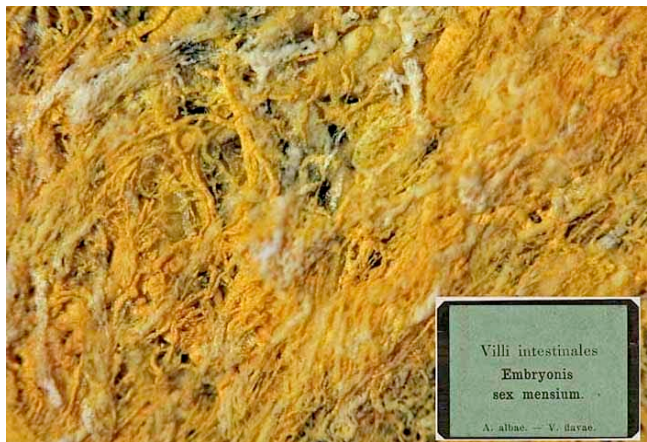
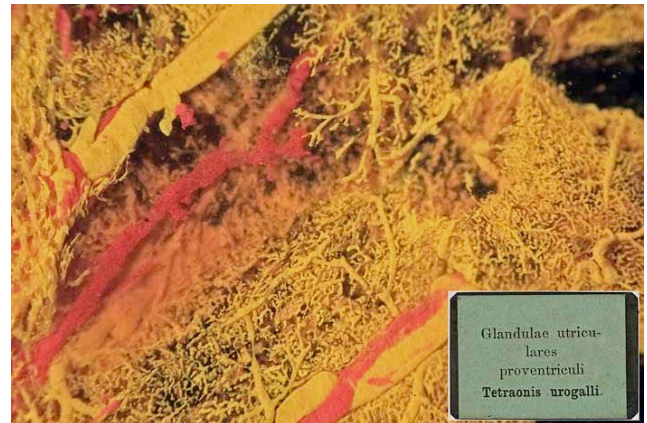
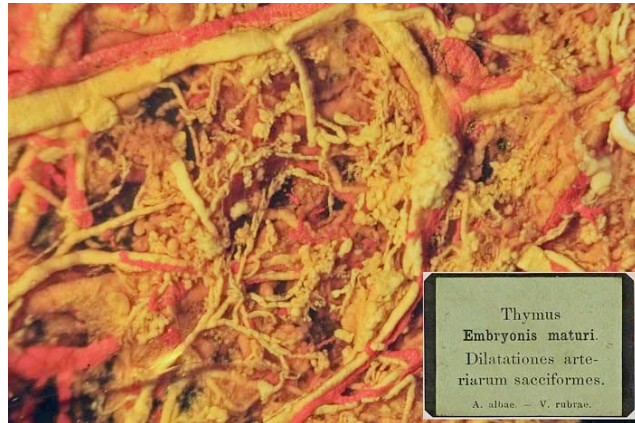
Josef Hyrtl (1810-1894) was born at Eisenstadt in Hungary, and came from a poor family background. He took up his medical studies in Vienna in 1831, having received his preliminary education in his hometown. His circumstances meant that he had to find some means to help defray the expenses of his medical education and he began producing preserved specimens. In 1833 while a medical student, he was appointed prosector in anatomy. As a student he set up a laboratory and dissecting room in his lodgings, and his injections of anatomical material were greatly admired. In 1837, at age 26, Hyrtl was offered the professorship of anatomy at the University of Prague. It was while there that he completed his textbook of human anatomy, which went through some twenty editions. The chair of anatomy at Vienna became vacant in 1845, and he was elected. Five years later he published his "Handbook of Topographic Anatomy," the first textbook of applied anatomy of its kind ever issued



It was as a teacher that Hyrtl did his greatest work. Professor Karl von Bardeleben, himself one of the leading teachers of the nineteenth century, did not hesitate to say that in this Hyrtl was unequalled. Hyrtl's slides were the absolute zenith of histological preparations using the injection/corrosion method. The injection technique consisted of injecting the blood vessels with gelatin, which could be colored. Often, the arterial and venous systems were injected with



different colors. Injected specimens could be “corroded” with a sodium hypochlorite solution, which dissolved the tissues away, leaving the cast of the vessels. Injected specimens are sometimes dismissed as yielding relatively little histological information. However, in some cases the technique is very useful, for example, in revealing the microcirculation in the lung and kidney and the arterial and venous systems of the liver. His fame spread throughout Europe, and he came to be looked upon as the jewel in the crown of the University of Vienna. In 1865, on the occasion of the celebration of the five-hundredth anniversary of the founding of the university, he was chosen rector in order that, as the most distinguished member of the university, he should represent her on that day. In 1880, there was a celebration of Hyrtl's seventieth birthday, when messages of congratulation were sent to him from universities all over the world.

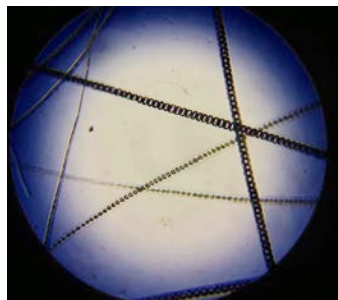
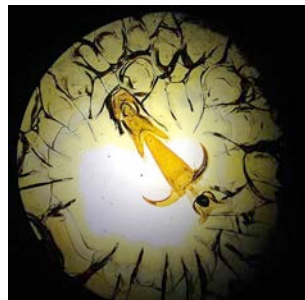
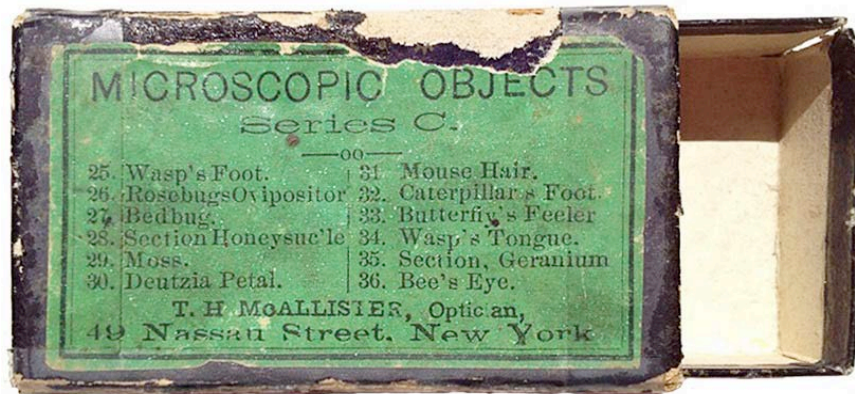


Josef Hyrtl *Texturae variae rariores* Slide Set



T. H. McAllister Slide Set, c1870

This is a boxed collection of 13 slides bearing the label T. H. McAllister, Optician, 49 Nassau St., New York. Thomas H. McAllister sold microscopes, slides, and other optical instruments in the last quarter of the nineteenth century. The slides are small,  $\frac{5}{8} \times 2 \frac{3}{16}$  inches, and probably French in origin. They are covered in tan paper covering the coverslip with McAllister's label pasted on. One of the slides listed on the cover of the box is missing but there are two additional slides. Some of the slides have cracked coverslips and shrinkage of the balsam but the specimens can be viewed in all. The box is worn with some paper missing at the edge but not seriously affecting the text. This rare set is of interest as an example of the type of microscopical objects available to the American public in the late nineteenth century.





## Diatom Slide Set, Arthur C. Cole, c1875

This is a rare complete set of 48 diatom microscope slides by A. C. Cole. The set is complete running from 1 to 48 with the original paper inventory pasted in the lid of the box. The label includes Cole's monogram, Prize Medal 1867, and the address 62 St Domingo Vale Everton Liverpool. It is entitled "Descriptive List of 48 Choice Selected Diatomaceae-Series A." The diatoms are from locations around the world. The label is signed Arthur C. Cole & Son. The slides are housed in a boxwood case with eight trays each holding six slides in its own compartment. This set was made around 1875.



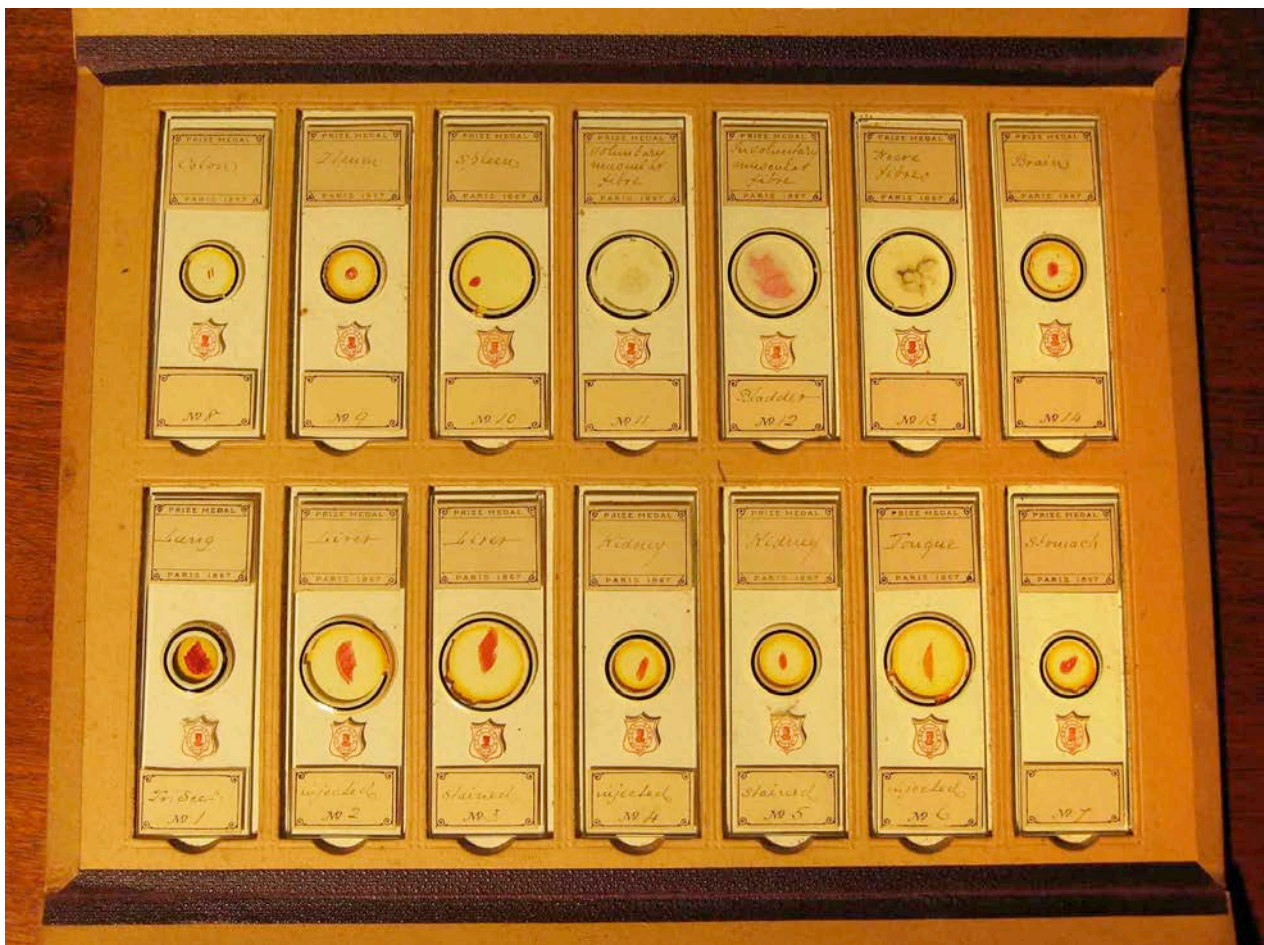
Diatoms are a major group of algae, and are one of the most common types of phytoplankton. A characteristic feature of diatom cells is that they are encased within a unique cell wall made of silica. Diatoms were probably some of the first minute life forms observed with early microscopes. Originally referred to and included in the broad grouping known as "Animacules" or "Infusoria," the Diatomaceae have been, and remain, a subject of intense interest

and study, most recently as a "window into the past" in studying climate change. All of the professional mounters during the Victorian era prepared and offered numerous diatom slides of material obtained from locations around the world. There were also a number of scientists, naturalists, and talented amateurs who specialized in their mounting, study, and classification. Importantly, diatoms were also mounted for many years specifically to be used as a way to test the resolving power of microscope objectives.

Arthur C. Cole (1821-1900) was initially an organist but was making slides by 1867. He mounted diatoms and histological subjects of high quality. They carried a small red and white label with a crest and the words Cole Deum (Worship God). He won a prize medal at the Paris Exhibition of 1867 and all of his subsequent slides bear this notation.

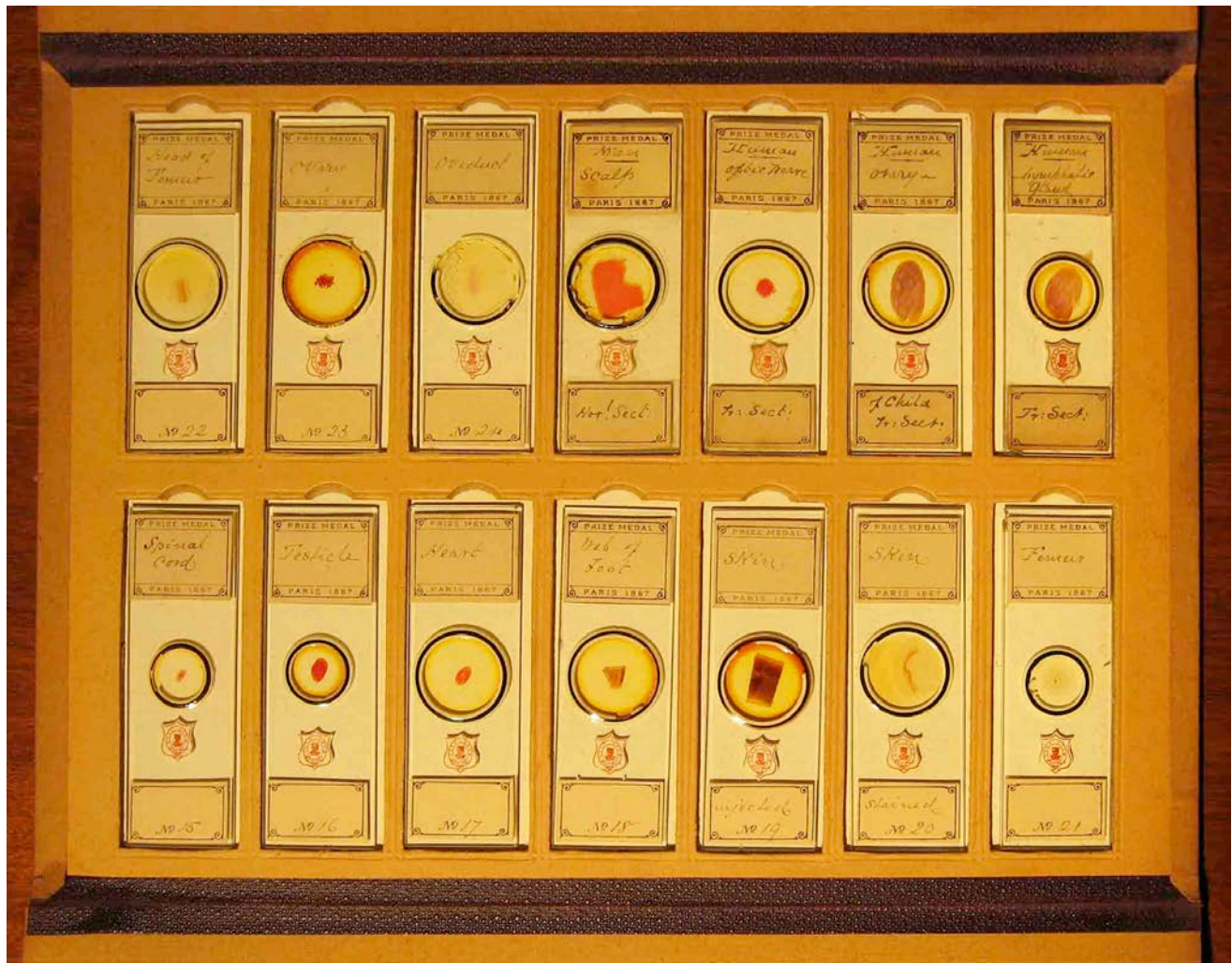
**Histology Slide Set, Arthur C. Cole, c1880. First histology slides issued as a set**

Although several firms offered histology slides, Arthur C. Cole (1821-1900) appears to have been the first to offer them in sets. He made slides of a variety of subjects, but many were of histology and pathology. In the 1880s, he offered to subscribers sets of slides accompanied by printed illustrations and descriptions. There were four volumes but, despite favorable reviews, they were not successful commercially and few complete sets remain. This is a complete set of 24 numbered slides plus four additional slides. It probably predates the issuance of the four volumes and represents one of the first sets of histology slides. It was most likely intended for medical students. The slides are of very high quality.



Folder 1





Folder 2

No. 1, Lung, Tr. Sect.	No. 11, Voluntary muscular fibre	No. 20, Skin, Stained
No. 2, Liver, injected	No. 12, Involuntary muscular	No. 21, Femur
No. 3, Liver, Stained	fibre, Bladder	No. 22, Head of Femur
No. 4, Kidney, injected	No. 13, Nerve fibres	No. 23, Ovary
No. 5, Kidney, Stained	No. 14, Brain	No. 24, Oviduct
No. 6, Tongue, injected	No. 15, Spinal Cord	Man, Scalp, Hor <sup>l</sup> . Sect.
No. 7, Stomach	No. 16, Testicle	Human, Optic Nerve, Tr. Sect.
No. 8, Colon	No. 17, Heart	Human, Ovary of Child, Tr. Sect.
No. 9, Ileum	No. 18, Web of Foot	Human, Lymphatic Gland, Tr.
No. 10, Spleen	No. 19, Skin, injected	Sect.

### Prudden Slide Set, College of Physicians and Surgeons, 1889

T. Mitchell Prudden, a graduate of the Sheffield Scientific School and Yale Medical School, became Director of the histological and pathological laboratory at the College of Physicians and Surgeons in 1882. He taught histology at Yale one day a week from 1880 to 1886. This set of 25 histology slides came from the laboratory in 1889 during the time Prudden was Director. The slides are sections of normal tissues. Printed on the label is "Normal Histology, Coll. Phys. & Surg., N. Y." Prudden had a distinguished career in pathology and bacteriology at Columbia.

T. (Theophil) Mitchell Prudden (1849-1924) was a founder of pathology as a field of research and teaching in the United States. He was born in Middlebury, Connecticut, the son of a Congregational minister. He attended the Sheffield Scientific School at Yale and received a Ph. B. degree in 1872. He entered the Yale School of Medicine and received the M. D. degree in 1875.



During the summer of 1873, he took part in the fossil-hunting expedition in the West headed by Othniel C. Marsh. In the spring of 1875, while in his last year at medical school, Prudden attended lectures in New York at the College of Physicians and Surgeons, and worked in the laboratory of the pathologist Francis Delafield. After graduating, he was an intern at New Haven Hospital and was given a fine microscope and this may have influenced his interest in microscopic investigation. He then studied for two years at Heidelberg under Julius Arnold and Richard Thoma. Upon returning to New Haven, he was unable to secure a position in pathology and opened an office for the practice of medicine. In 1877, alumni of the College of Physicians and Surgeons raised funds for the establishment of a histological and pathological laboratory. Undoubtedly on Delafield's recommendation, Prudden was offered a position as first assistant in the new laboratory. He accepted the position and began a long and successful career at Columbia. In 1880, he was offered a professorship in histology at Yale, but decided to stay in New York. He did agree to commute one day a week and teach histology at the Yale Medical School from 1880 to 1886. At Columbia,

he became director of the laboratory in 1882 and Professor of Pathology in 1892. His first books "A Manual of Practical Histology" and, with Delafield, "A Handbook of Pathological Anatomy and Histology," later "A Text Book of Pathology," went through many editions. In 1885, he studied in the laboratory of Robert Koch in Germany. He applied his new knowledge of bacteriology to studies on the purity of water and ice supplies, the nature and spread of tuberculosis, and the causative agent of diphtheria. At the founding of the Rockefeller Institute for Medical Research in 1901, Prudden served as vice-president of its board of scientific directors. During summer vacations he made many trips to the West, and he wrote on the archaeology and Indians of the Southwest. He visited the prehistoric cliff dwellings of the region and contributed the materials gathered on his expeditions to museums including the Peabody Museum at Yale.

These slides belonged to Dr. Frank Landau Tucker who graduated from the College of Physicians and Surgeons. They were most likely used by him when he was in medical school. It is not known if they were made by Prudden, but they certainly came from the histology laboratory that Prudden directed.



### College of Physicians and Surgeons, Columbia University, Teaching Set

This is a set of 218 teaching slides from around the turn of the twentieth century. The slides are held in trays housed in an 8 ½ x 8 x 4 ½ inch mahogany box that opens front and top. The slides are labeled "College P. & S. N.Y." or "Coll. Phys. & Surg. Columbia Univ., NY." 99 slides are "Normal Histology," 99 slides are "Pathological Histology," 10 slides are "Bacterial Laboratory" or "Bacteriology," and 10 are unlabeled. The slides were prepared during the time T. Mitchell Prudden, a graduate of the Yale Medical School, was director of the histological laboratory at Columbia. This appears to be a teaching set that includes nearly all the slides a medical student would need in the first two years of study in medical school. It is an important set because it reflects the teaching in medical schools at the end of the nineteenth century and has been preserved intact. Donated by Dr. James B. McCormick.



### R. Fuess Petrographic Slide Set

This is a set of 30 1 x 2 inch petrographic slides. Each slide has the trade label "R. FUESS, BERLIN." The original guide dated 1876 is titled "Sammlung Nr. 7, 30 Dünnschliffe von typischen Gesteinen." The thin sections are of Granit, Granitporphyr, Granulit, Felsitporphyr, Sanidintrachyt, Trachyt, Pechstein, Pechstein, Kugeldiorit, Metaphyr, Diabas, Diabas, Kalkdiabas, Nosean-Leucitophyr, Leucitophyr, Hauyngestein, Noseangestein, Noseanphonolith, Vesuvlava, Augitandesit, Augitandesit-Lava, Gabbro, Eklogit, Eulysit, Olivinfels, Ophicalcit, Lithographischer Kalkstein, Grauwacke, Trass, Basaltbreccie. R. Fuess was a famous instrument and optical firm in Berlin. Its specialty were exceptional mineralogical instruments including spectrosopes, refractometers, goniometers, and petrographic microscopes and their accessories.

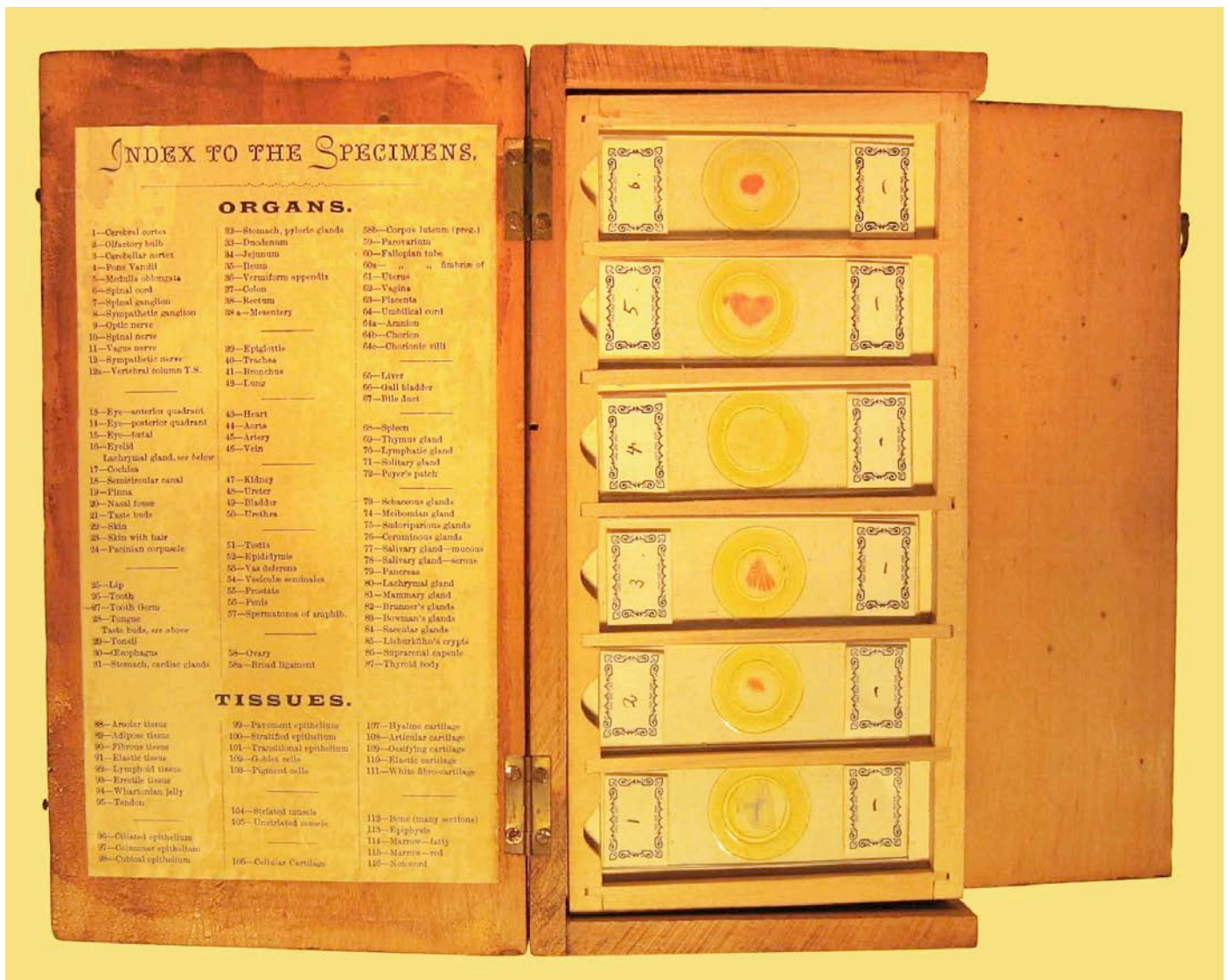




Histology Slide Set, c1900

This is a complete set of 72 histology slides. The slides are held in 12 trays within a wooden case that opens. A list of slides is pasted on the inside of the top cover. This appears to be a commercial set intended for medical students. It dates from 1890 to 1910. The maker is not known but it is probably a slide-making firm in England, possibly Abraham Flatters. The set is complete and of high quality.





Botanical Slide Set, c1890

This is a set of 12 slides of botanical objects. All of the slides are labeled Northern College of Pharmacy, 100-102 Burlington St., Manchester and E. Coll. N. C. P. Manchester. The slides are Sori, From Jamaica Hymenophyllum Sericeum, Decoloured leaf of fuchsia, onion skin shewing Raphides, T. S. joint of stem Barley, T. S. Stem Salia universalis Osier, Seeds Rose lychnis, Seeds Oxalis tropaeoloides, Oak Fern Spore Cases, Scales Fern, T. S. Stem Phlebodium aureum, Petal of Geranium Pelargonium. The slides are sections and whole mounts. The slides are in excellent condition and very attractive with decorative ringing of different colors. The slides are held in a fitted cardboard holder with folding covers with marbled papers pasted on. The slide holder fits into a cardboard case labeled Microscopical Preparations. There is wear to the edges of the slide holder and case.



Botanical Slide Set

### Outstanding histology slide set of 100 slides made by Dr. F. Sigmund in the 1920s

Professor Sigmund, Stuttgart, prepared six series of slides in the 1920s. Each series contains ten parts of ten slides and each slide has a multi-language label. One series is the Physiological Histology of Man and Mammalian Animals (*Histologia Physiologica*). The ten parts of this series are The Skin; Organs of Movement; Central Nervous System; Reproductive Organs; Respiratory and Urinary Organs; The Eye; Organs of Hearing, Smell, Taste, and Touch; Circulatory and Blood-forming Organs; and Digestive Organs (2 parts). This is a complete set of the *Histologia Physiologica* consisting of 100 slides. The slides are noteworthy because of their exceptional quality with thin sections beautifully mounted and stained. Some preparations are injected. Sigmund's slides were mainly meant for an educational market, but their beauty and quality were



such that they came to the attention of non-professionals and collectors. Perhaps as a result, sets were dispersed, and single slides are now scarce and expensive and complete sets are extremely rare.



The slides are housed in a “book box,” a slide box with covers in the form of a book so that the box would look like a book when placed vertically on a shelf. The slides are listed on the inside of the front cover.



### Möller Materia Medica Slide Collection

Johann Dietrich Möller (1844-1907) began making slides of diatoms around 1867. After his death, his son took over the business which produced a wide range of slides into the 1960s. This is a collection of 70 slides of leaves, flowers, fruits, herbs, roots, seeds, rhizomes, bark, and other parts of medicinal plants. The monogram in the corner of the label is a circle around the letters JM. Extracts of these plants formed much of the pharmacopoeia of the nineteenth century and first part of the twentieth century. The use of some dates from antiquity, and the active ingredients of many are still used medicinally today.

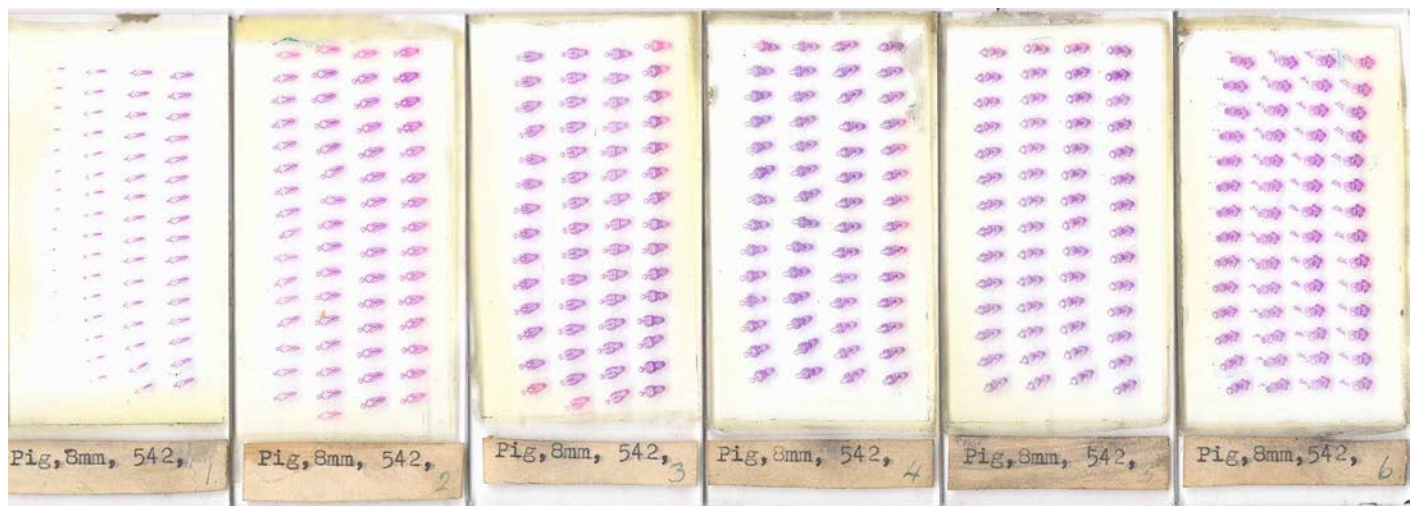




Möller Materia Medica Slides

Serial Sections of 8mm Pig Embryo, c1920

This is a set of serial sections through an entire 8mm pig embryo. The sections on 13 1/2 X 3 inch slides are 10 microns thick and stained with Alum C and Orange G. The paper labels have "Pig, 8mm, 542" and the number of the slide in pencil. The number of the slide is also diamond engraved on the glass below the label.



Serial Sections, Pig Embryo, c1920



**NBS Microslides Set of Spider Whole Mounts**

Northern Biological Supplies (N. B. S.) was founded in 1938 by J. Eric Marson. Its specialty is providing natural history slides. This is N.B.S. Set 6/BH, six spider whole mounts. c1960.



**NBS Microslides of Spider Whole Mounts**

**Volcanic Ash and Sand**

This is a set of 25 slides of volcanic ash and sand from volcanoes around the world including Mount Etna, Stromboli, Pinatubo, Quizapu, Mt. St. Helens, and others. Each slide is prepared with square rings and labeled with metallic silver thermal printed labels. The largest eruption of the twentieth century occurred in 1912 on the Alaska Peninsula to form Novarupta.



**Volcanic Ash from Novarupta**

### Slide Set, Wait's Drugstore, Traverse City, Michigan. c1880

This is an unusual American set of 12 slides in a small cardboard box labeled "Wait's Drugstore, Traverse City, Mich." The slides are small, 57 x 17 mm, and wrapped in paper. One side of each slide is labeled with the subject and "Microscopic Objects, Prepared by S. E. Wait." The other side is labeled "Nature is Man's best Teacher. She unfolds her treasures to his Search." The slides are Hen's Feather, Juniper Pine Hemlock Leaf, Live Forever Leaf, Wing of Butterfly, Caterpillar's Hair, Wing of Fly & Wasp, Lettuce Leaf, Maple Moss, Sponge, Apple Skin (specimen missing), Tea Leaf (specimen missing), Snake Skin (specimen missing). The set is in generally good condition noting a few slides with cracked coverslips and three specimens missing. c1880.

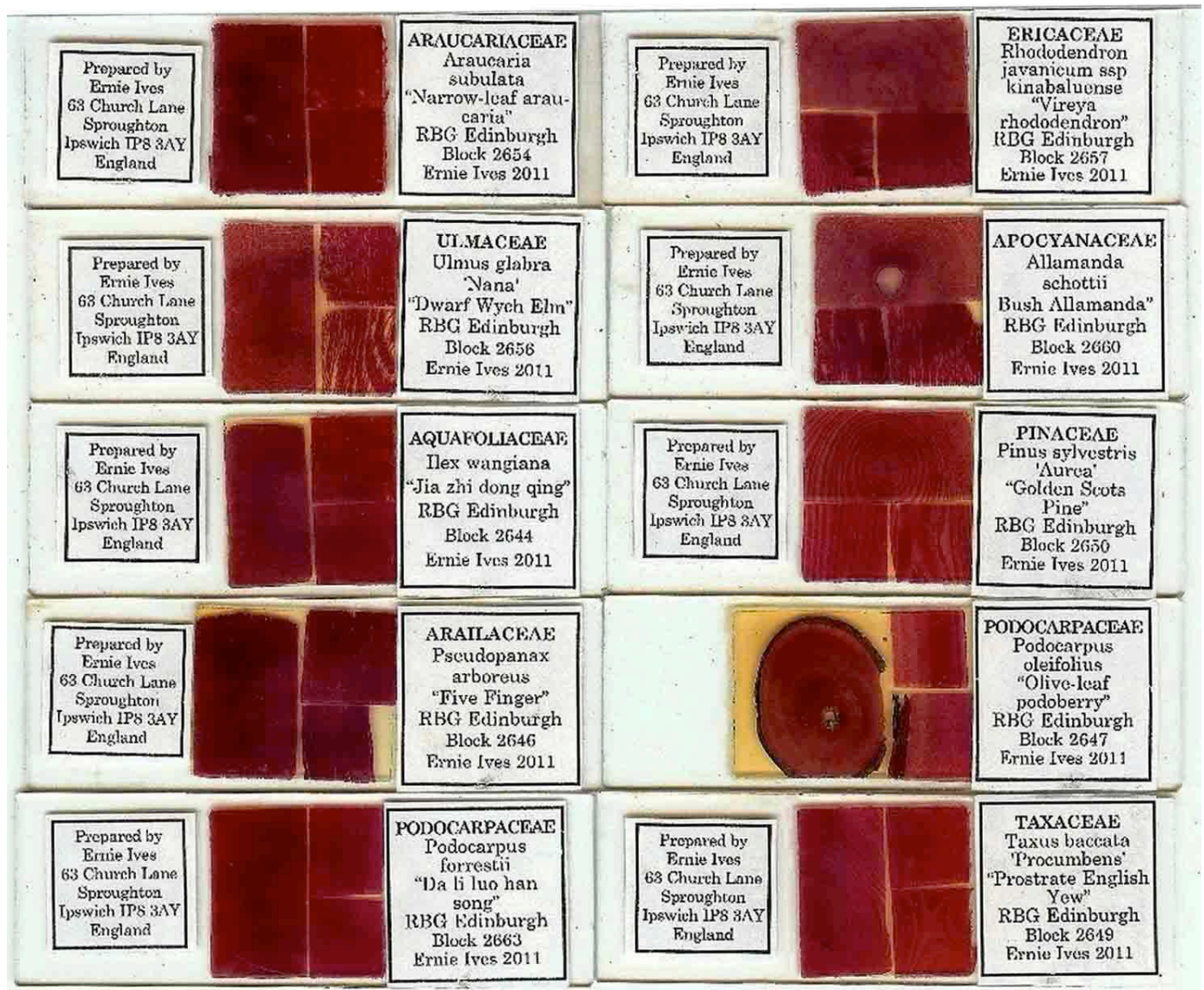


Wait's Drugstore, Traverse City, Michigan

### Wood Sections from the Royal Botanic Garden Edinburgh by Ernie Ives

These are ten mounts of transverse, radial, and tangential sections of woods from Royal Botanical Garden Edinburgh by the late Ernie Ives. The Royal Botanic Garden Edinburgh is a scientific center for the study of plants, their diversity and conservation, as well as a popular tourist attraction. It was originally founded in 1670 as a physic garden to grow medicinal plants. Ernie Ives is known for his high quality wood sections and was the author of *A Guide to Wood Microtomy*. The slides were made in 2011.





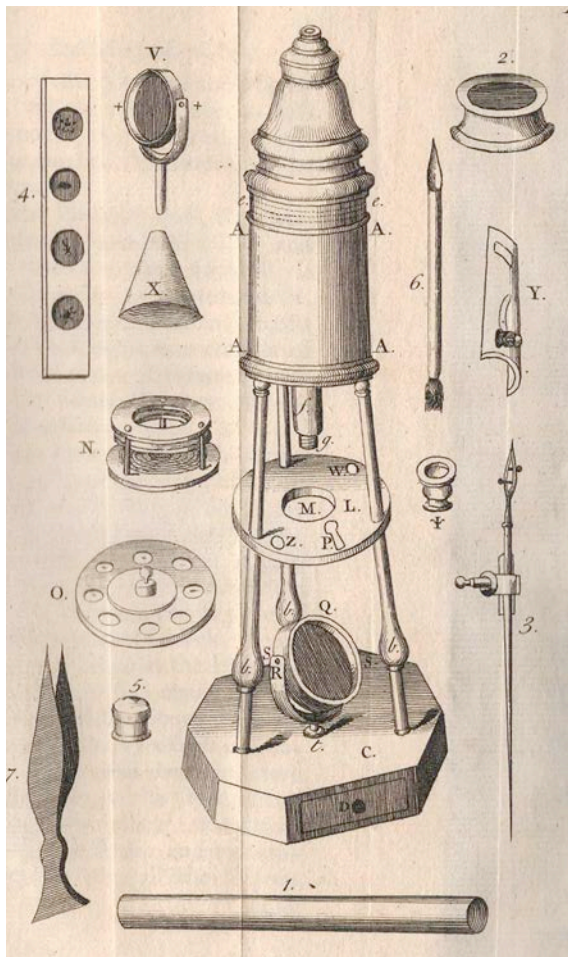
Wood Sections from the Royal Botanic Garden

## Books

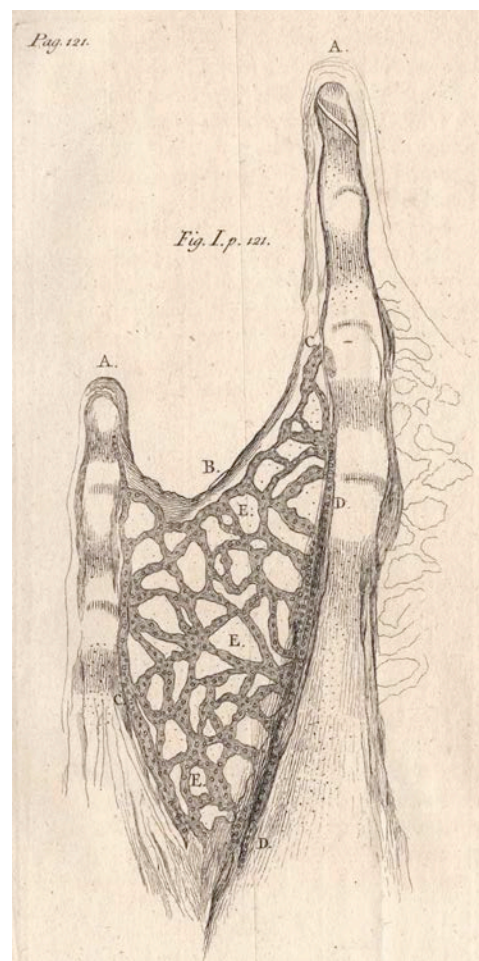
### Books on Histology and Microscopy

The Lentz Collection includes a small collection of books on histology and the history of microscopes. Some are illustrated here.

Baker, Henry 1743 *The Microscope Made Easy: Or, I. The Nature, Uses and Magnifying Powers of the best Kinds of Microscopes Described, Calculated, and Explained: For The Instruction of such, particularly, as desire to search into the Wonders of the Minute Creation, tho' they are not acquainted with Optics. Together with Full Directions how to prepare, apply, examine, and preserve all Sorts of Objects, and proper Cautions to be observed in viewing them. II. An Account of what surprizing Discoveries have been already made by the Microscope: With useful Reflections on them. And Also A great Variety of new Experiments and Observations, pointing out many uncommon Subjects for the Examination of the Curious.* 8vo, modern full tan calf with gilt lettering labels, 15 copper plates, 12 folding, fine. Second edition. Printed for R. Dodsley and sold by M. Cooper and J. Cuff, Optician, xvi, 341pp, index.



Double Reflecting Microscope



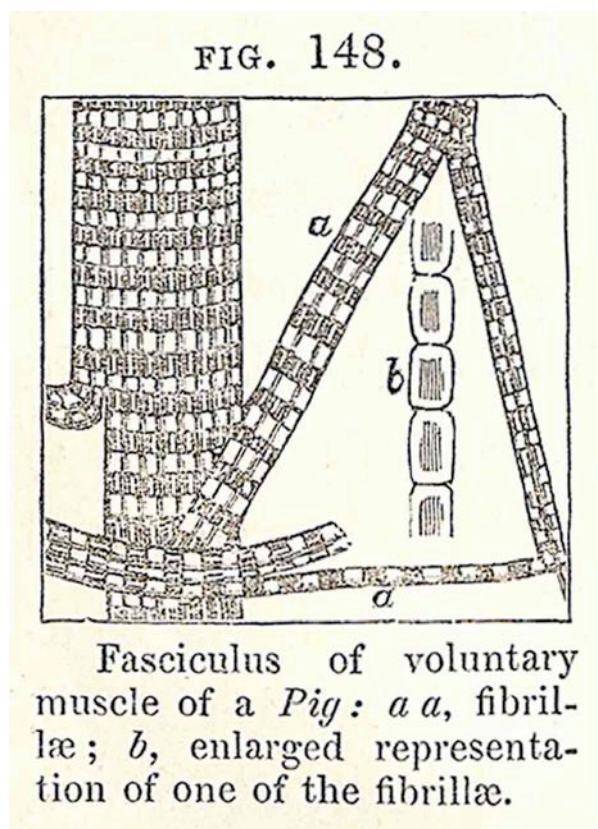
Circulation of blood in web of frog's foot

Henry Baker (1698-1774) was a typical eighteenth century polymath; naturalist, speech therapist, historian, poet, translator, editor, and correspondent. He made a series of pioneering observations of crystal morphology. He was a cofounder of the Royal Society of Arts and a Fellow



of the Royal Society of Antiquaries. Experiencing difficulties in the use of current microscopes, Baker expressed his concerns to John Cuff who within a year produced his side-pillar microscope that set the standard for the next generation of microscopes. *The Microscope Made Easy* was a bestseller and greatly popularized microscopy because it gave understandable instructions on use of the microscope and the preparation of specimens. There is no doubt that *The Microscope Made Easy* was widely read not only by natural historians, but also writers, poets, and thinkers of the day. Baker's purpose in writing the book was to increase interest in the use of the microscope and instill in others a curiosity for objects previously invisible to the naked eye.

Quekett, John. 1852. *Lectures on Histology, Delivered at the Royal College of Surgeons of England, In the Session 1850-51. Elementary Tissues of Plants and Animals*. 159 woodcuts, Hippolyte Bailliere, London, viii, 215 [1] pp. Quekett's work as an histologist was remarkable for its originality and for its influence upon the histological studies of the medical profession.



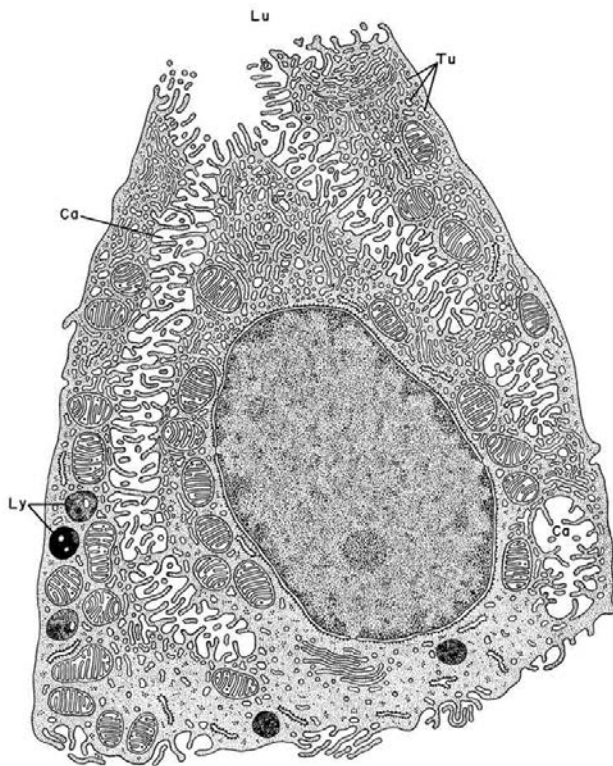
Muscle, *Lectures on Histology*, Quekett, 1852



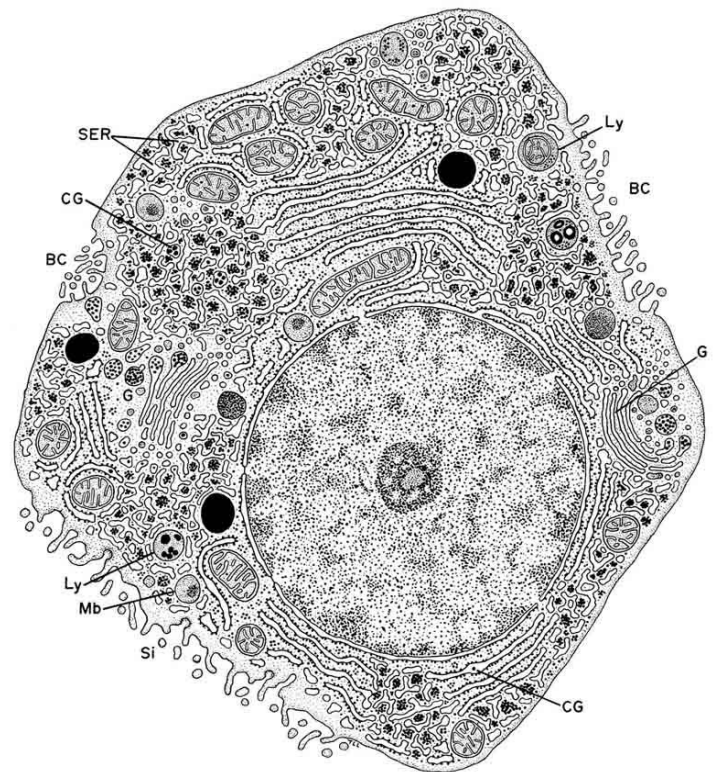
Haversian Canal, *Manual of Human Histology*, Kölliker, 1853.

Kölliker, A. 1853. *Manual of Human Histology*. Vol. 1., xiii, (1), 498pp; Vol. 2, ix, (1), 434pp. First English edition, Sydenham Society, London. This is the first textbook of histology by one of the foremost histologists of the nineteenth century.

Lentz, Thomas L. 1971. *Cell Fine Structure. An Atlas of Drawings of Whole-Cell Structure*. W. B. Saunders Co., Philadelphia, 437pp. 35mm Slide Set. *Cell Fine Structure* consists of drawings of all of the cell types in the body, each compiled from a number of electron micrographs of the cell. The original 9 x 12 inch pen and ink drawings are included in the collection.



Parietal Cell, *Cell Fine Structure*, Lentz, 1971

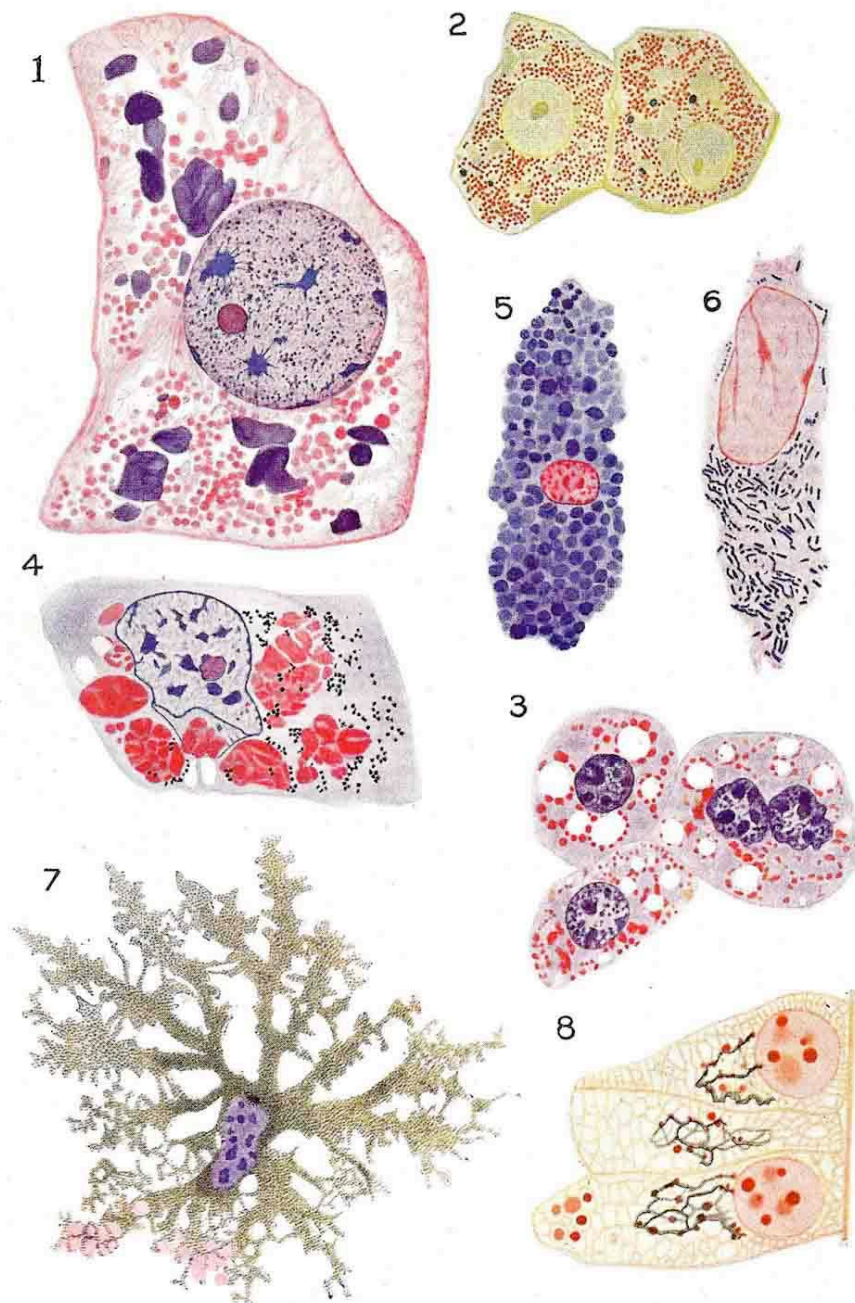


Hepatocyte, *Cell Fine Structure*, Lentz, 1971

Maximov, A. A. and Bloom, W. 1930. *A Text-Book of Histology*. W. B. Saunders Co., Philadelphia, 833pp. First edition of the classical histology textbook of the twentieth century.

Alexander Alexandrowitsch Maximow (1874-1928) was a Russian-American scientist in the fields of histology and embryology. A professor in Saint Petersburg, he fled communist Russia with his family in 1922. From 1922 until his death in 1928, he served as a Professor of Anatomy at the University of Chicago and conducted his research with his sister Claudia as congenial lab technician and co-worker at his side. Maximow is renowned for his experimental work on the unitarian theory of hematopoiesis, namely, that all blood cells develop from a common precursor cell. For four years before Maximow's death, fellow histologist William Bloom worked closely with him on the *Textbook of Histology*. Bloom ultimately completed the work, which was first published in 1930. Bloom was a graduate of the Johns Hopkins School of Medicine and later chairman of the Department of Anatomy at Chicago.



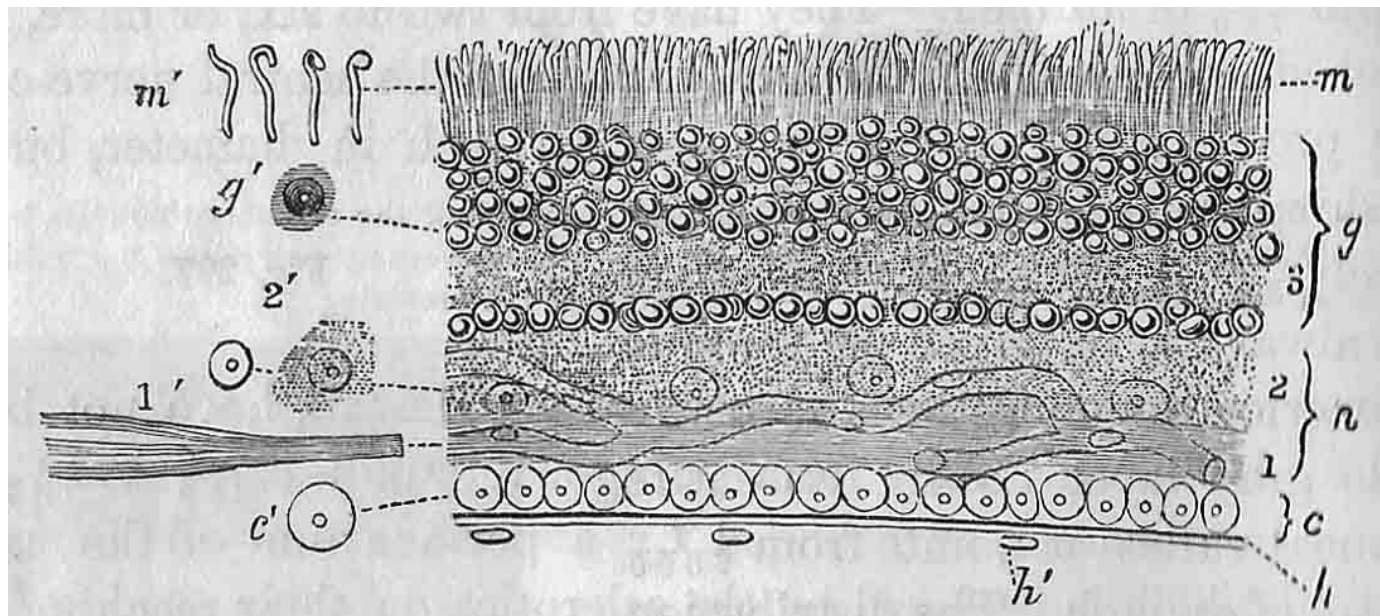


**Cells, organoids and inclusions, Maximow and Bloom, 1930**

Peaslee, E. R. 1857. *Human Histology In its Relations to Descriptive Anatomy, Physiology, and Pathology*. First edition, 23.5 cm, 434 woodcuts, ads, original full leather, fine. Blanchard and Lea, Philadelphia, 616 [1] pp. First American textbook of histology by graduate of Yale Medical School.

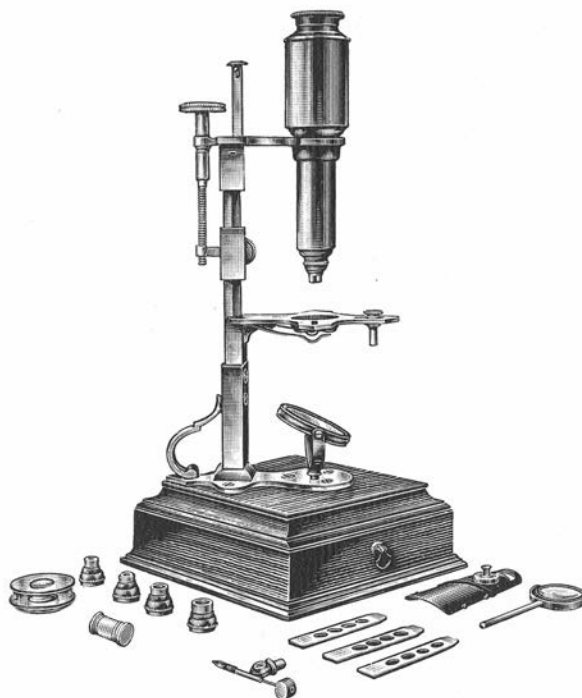
Edmund Randolph Peaslee (1814-1878) graduated from Dartmouth College in 1836 and received the degree of MD from the Yale Medical School in 1840. He became Professor of Physiology and Pathology at the New York Medical College, Professor of Anatomy at Dartmouth College, and Professor of Surgery at the Medical School of Maine. He is important in the history of American medicine as a pioneer in abdominal and pelvic surgery. He was among the first in

America to apply the microscope to teaching physiology, pathology, and histology. In 1857, he published *Human Histology*, the first American textbook of histology. The book is organized according to Peaslee's lectures and is based on European textbooks.



Retina, Textbook of Histology, Peaslee, 1857

Replica Rara. 1974. *History of the Microscope 1665 to 1830*. Replica Rara, Limited. Twenty four woodcuts of the microscopes illustrated in *The Atlas Catalogue of Replica Rara Ltd. Antique Microscopes*. Set 32/1000. The prints are lithographed on high quality paper from original woodblock engravings by N. Paul Quirk, master engraver. Each 8 ½ x 11 inch print has a translucent protective cover-sheet on which is printed a brief historical note. The woodcuts are stored in a gold-embossed bookshelf library portfolio.

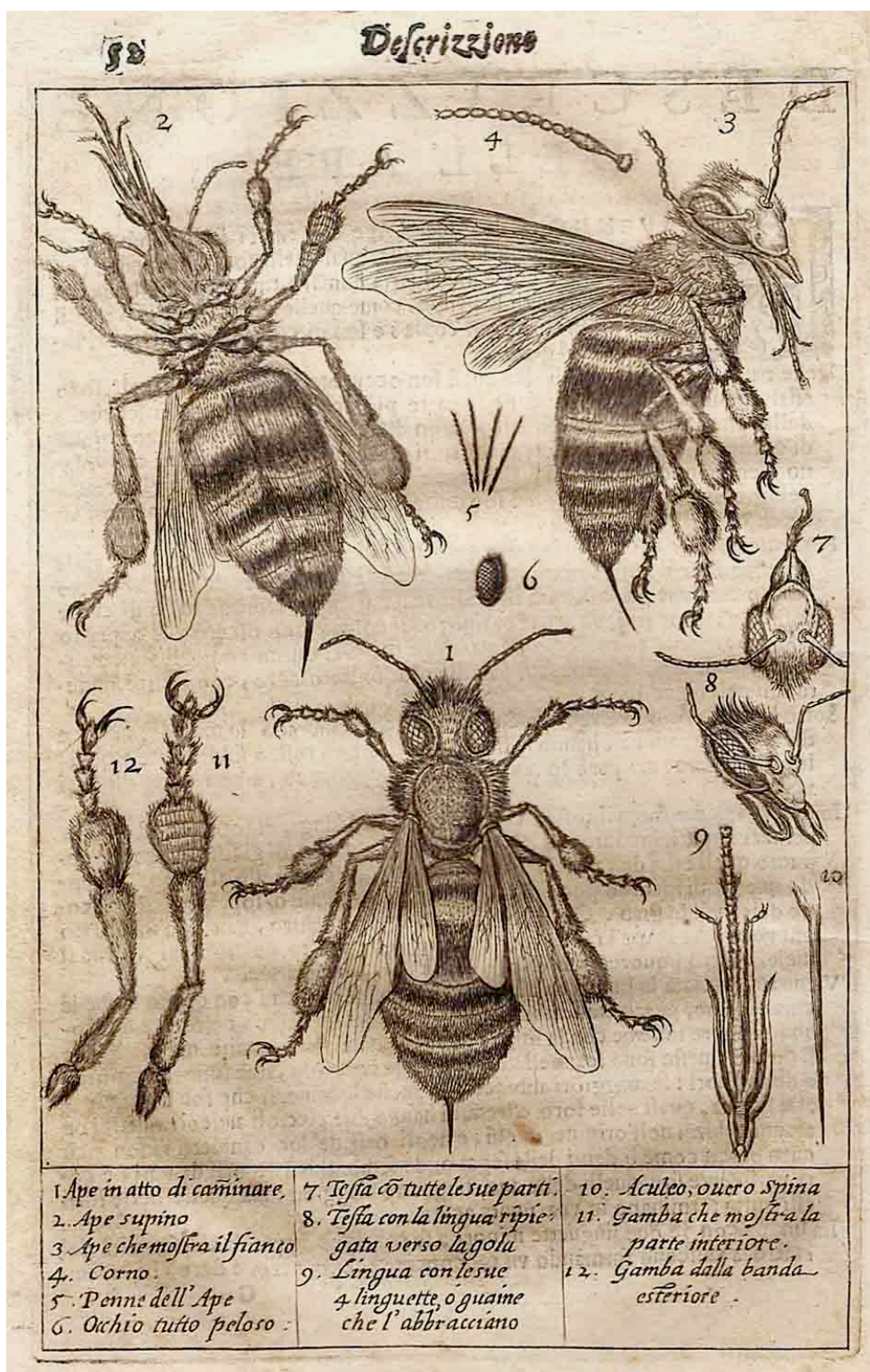


Woodcut of 1745 Cuff microscope from *History of the Microscope 1665 to 1830*, Replica Rara



Stelluti, Francesco. *Persio Tradotto in verso sciolto e dichiarato* Da Francesco Stelluti Accad. Linceo Da Fabriano All'Ill.<sup>mo</sup> et R.<sup>mo</sup> Sig.<sup>re</sup> Il Sig. Cardinale Barberino. Appresso Giacomo Mascardi. In Roma. 1630. 4to (21.5 x 15 cm), 12 p.l., 218, [20] p. Engraved title page, text engravings, including full-page image of the parts of a bee observed with the aid of a microscope. Bound in contemporary limp vellum, title stenciled in gothic lettering on spine. Some browning, minor dampstains, page missing a corner, and lacking a preliminary leaf and pages 35 and 36, but otherwise very good.

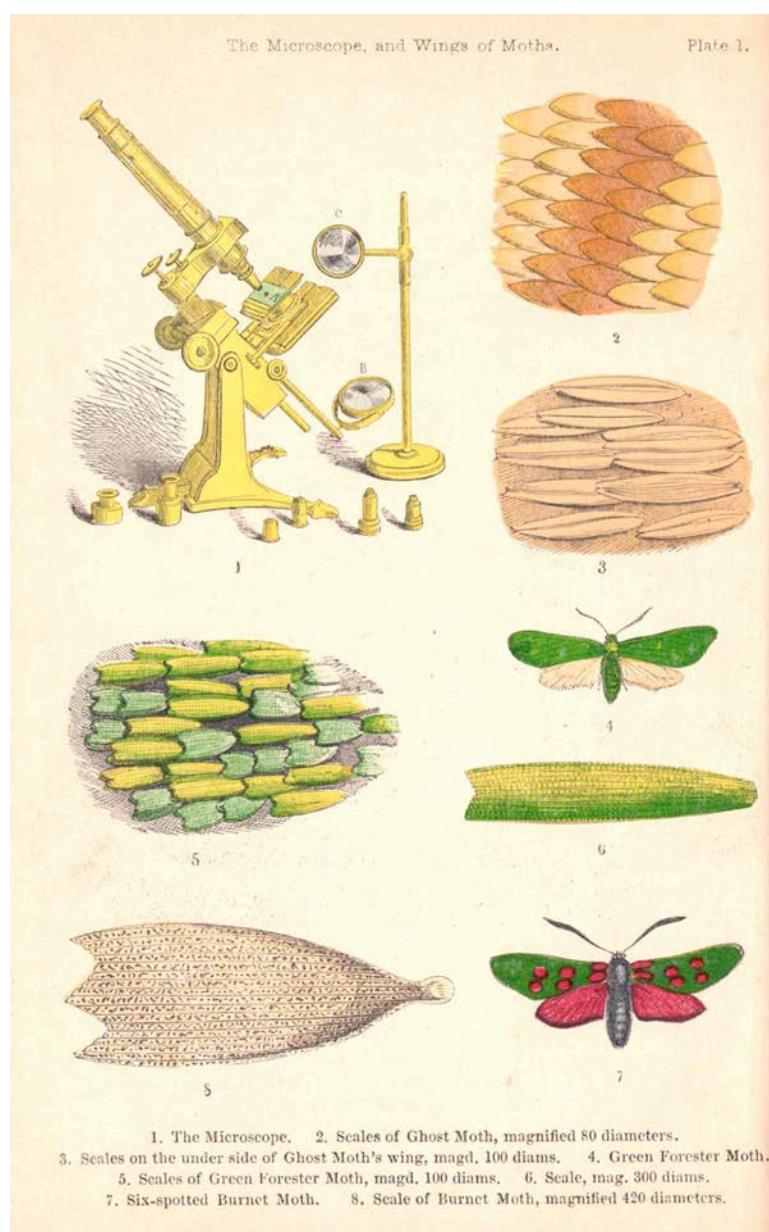
First edition of this illustrated Italian translation of the Roman poet Persius (34-62 AD) by Francesco Stelluti (1577-1652) containing the first illustrations prepared with the aid of a microscope that were set forth in a printed book. The book's striking full-page images of a magnified bee (p. 52), show minute details of the antennae, eyes, legs, sting, head, and tongue that can only be seen with a microscope. The engraving is accompanied by the pertinent *Decrizzione Dell'Ape* - Description of the Bee. On page 127 is a smaller illustration of a magnified grain weevil, including a detail of the tip of the insect's snout and mandibles. These remarkable scientific images are found, oddly enough, in Francesco Stelluti's translation of the works of the Latin poet Persius, dedicated to the powerful Cardinal Francesco Barberini in an attempt to gain the Cardinal's patronage for the Accademia dei Lincei. The "Academy of Lynxes," one of Europe's first scientific societies, had been founded by Stelluti, Federico Cesi, Johannes Van Heeck, and Anastasio de Filiis in 1603. Stelluti's edition of Persius was intended for the most part as a means for advertising the Accademia's activities. Whenever he could, Stelluti took a word or phrase in Persius and used it as an excuse to refer to one or another aspect of the natural historical researches of the Linceans. These include notes on Galileo's observations of Jupiter and Venus, as well as his recent work-in-progress, the 1632 *Dialogue*. An obscure reference in Persius's first satire to what may have been the ancient town of Eretum gave Stelluti his pretext for including the bee images, since the former Eretum was now Monterotondo, seat of the Barberini country estate, and the Barberini family had adopted the bee as its emblem. Stelluti's weevil image was likewise prompted by a mention of that insect in another of Persius's poems. Stelluti's bee image is similar, but not identical to, an earlier image showing magnified views of a bee, published as a broadsheet in 1625 under the title *Apiarium*; this broadsheet is extremely rare, with only two or three copies recorded. The *Apiarium* was intended to form part of a projected encyclopedia by Cesi, but this project was never realized. In 1624, Cesi had been sent a microscope by Galileo, another Lincean, and it was most likely this instrument that Cesi and Stelluti used to prepare their pioneering images of insects under magnification. See Brian J. Ford, *Images of Science: A History of Scientific Illustration*, 1993 and David Freedberg, *The Eye of the Lynx: Galileo, His Friends, and the Beginnings of Modern Natural History*, 2002.



Ward, The Hon. Mrs. 1869. *The Microscope, or Descriptions of Various Objects of Especial Interest and Beauty, Adapted for Microscopic Observation. With Directions for the Arrangement of a Microscope, and the Collection and Mounting of Objects.* Illustrated by the Author's Original Drawings. Groombridge and Sons, London. Third edition, 18.5 cm, pictorial green cloth stamped in gilt, aeg, vi, 154 [4] pp, index, 25 text woodcuts, 8 color plates each with a tissue guard. Near fine.



Mary Ward (1827-1869) was an Anglo Irish amateur astronomer, microscopist, artist, and entrepreneur. She was born at Ballylin, Co. Offaly, the youngest child of the Rev. Henry King and his wife Harriette. From an early age she showed a great interest in astronomy and natural history which was encouraged by her cousin William Parsons, 3rd Earl of Rosse, who in 1845 built a 72-inch reflecting telescope, the "Leviathan," which was the world's largest telescope until 1917. In 1854, she married Henry William Crosbie Ward of Castle Ward, Co. and had three sons and five daughters. When Ward wrote her first book, *Sketches with the Microscope* in 1857, she apparently believed that no one would print it because of her gender or lack of academic credentials. She published 250 copies of it privately, and several hundred handbills were distributed to advertise it. The printing sold during the next few weeks, and this was enough to convince a London publisher take the risk and contract for future publication. Mary did not use her full name but was referred to as The Hon. Mrs. Ward. The book was reprinted eight times between 1858 and 1880. Mary was tragically killed in 1869 when she fell under the wheels of an experimental steam car built by her cousins.



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