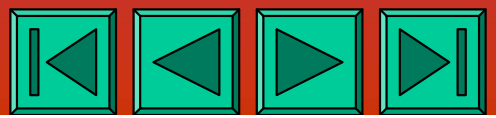
INTRODUCTION

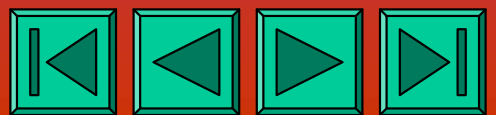
The program, prepared in Powerpoint 97, was converted to HTML format in Windows XP, and should be readable by most PC browsers. Any warning messages that might appear can be clicked through and disregarded. It is intended to be run as a slide show (icon on the lower right), although once in the slide show mode, a viewer can drop back to use the directory by pressing ESC or the return button on the lower left of the screen; the directory can be expanded to show full text with the button below the bottom of the outline column. I have not (yet?) added any notes, so the note window can be closed with repeated presses of the “notes” button.

The program is intended as an instructional tool, and therefore is tailored to run through in a limited time; consequently it is not intended to be comprehensive, but contains what I consider the most important milestones. It is divided into two major sections: The Simple Microscope, whose importance continues to be inadequately appreciated, and The Compound Microscope. The latter is divided into three sections, dealing with English, European, and American Microscopes. English and early European microscopes are better researched and documented, with considerable literature available (especially for the English), therefore I have concentrated on the American makers, where my own interests lie, and I have the most to contribute. The latter section can be ended after the treatment of Bausch & Lomb, or can be run to completion -- the full program contains nearly all makers with known surviving instruments, and can therefore be considered comprehensive; for some of the better known makers I have chosen to use examples of less familiar models.

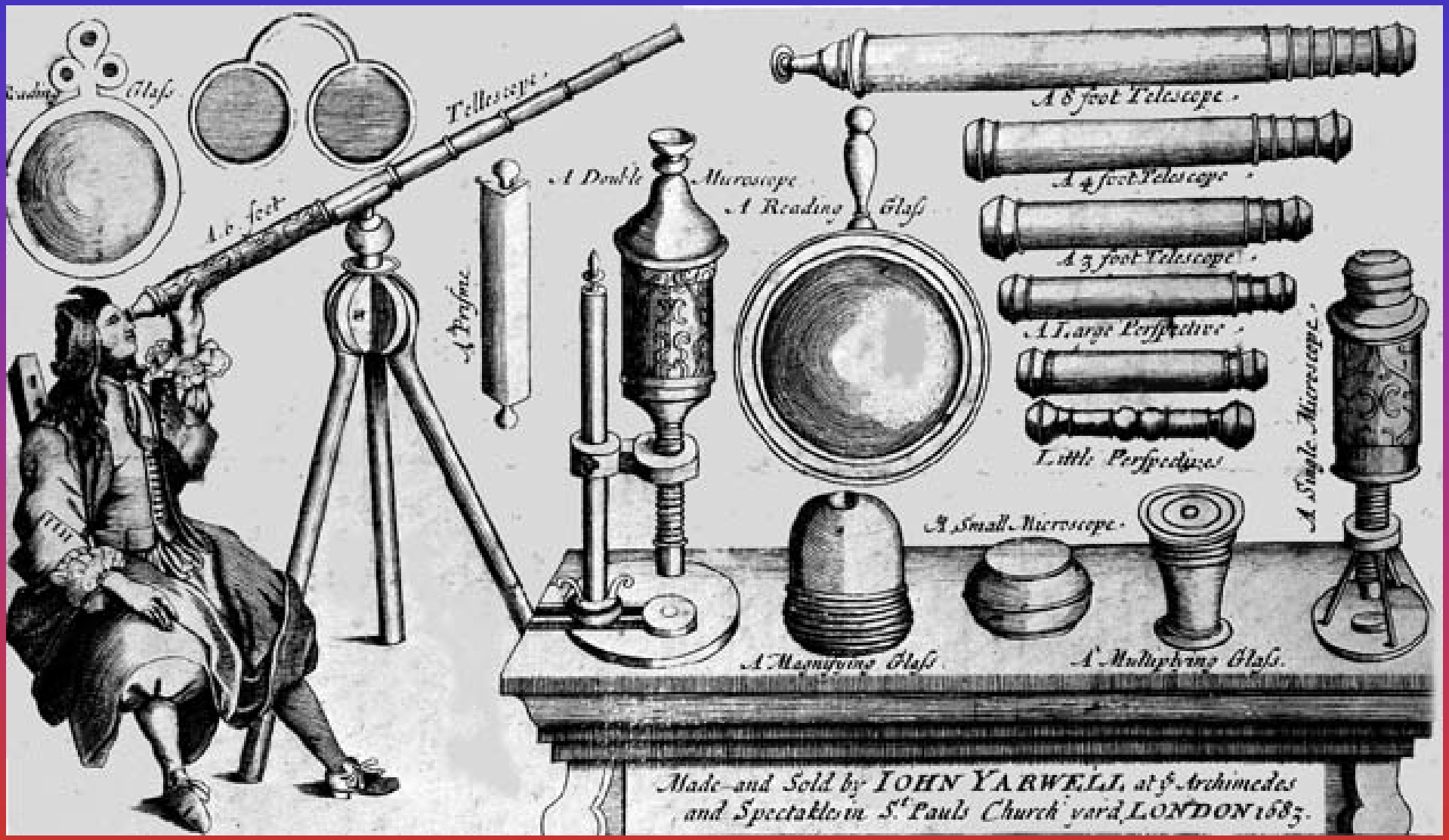
I would appreciate any comments, suggestions or corrections. Because of time and space constraints, I may not be able to utilize all of them, but the effort will be appreciated nonetheless (and perhaps incorporated in future versions). I could use original or copyright-free color photos (or references to the same) of instruments illustrated by drawings or “representative instruments” in the program. I especially need a color photo of an early tripod, an early Marshall, a box microscope, and an early wood/ivory/leather/shagreen Culpeper for replacements. Email:swarter@csulb.edu

BEGIN

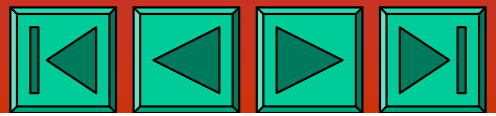
TRADE CARD OF JOHN YARWELL
LONDON, w. 1671-1708



ORIGIN AND DEVELOPMENT OF THE LIGHT MICROSCOPE

1600-1900

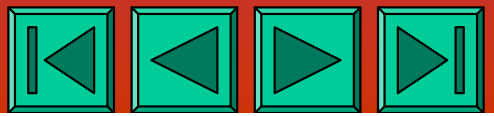
Stuart L Warter, Professor Emeritus
Department of Biological Sciences
California State University, Long Beach

THE LIGHT MICROSCOPE

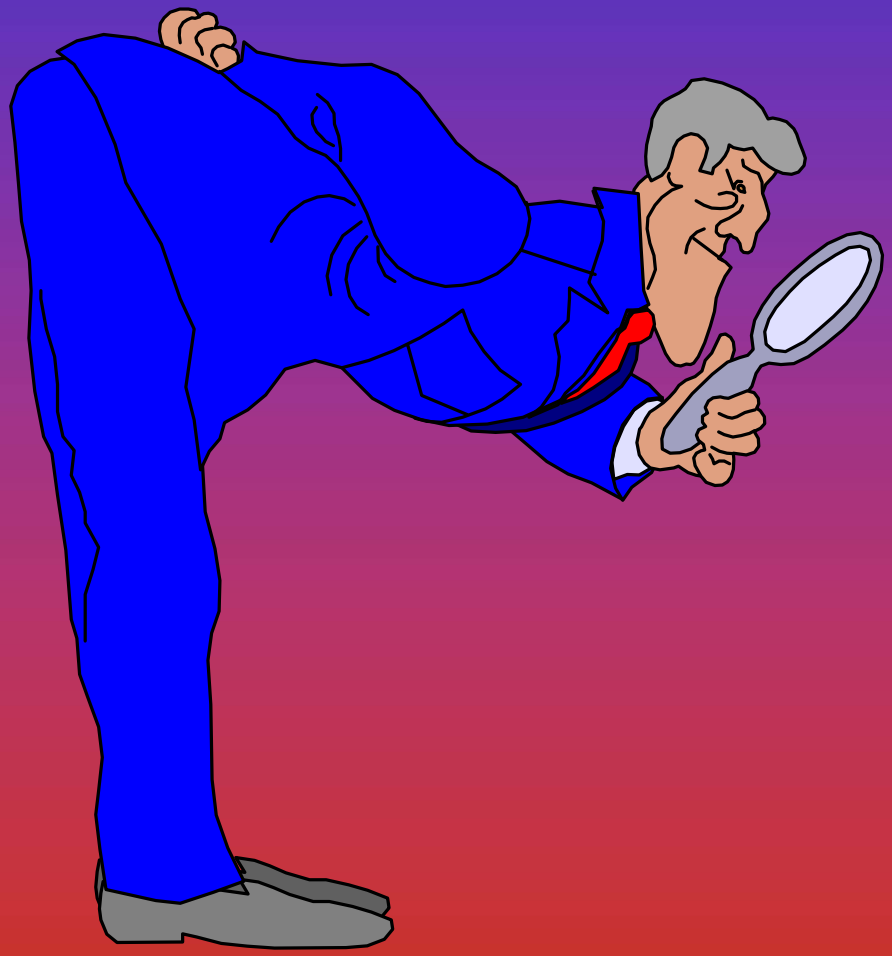
Plan of the Presentation

- Introduction
- The Simple Microscope
- The Compound Microscope
  - The English Microscope
  - The European Microscope
  - The American Microscope

SEEING IS BELIEVING

The light microscope opened the mind to the world of the hitherto unseen. Its acceptance was a seminal event in history that enabled people to conceive the inconceivable and encouraged them to think the unthinkable.



THE SIMPLE MICROSCOPE

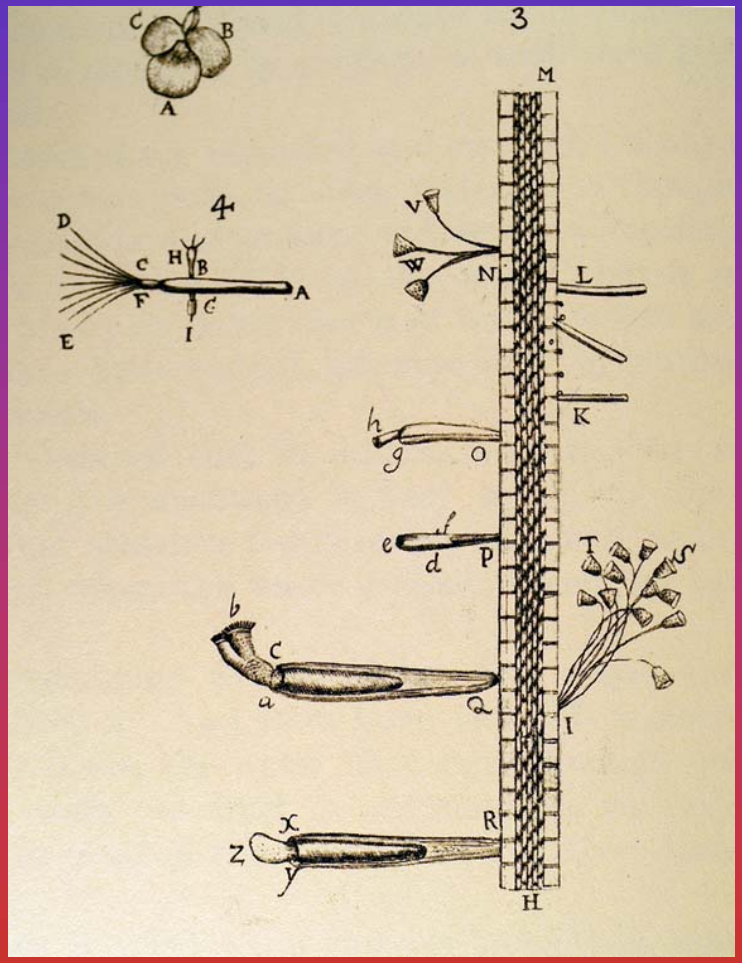
The first microscopes were essentially simple magnifiers, although some achieved quite high powers. Much important work was done with simple microscopes well into the 19th Century.

17th CENTURY

Flea glasses were small simple microscopes used to study insects (and other small objects) impaled on a pin. They were made of ivory, bone, wood or tortoise shell. Very few survive.

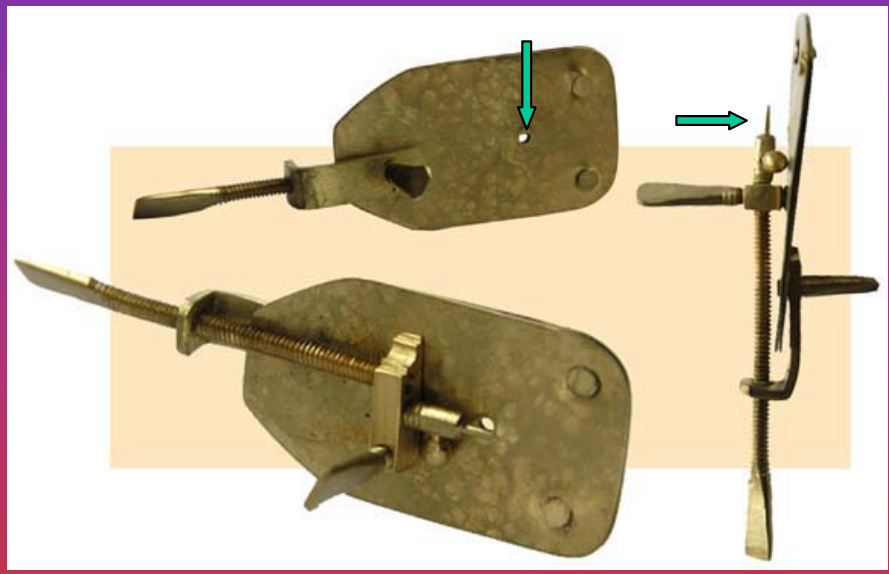
17th CENTURY

Antoni van Leeuwenhoek's observations through his high power simple microscopes were communicated to the Royal Society in London but his published figures of "animalcules" were met with skepticism.



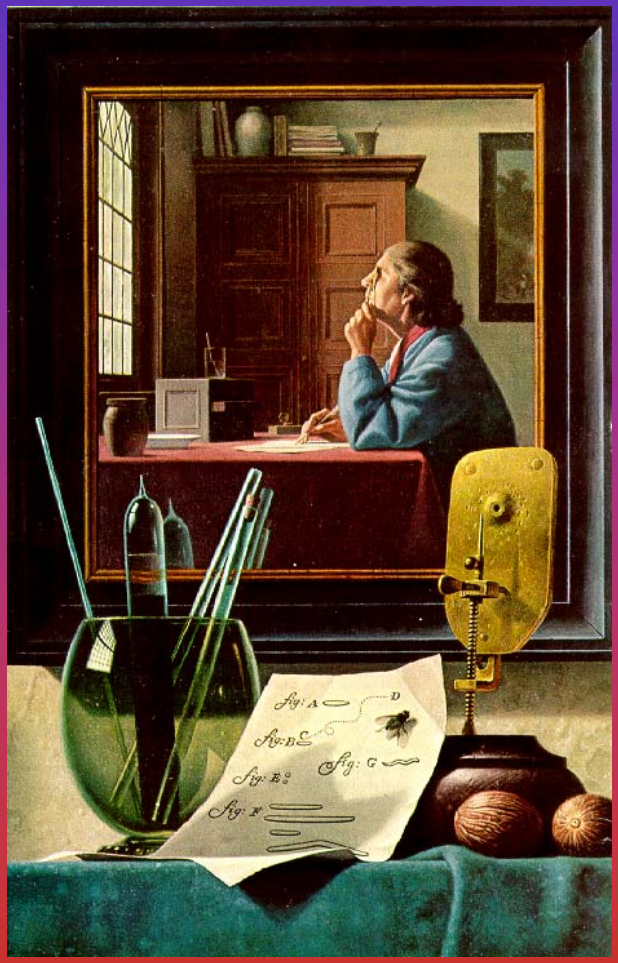
17th CENTURY

Leeuwenhoek's microscope had a glass bead lens sandwiched between two plates of brass. A specimen could be affixed to a spike and held close to the eye for critical examination.



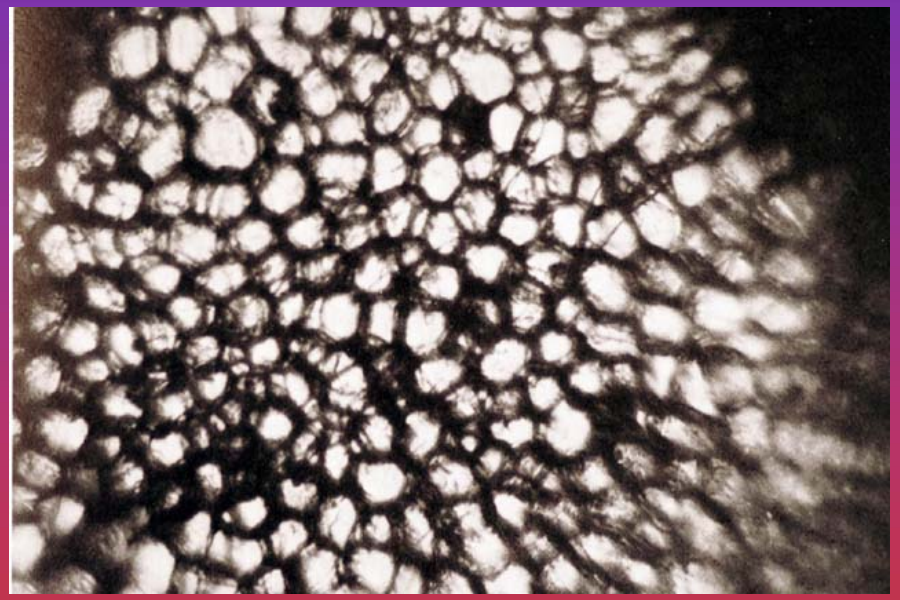
17th CENTURY

This painting purports to depict Leeuwenhoek's observation of bacteria, but for that purpose a different configuration of the microscope would have had to have been used, rather than the one portrayed.



17th CENTURY

A photograph recently taken by Brian Ford of an original Leeuwenhoek cork preparation through an original Leeuwenhoek microscope demonstrates that he was able to see detail down to the cellular level.



18th CENTURY

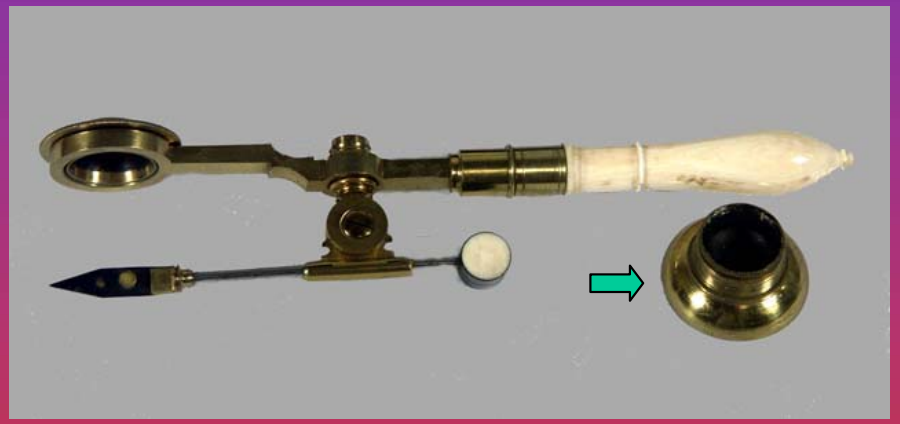
Introduced to England from Holland in 1702, the screw barrel microscope had interchangeable lenses of different powers for viewing slides. It could be hand held or attached to a stand, and fitted with attachments for viewing free objects.

18th CENTURY

The Ellis Aquatic Microscope was developed in 1752 from an earlier design by John Cuff for observation of small organisms in water. Free movement of its lens made it easy to scan a sample. The pattern was used in many later instruments.

18th CENTURY

The compass microscope was a pocket magnifier equipped for holding insects and plant specimens for close examination. It could be fitted with a reflective mirror introduced to England from Germany by Lieberkuehn in 1740.

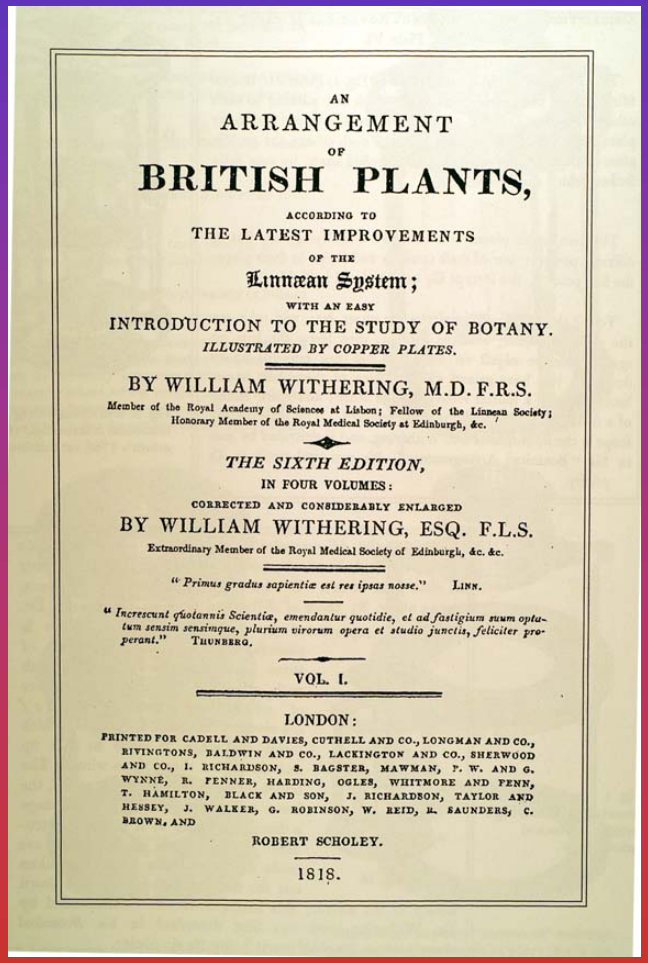


18th/19th CENTURY

Smaller folding botanical pocket magnifiers developed from the compass pattern were commonly used throughout the 1800's.

18th/19th CENTURY

William Withering's floras of the British Isles (in 17 editions 1776-1858), along with the microscopes he designed for the examination of plants and their parts in the field, stimulated the study of botany in the 19th Century.



AN
ARRANGEMENT
OF
BRITISH PLANTS,
ACCORDING TO
THE LATEST IMPROVEMENTS
OF THE
Linnæan System;
WITH AN EASY
INTRODUCTION TO THE STUDY OF BOTANY.
ILLUSTRATED BY COPPER PLATES.

BY WILLIAM WITHERING, M.D. F.R.S.
Member of the Royal Academy of Sciences at Lisbon; Fellow of the Linnean Society; Honorary Member of the Royal Medical Society at Edinburgh, &c.

THE SIXTH EDITION,
IN FOUR VOLUMES:
CORRECTED AND CONSIDERABLY ENLARGED
BY WILLIAM WITHERING, ESQ. F.L.S.
Extraordinary Member of the Royal Medical Society of Edinburgh, &c. &c.

"Primus gradus sapientiæ est res ipsas nosse." LINN.

"Increscunt quotannis Scientiæ, emendantur quotidie, et ad fastigium suum optatum sensim sensimque, plurium virorum opera et studio junctis, feliciter properant." THUNBERG.

VOL. I.

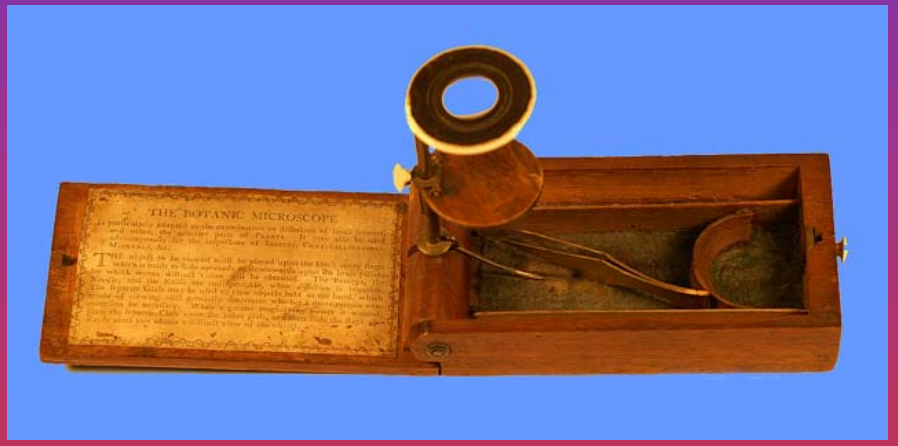
LONDON:
PRINTED FOR CADELL AND DAVIES, CUTHELL AND CO., LONGMAN AND CO., RIVINGTONS, BALDWIN AND CO., LACKINGTON AND CO., SHERWOOD AND CO., J. RICHARDSON, S. BAGSTER, MAWMAN, P. W. AND G. WYNNE, R. FENNER, HARDING, OGLES, WHITMORE AND FENN, T. HAMILTON, BLACK AND SON, J. RICHARDSON, TAYLOR AND HESSEY, J. WALKER, G. ROBINSON, W. REID, R. SAUNDERS, C. BROWN, AND
ROBERT SCHOLEY.
1818.

18th/19th CENTURY

Withering, who was a physician, botanist and herbalist, now known primarily for his discovery of digitalis from the foxglove, introduced his first pocketable botanical microscope in the first edition (1776).

18th/19th CENTURY

Withering's folding botanical microscope, introduced in 1796, was also featured in his books on British flora. It was both convenient and inexpensive, thus encouraging the field study of plants, and of natural history in general.



19th CENTURY

Numerous variations of Withering's first form were widely used in the 19th Century. This popular example carried a few small instruments for dissection of floral parts.

19th CENTURY

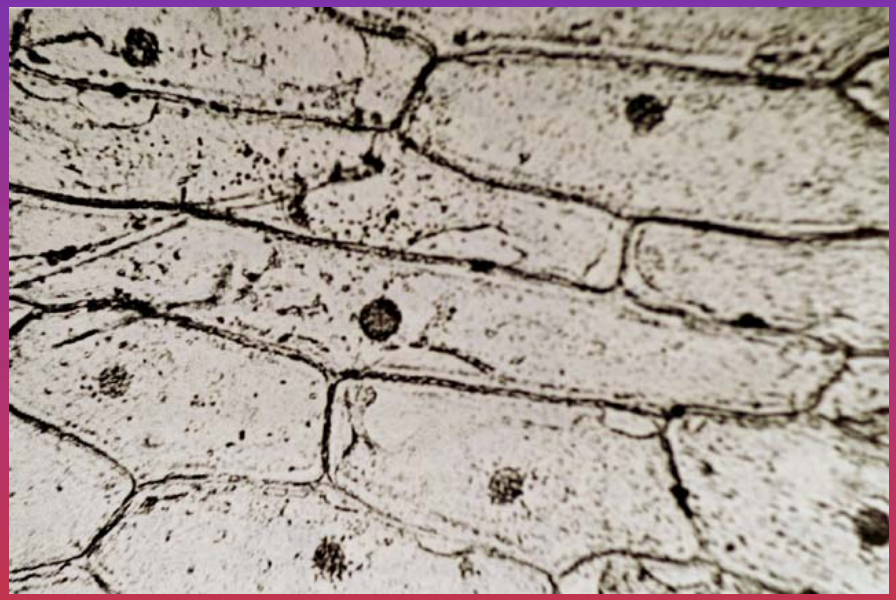
A simple microscope similar to this one was built by Robert Banks for Charles Darwin to take on the seminal 1831 voyage of HMS Beagle to South America and the Galapagos Islands.

19th CENTURY

Others by Banks were used by the botanist Hooker (Darwin's mentor), and by Robert Brown in his observations of the cell nucleus, cytoplasmic streaming (cyclosis), and the phenomenon now known as Brownian motion.

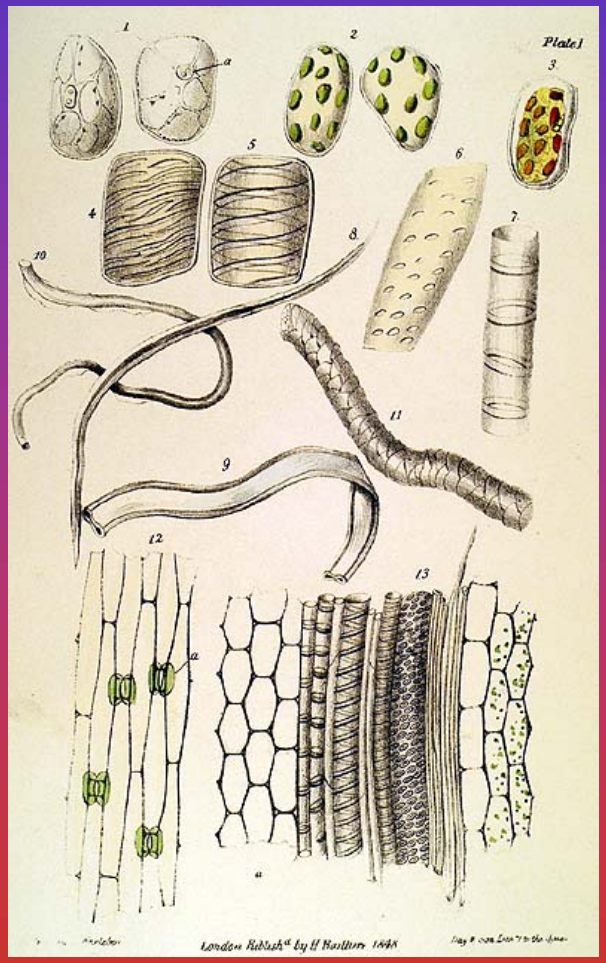
19th CENTURY

A photograph recently taken by Brian Ford through Brown's surviving microscope proves that it was able to resolve plant cell nuclei and other subcellular details.



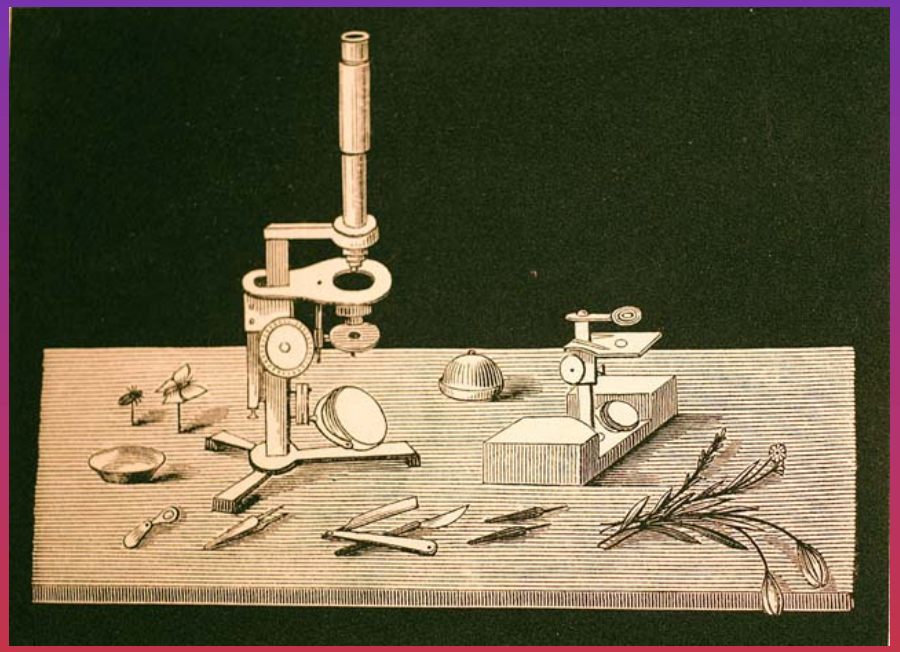
19th CENTURY

Brown's observations led to the Cell Theory developed by Schleiden and Schwann. An 1848 plate by Schleiden shows that he also was able to make such detailed observations of the cellular structure of plants.



19th CENTURY

This 1848 drawing from Schleiden shows the typical “stock in trade” of a microscopist of the time: a compound microscope by Amici and a simple microscope for preparation of material, plus a few accessories.



19th CENTURY

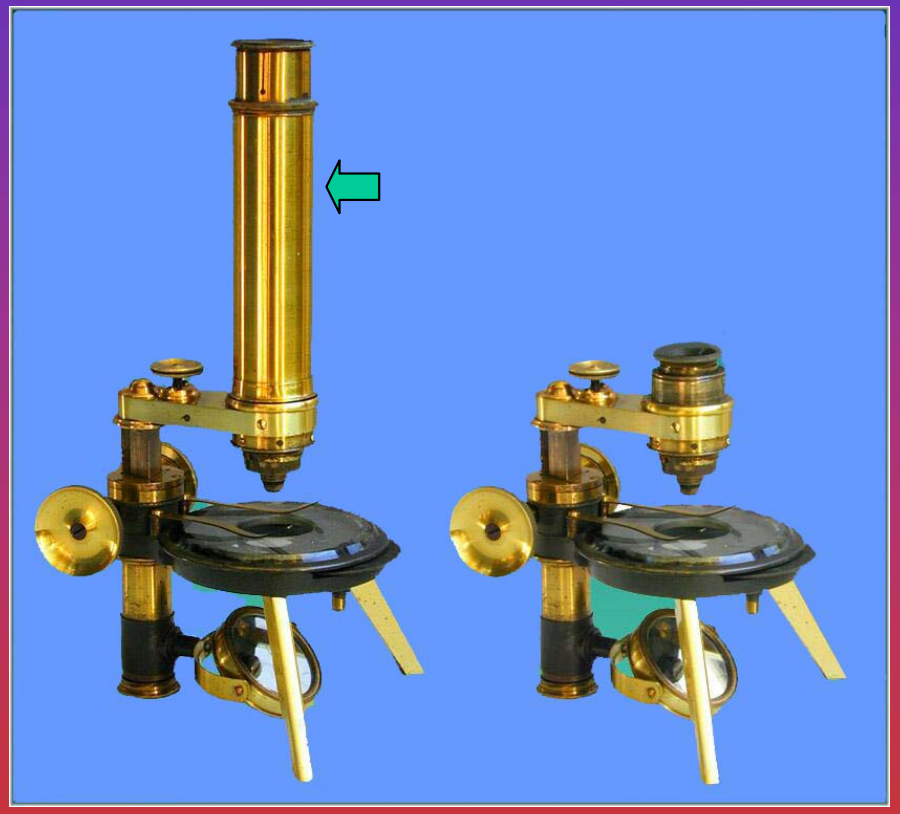
A similar microscope was designed by Francois Vincent Raspail, the French scientist, physician, politician, and revolutionary, who did pioneering histological work. This microscope was popular in Europe and imported into the U.S.

19th CENTURY

Thirty-five years after obtaining the Banks microscope for the Beagle voyage, Darwin designed his own improved simple microscope, which was made for him by Smith & Beck, who marketed the model themselves beginning in 1848

19th CENTURY

Some low power dissecting microscopes, like this one, designed by Thomas Huxley and made by James Parkes, could be converted into compound microscopes by the addition of a body tube.



19th CENTURY

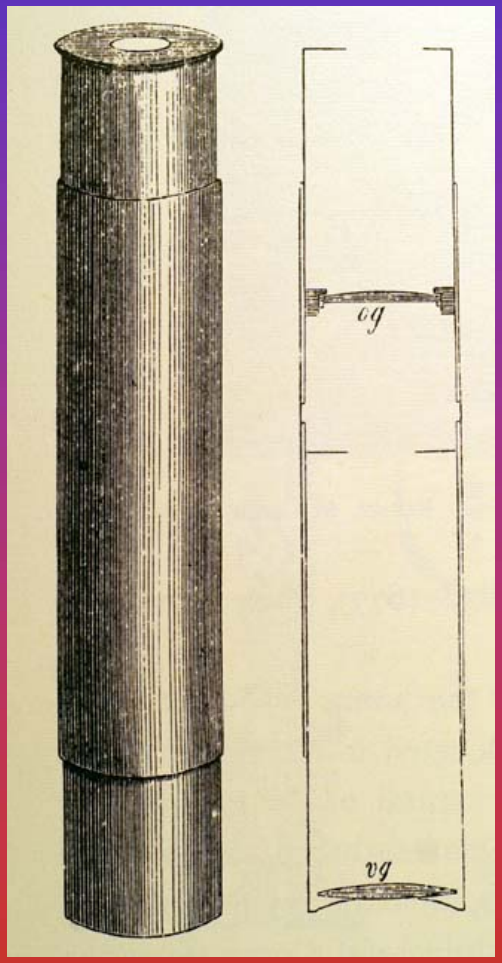
Improved simple microscopes were later developed for dissection and manipulation of larger objects. Prismatic binocular (stereoscopic) dissecting microscopes were not developed until the end of the 19th Century

THE COMPOUND MICROSCOPE

Compound microscopes have been known since the mid 1600's, but were severely limited by chromatic and spherical aberrations as well as by small apertures, and thus remained of limited usefulness for nearly 200 years.

16th CENTURY

The first known (c.1595) compound microscope is attributed to Zacharias Janssen, a Dutch spectacle maker also credited with the invention of the telescope. A microscope is simply a telescope in reverse.

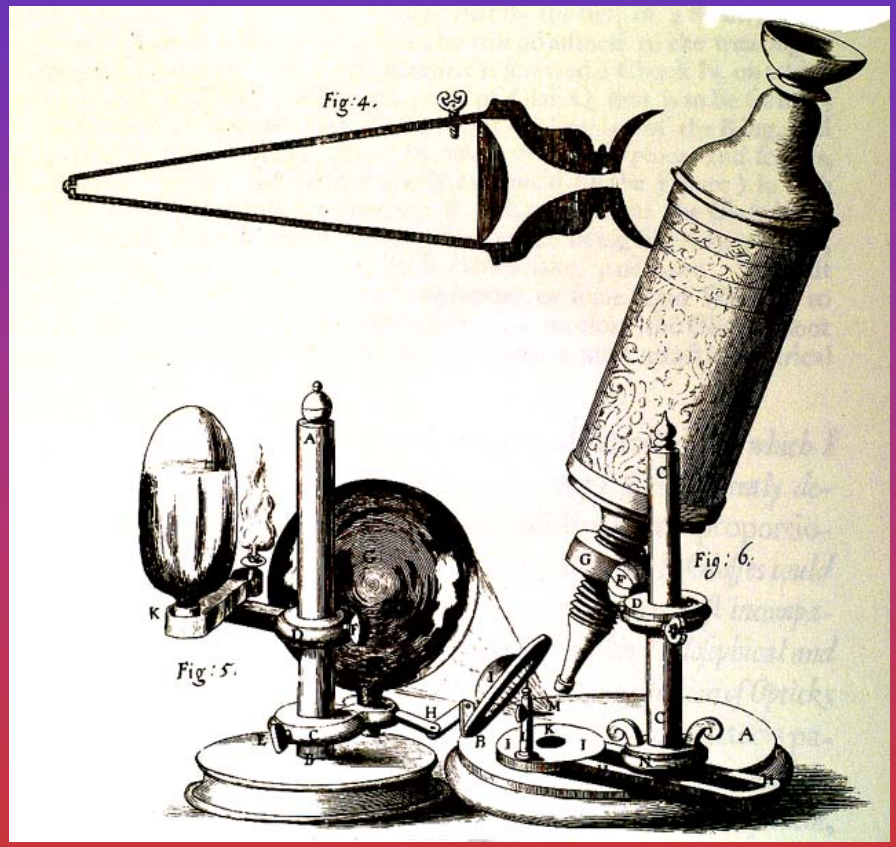


THE ENGLISH MICROSCOPE

English microscopes are the best known, having been produced in great profusion, and are well documented in the literature. Fairly large numbers of 19th Century examples have survived and are still readily obtainable.

17th Century

Robert Hooke's microscope, published in 1665, is considered to be the progenitor of the modern compound microscope. Parts were made of wood and brass, with tubes of leather covered pasteboard.



17th/18th CENTURY

John Marshall improved upon Hooke's design by providing a means of mechanical focus. More than a dozen examples of his microscopes survive. This illustration was published in 1704.

18th CENTURY

Edmund Culpeper's design was introduced in the mid-1720's. It utilized a stage and a substage mirror for transmitted illumination. Construction was in the 17th Century manner.

18th CENTURY

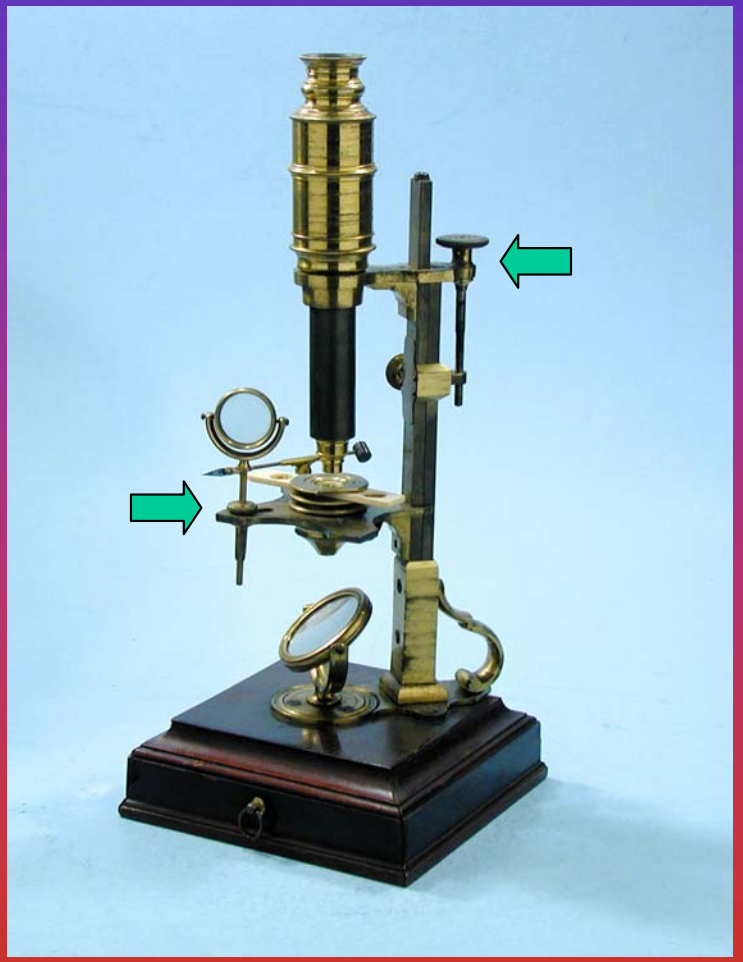
Transitional instruments, such as this one by Matthew Loft, provided improved optics.

18th CENTURY

Later in the century, and into the 19th, all brass construction was used. The Culpeper design was in use for over a century following its initial introduction.

18th CENTURY

John Cuff's 1744 design was the next major advance in compound microscopes, providing precise fine focus and easier access to the stage. It was widely copied in England and on the Continent, and lasted into the next century. A portable chest variant was also made.



18th CENTURY

Benjamin Martin's "Pocket Compound Microscope", made first in 1738 in wood and vellum, and later in brass, was the forerunner of the cylindrical "drum microscopes" that were popular for nearly 200 years.

18th CENTURY

Benjamin Martin's 1759 Universal Microscope introduced the use of an extra lens (the "between lens") between the objective and the two lenses above (ocular + field lens) to reduce spherical aberration.

18th CENTURY

A smaller companion to Adams' large "Variable" microscope of 1771 was his "New compendious Pocket Microscope." It set the pattern for the Cary and other small microscopes of the first half of the next century.

18th CENTURY

George Adams published his Improved Compound Microscope, mounted on an inclinable bar, in 1787. This is the second form, his Universal Compound Microscope, c. 1790, the pattern for its much imitated successor, the Most Improved (1798).

18/19th CENTURIES

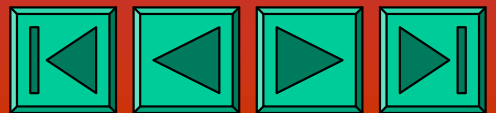
To achieve portability of larger compound microscopes, the “chest microscope” was developed, in which the instrument was collapsed into its chest for carrying, and then erected for use.

19th CENTURY

The Cary-Gould Pocket Compound Microscope, which functioned also as a simple microscope, was designed by Charles Gould in the 1820's. Produced by Wm. Cary and his sons, among others, it was popular for a half-century or more.

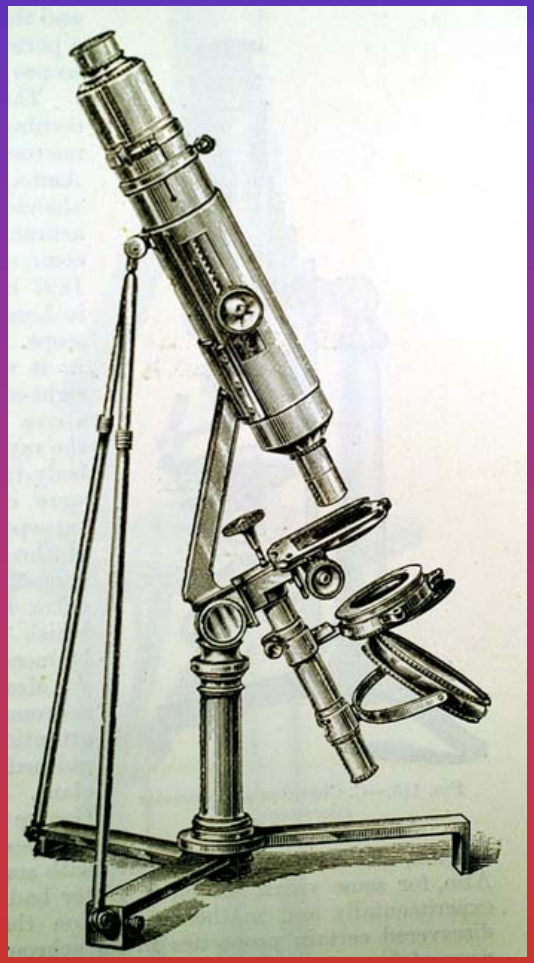
THE ACHROMATIC LENS

Chromatic aberration limited the resolution of early lenses. Solutions were attempted by a number of workers, including Harmanus van Deijl (1807) and Joseph Fraunhofer (1811) but the first practical achromatic objectives are generally accepted to have been designed by Giovanni Battista Amici of Modena working with Vincent and Charles Chevalier of Paris early in the 19th Century. Achromatic lenses combine elements of different refractive characteristics that cancel out the aberrations, thus sharpening the image. The development of these lenses was a major advance.

19th CENTURY

Early compound microscopes had been convertible to simple microscopes which provided better images. J. J. Lister's 1826 microscope design demonstrated the superiority of his large aperture achromatic lenses by eliminating the provision for use of simple lenses.



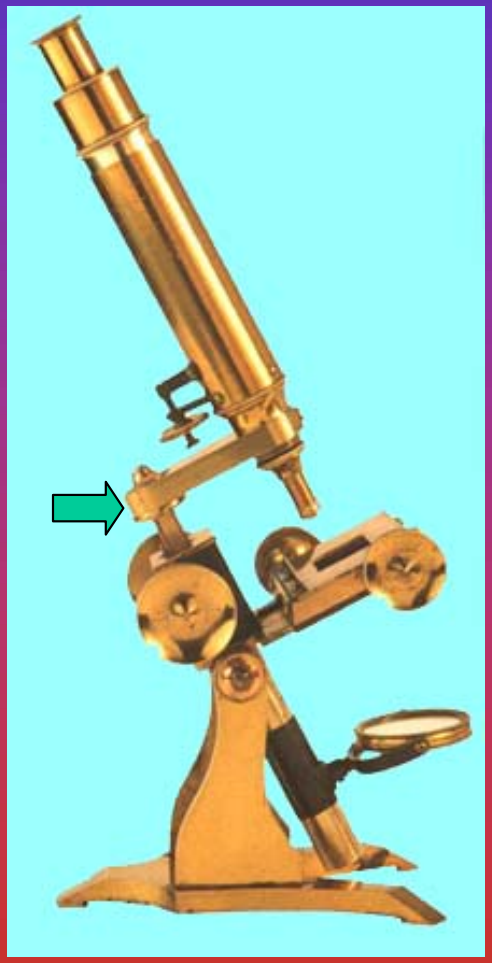
19th Century

The 1830's and 1840's were a period of experimentation and innovation in which many new features were developed. The focusing features found on this odd microscope by A. Abraham for Horne & Co. did not survive.

19th CENTURY

Two dominant designs emerged and lasted until both were replaced by the continental form:

The bar-limb, cheaper and easier to make . . .

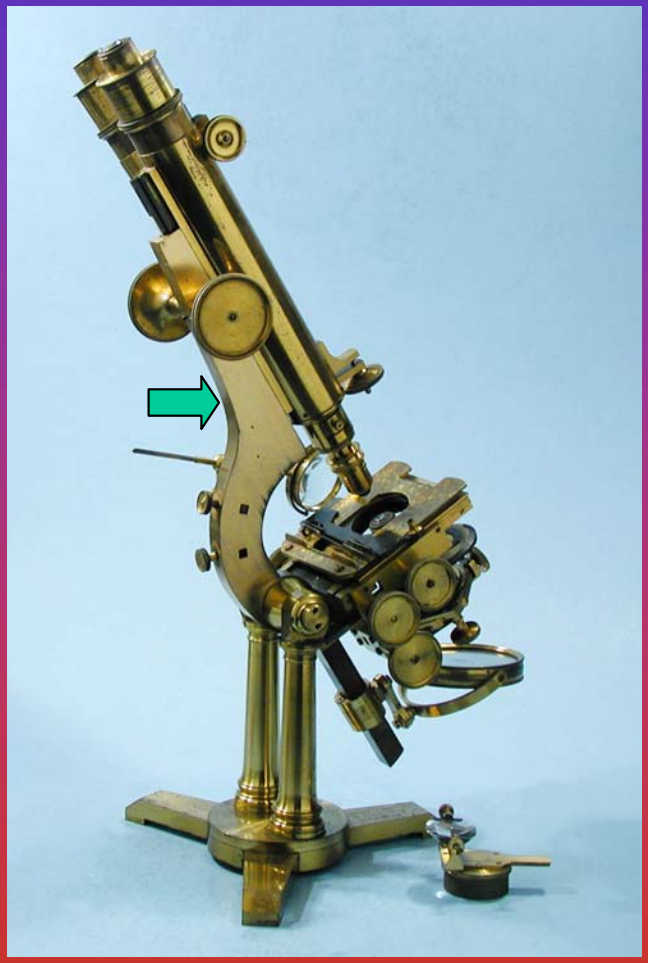


19th CENTURY

Two dominant designs emerged and lasted until both were replaced by the continental form:

The bar-limb, cheaper and easier to make and

The Lister limb, an optical bench design dominant in America.



THE BINOCULAR COMPOUND MICROSCOPE

In the 1850's Francis Wenham developed an original binocular system that allowed for an orthoscopic-stereoscopic image to be viewed through a single objective by the use of a special prism that provided each eye with a slightly different, divergent image.

THE BINOCULAR COMPOUND MICROSCOPE

This design had several limitations, including the fact that it was useful only at lower magnifications. With high powers, and with polarizers, the prism was withdrawn from the light path, with one tube then functioning as a monocular.

THE BINOCULAR COMPOUND MICROSCOPE

The popularity of the Wenham design impeded the development of higher powered binocular instruments for over half a century. It also was made in America, but not in Europe, and was used until the eventual adoption of the continental pattern.

19th CENTURY

English microscopes became increasingly complicated, with an accessory for every conceivable function, until the beginning of the 20th Century, when the continental pattern was adopted.

19th CENTURY

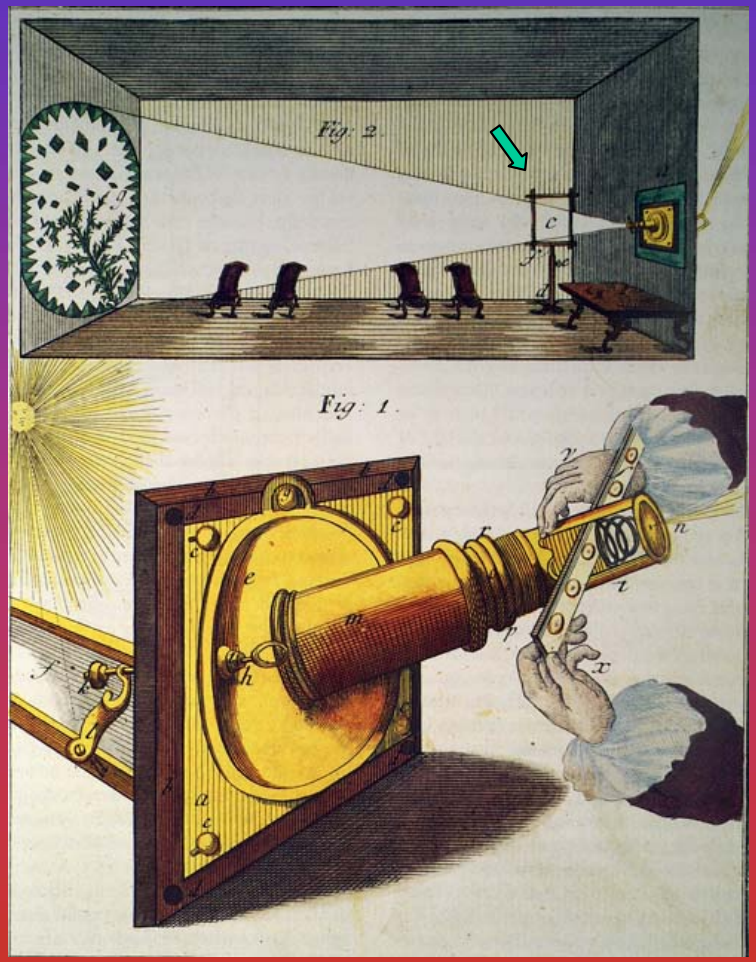
Because of the great complexity and expense of English microscopes, the Society of Arts in 1854 had offered a prize for a practical and affordable student microscope. It was won by Robert Field, and the pattern was widely produced.

SPECIALTY MICROSCOPES

Solar microscopes were developed in the 1740's to project slide images into a darkened room by illumination from the sun. They were used until adequate artificially illuminated projectors could be developed.

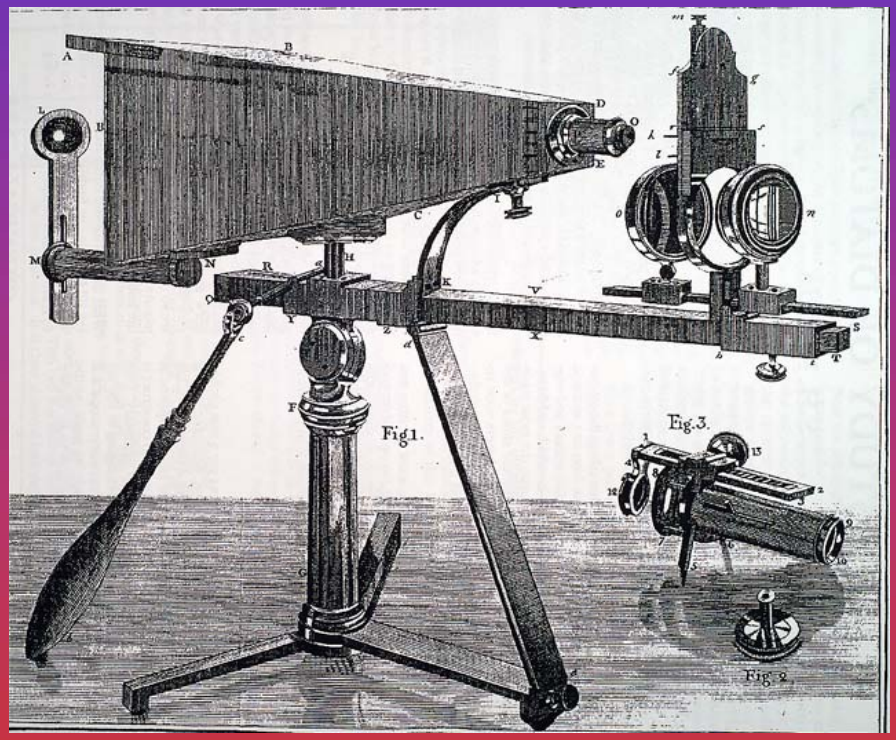
SPECIALTY MICROSCOPES

In this 1762 plate, M. F. Ledermueller illustrates the use of the solar microscope to project an image on a wall in a darkened room for group viewing. A smaller translucent screen could also be used for brighter viewing by fewer people.



SPECIALTY MICROSCOPES

George Adams' Lucernal Microscope of 1787 could be used for the nocturnal viewing of slides or opaque objects that were illuminated by light from an oil lamp. It was replaced later in the 19th Century by the Magic Lantern.



SPECIALTY MICROSCOPES

In 1826 Philip Carpenter opened a commercial exhibition theater in London, the Microcosm, in which patrons could view microscopic objects shown by day with solar microscopes and by night with the lucernals.

PANIC!

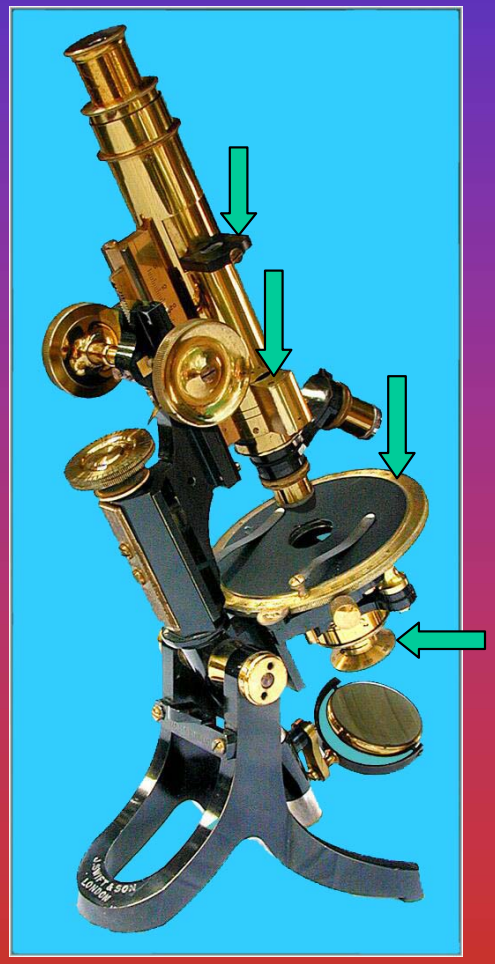
As more people became exposed to the subject, this was the public's reaction!

SPECIALTY MICROSCOPES

A wide variety of small and large portable microscopes was developed. Often these were conventional microscopes modified to fold up for compact portability.

SPECIALTY MICROSCOPES

Calcite polarizing and analyzing prisms had been used as accessories since the 1700's; later in the 19th Century specialized polarizing microscopes with built-in features were developed for crystallographic and chemical work.



THE EUROPEAN MICROSCOPE

While more well-to-do English were developing their microscopes into increasingly elaborate and complicated devices to pursue their Victorian natural history hobbies, Europeans on the Continent used simpler, more basic instruments to advance more technical studies such as histology and embryology. Fewer of their instruments and historical records survive, having been lost in the many wars that swept the Continent over the centuries.

17th/18th CENTURY

Holland, France and Germany produced microscopes that were similar to those in England until the 19th Century, when the continental pattern of microscope began to emerge.

17th/18th CENTURY

An exception was the uniquely European Box Microscope, in which the substage mirror was enclosed within the box that served as a base. This pattern foreshadowed the drum microscope.

19th CENTURY

One of the first successful achromatic microscopes was made by Vincent Chevalier in Paris. It was a box-mounted portable that was dismounted and disassembled for packing into its box.

19th CENTURY

Another early achromatic microscope is this portable instrument by Giovanni Battista Amici, who has been credited with the development of the first successful achromatic lens.

THE REFLECTING MICROSCOPE

An attempt was made in the early 19th Century by Amici and others to eliminate chromatic aberration by replacing the objective lens with a concave mirror in a horizontal microscope.

THE HORIZONTAL MICROSCOPE

The horizontal compound microscope, distinguished from the reflecting type, constituted an attempt to compensate for a long body tube that could not be inclined during observation of subjects suspended in a fluid medium.

THE DRUM MICROSCOPE

Joseph Fraunhofer's 1813 "drum microscope" was the progenitor of the European "continental microscope," from which nearly all 20th Century microscopes were developed.

THE DRUM MICROSCOPE

The base of the Fraunhofer cylindrical microscope was enlarged into a drum-like cylinder, which allowed little flexibility of illumination with transmitted light.

THE CONTINENTAL MICROSCOPE

The drum base was eliminated and replaced with a horseshoe foot and a pillar, which allowed for greater flexibility of illumination, and the continental microscope was born.

THE CONTINENTAL MICROSCOPE

This model by W&H Seibert (Seibert & Krafft) was used by Hans Christian Gram, developer of the Gram stain, and by Walther Flemming, pioneer in the study of mitosis. Another model was used by Robert Koch, who established bacteria as the cause of tuberculosis, cholera, and anthrax.

THE CONTINENTAL MICROSCOPE

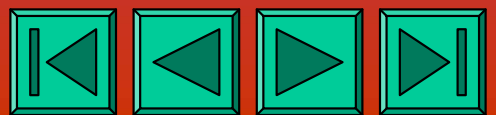
Microscope quality was significantly advanced by Carl Zeiss, who used superior optics designed by Ernst Abbe and made with advanced optical glass formulated by Otto Schott.

SPECIALTY MICROSCOPES

The Grand Model by Camille Nachet is an example of a large, general-purpose drum microscope. In this undocumented configuration, made before 1863 when the Grand Model was discontinued, it has been equipped as a polarizing microscope.

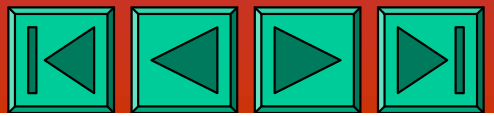
THE AMERICAN MICROSCOPE

No microscopes were made in America in the 1700's. The few who dabbled in science and owned microscopes (like Benjamin Franklin, Thomas Jefferson, Benjamin and David Rittenhouse) obtained them from England or Europe. Estates of a few wealthy citizens, such as Governor Bradford of Massachusetts, each contained several scientific instruments, including a microscope or two. One dealer in navigational and surveying instruments advertised "a neat microscope" for sale. Few of these anonymous instruments have been identified and none is known to have survived; several of those owned or used by early faculty are preserved at universities such as Harvard and Yale.

THE AMERICAN MICROSCOPE

Americans were slow to adopt the microscope. Commercial importation did not begin until well into the 19th Century. Few were constructed here. As late as 1898, more foreign made microscopes were sold in the U.S. than were made here, as most American microscopes were still being constructed by hand. Edward Bausch, “the Henry Ford of American Microscopy,” introduced manufacturing techniques that made large scale production possible. He and Herbert Spencer monopolized the 20th Century American market until after the Second World War, through the Bausch & Lomb Optical Co. and the Spencer Lens Company (later American Optical).

19th CENTURY

An Early English Import to the United States

This microscope, made by J.P.Cutts of Sheffield (w. 1822-1841), was imported and sold by John McAllister & Co. of Philadelphia (w.1830-c.1850) in the 1830's and is therefore one of the earliest documented commercial imports.

AN 1851 CATALOGUE

SHOWING IMPORTED FRENCH MICROSCOPES

CATALOGUE

OF

Mathematical and Optical Instruments,

FOR SALE BY

McALLISTER & BROTHER,

NO. 48 CHESTNUT STREET, PHILADELPHIA.

MICROSCOPES.

19th CENTURY

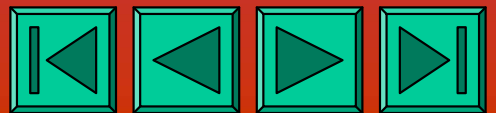
Some Early French Imports to the United States

19th CENTURY

Some Early French Imports to the United States

19th CENTURY

The first microscopes made in America in the 1840's were copies of French and English microscopes, but soon American ingenuity improved on these and later designs with novel features, some of which either were incorporated into English products or copied outright as whole instruments by the French. Small scale commercial production began in America in the 1850's, and by the 1880's there were over two dozen makers (mostly known by only a few examples), and more are still coming to light today. With the advent of industrialization, all but two had disappeared by the early part of the 20th Century.

19th CENTURY

The few well known makers were large and/or influential:

Charles and (later) Herbert Spencer (New York State)

Julius and William Grunow (New Haven, CT)

Joseph Zentmayer (Philadelphia, PA)

Robert B. Tolles (Boston, MA)

Walter H. Bulloch (Chicago, IL)

James W. Queen (Philadelphia)

John J. Bausch (and Henry Lomb) (Rochester, NY)

19th CENTURY

The few well known makers were large and/or influential:

By 1838 Charles Spencer was producing the first commercial microscopes in America as copies of French and English horizontal and vertical compound microscopes. He produced excellent lenses throughout the century, but microscope production was slow and sporadic.

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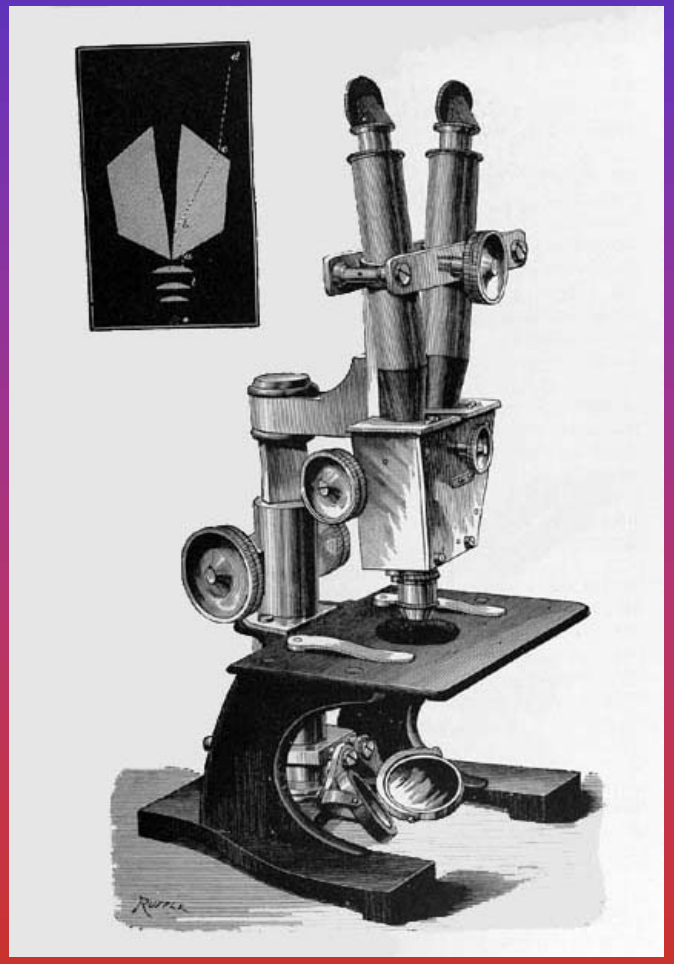
19th CENTURY

The few well known makers were large and/or influential:

J.A.Riddell of New Orleans invented the first binocular microscope in 1851. It was built by the Grunows and later by Swift (following Stephenson's modification) in England, but due to dominance of Wenham's binocular, was never popular. Ernst Leitz's 1913 design, based on a 1903 U.S. patent by F.E.Ives, became the standard.



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19th CENTURY

The few well known makers were large and/or influential:

Joseph Zentmayer is credited with inventing a swinging substage, which enabled the mirror to provide both oblique illumination from below and direct lighting from above. This and his internal long lever fine focus mechanism were copied here and abroad.

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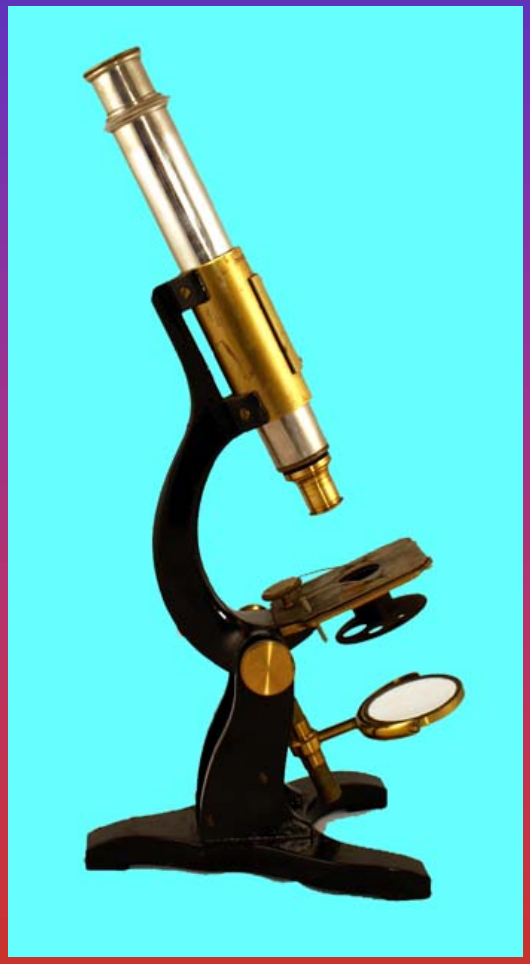

19th CENTURY

The few well known makers were large and/or influential:

Trained by C.A.Spencer, Tolles invented the solid ocular, an immersion lens, and a binocular eyepiece. A finicky workman, his production of finely crafted microscopes was not great. He was succeeded by Charles X. Dalton who continued to operate Tolles' Boston Optical Works.

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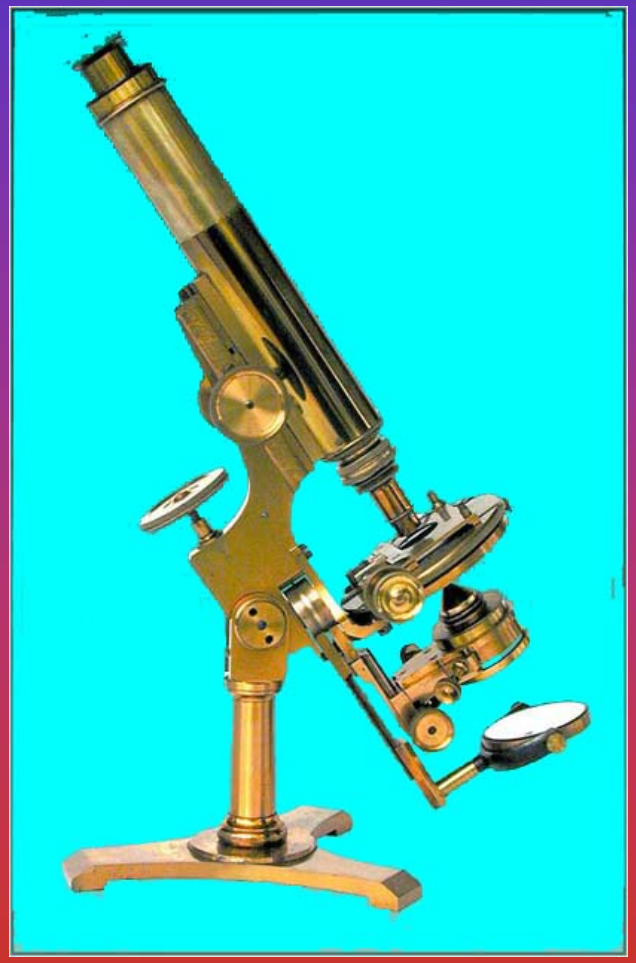

19th CENTURY

The few well known makers were large and/or influential:

Bulloch vies with Zentmayer for primacy of the swinging substage and internal long lever fine focus. His 1878 Congress microscope and Zentmayer's 1876 Centennial were the largest and most complex American microscopes made.

19th CENTURY

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John J. Bausch (and Henry Lomb) (Rochester, NY)

19th CENTURY

The few well known makers were large and/or influential:

Prior to mass production, microscopes were expensive and not available in sufficient numbers to equip classes. Demonstration microscopes were passed around the class instead. In 1879, J. W. Queen offered “Holmes’ Class Microscope” designed by Dr. Oliver Wendell Holmes, Sr., for his Harvard medical classes. It was also sold by R&J Beck.

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John J. Bausch (and Henry Lomb) (Rochester, NY)

19th CENTURY

The few well known makers were large and/or influential:

Bausch & Lomb produced their first microscope in 1874, began mass production in 1876, and by 1900 had produced 30,000 -- more than the total of all other American manufacturers combined. By 1906 this number had doubled.

19th CENTURY

The few well known makers were large and/or influential:

In 1892 Bausch & Lomb introduced their first true continental models, and the rest is history. The continental microscope dominated the American scene with relatively little change until the Second World War, after which further development of the microscope proceeded rapidly.

19th CENTURY

Other better known makers with multiple examples are:

Ernst Gundlach
Rochester, NY

Thomas H. McAllister
New York, NY

Lyman McIntosh
Chicago, IL

Leopold Schrauer
New York, NY

George Wale
Hoboken, NJ

19th CENTURY

Other better known makers with multiple examples are:

A difficult man, Gundlach had made microscopes and lenses in Germany before coming to the U.S. and working for B&L where he designed their first microscopes and lenses. After a falling out, he left and went on his own, entered a brief partnership with Yawman and Erbe, and then formed the Gundlach Optical Co., before returning to Germany.

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19th CENTURY

Other better known makers with multiple examples are:

McAllister is known primarily for his use of focusing by fusee chain, and offered several unique and inexpensive models perhaps of his own design. His largest model, the "Professional", however, was similar to one made by Daniel Pike, who also used the fusee chain.

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Rochester, NY

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New York, NY

Lyman McIntosh
Chicago, IL

Leopold Schrauer
New York, NY

George Wale
Hoboken, NJ

19th CENTURY

Other better known makers with multiple examples are:

McIntosh, a physician by training, produced a wide variety of medical and quack medical devices. His unusual microscopes are unique, except for his “Medical” model which is similar to Queen’s Acme No. 4, made by John Sidle.

19th CENTURY

Other better known makers with multiple examples are:

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Rochester, NY

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Lyman McIntosh
Chicago, IL

Leopold Schrauer
New York, NY

George Wale
Hoboken, NJ

19th CENTURY

Other better known makers with multiple examples are:

Schrauer's microscopes were advertised and sold only by him, except for a brief offering by Queen. He was perhaps the last to offer completely hand made instruments, and his output was not great. He also resold instruments made by Daniel Pike.

19th CENTURY

Other better known makers with multiple examples are:

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Rochester, NY

Thomas H. McAllister
New York, NY

Lyman McIntosh
Chicago, IL

Leopold Schrauer
New York, NY

George Wale
Hoboken, NJ

19th CENTURY

Other better known makers with multiple examples are:

George Wale is noted for the invention of the concentric inclination joint, which was adopted by other makers both here and in England.

Some minor makers who are obscure or known by only one or a few surviving examples follow next:

JOSIAH BENNET ALLEN

SPRINGFIELD, MA

The second American maker after Charles Spencer, Allen was possibly the first to produce an original design.

JOSIAH BENNET ALLEN

SPRINGFIELD, MA

This undocumented instrument may have been his first. Some of its specialized operational features are not yet fully understood.

SAMUEL MURSET

Philadelphia, PA

This hitherto unknown immigrant Swiss instrument maker supplied instruments to the Philadelphia firms of Queen and McAllister.

SAMUEL MURSET

Philadelphia, PA

The source of these microscopes was unknown, and some were thought to have been French imports. He characteristically used a brass sliding stage plate, rather than the usual glass plate used on American microscopes of the time.

CHARLES FASOLDT

ALBANY, NY

Charles Fasoldt was known for his fine rulings; to make these he built his own ruling engine. His microscopes were designed for use with these specialized slides, which were used to measure the resolution of microscope objectives.

ERNEST CHARLES FASOLDT

ALBANY, NY

Only seven microscopes made by Ernest and his better known father, Charles, are known.

Their only surviving instruments are each one of a kind, except this more basic model of which two are known.

DANIEL PIKE

NEW YORK CITY

This son of instrument maker Benjamin Pike carried on his father's business. Not documented as a microscope maker, he is believed to have added them to the output of his large shop, and supplied other New York makers and retailers with microscopes.

DANIEL PIKE

NEW YORK CITY

Daniel worked under the names of Benj.Pike & Son(s), and Benj. Pike's Son (1844-1893). He used some features in common with those used by the Grunows and others. He is not to be confused with Benj. Pike, Jr, who ran a competing business.

MILLER BROTHERS

NEW YORK CITY

The Miller Brothers made lenses and a few microscopes, but also resold microscopes from makers like Pike, Zentmayer and Schrauer, as did other New York firms like C.B. Kline, T.H.McAllister, and Schrauer himself.

JOHN W. SIDLE

LANCASTER, PA

In 1880 J.W. Sidle began producing advanced microscopes in his Acme Optical Works. He was quickly bought out by J.W. Queen & Co., and produced his Acme microscopes for them under the Queen name, so early examples signed by him are very scarce.

JOHN W. SIDLE

LANCASTER, PA

One of the innovations for which Sidle is known is his use of a calibrated sector disk for the precise measurement of angles of illumination.

YAWMAN AND ERBE

ROCHESTER, NY

These former employees of Bausch & Lomb had a brief period of association with Ernst Gundlach, before being forced out of the microscope business by B&L, either because of perceived competition, or because of the use of disputed patents.

YAWMAN AND ERBE

ROCHESTER, NY

This undocumented model has a poorly designed fine focus mechanism, possibly made in an ill-advised attempt to circumvent patents disputed between Gundlach and Bausch & Lomb.

LABAN HEATH

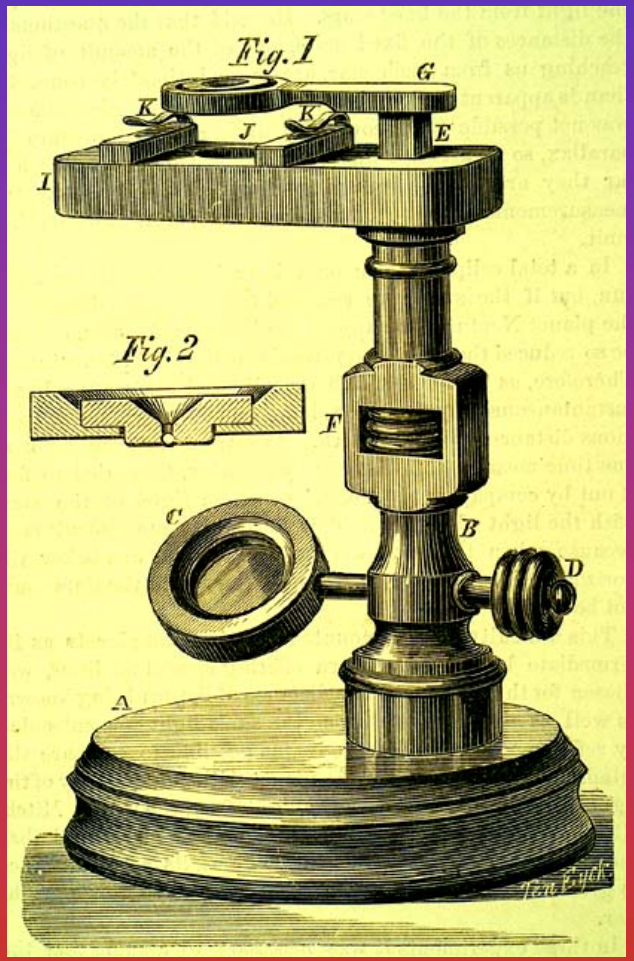
BOSTON, MA

In 1866 and later in 1877 Laban Heath patented two instruments to be used in detecting counterfeit currency. The first could also be disassembled into a telescope and a hand magnifier.

JAMES H. LOGAN

WASHINGTON, D.C.

In 1869 James H. Logan patented a simple microscope made almost entirely of wood. It came with three glass bead lenses (150X, 300X, 500X) like those used by Hooke and Leeuwenhoek. Two examples survive in museum collections.



GEORGE L. GOWLLAND

CAMBRIDGE, MA

This maker, known only from the signature on this unique microscope, remains undocumented. It is marked “No. 117.”

GEORGE L. GOWLLAND

BOSTON, MA

The instrument seems to have been designed for industrial use, but its specialized features are not yet understood.

LOUIS M. PRINCE

CINCINNATI, OH

This known Cincinnati maker of surveying and meteorological instruments was unknown as a maker of microscopes until this example appeared.

E.H. AND F.H.TIGHE

DETROIT, MI

As the last purported makers to appear at the end of the 19th century, their microscopes were unique and briefly popular, overlapping into the 20th century. That they claimed to be makers was not recognized until recently.

E.H. AND F.H.TIGHE

DETROIT, MI

The Tighes offered a line of five models in the brief period of the firm's existence. After discontinuance of microscopes by the Tighes about 1905, production was continued by the Gundlach- Manhattan Optical Co. (GMOC), which may have been the actual manufacturers all along.

THE FINE PRINT

MOST INSTRUMENTS DEPICTED ARE (OR WERE) OWNED BY ACTIVE OR CORRESPONDING MEMBERS OF THE MICROSCOPICAL SOCIETY OF SOUTHERN CALIFORNIA:

Kenneth Gregory Barry Sobel James Solliday

Stuart Warter Allan Wissner

IMAGES CONTRIBUTED BY (some edited for uniformity):

David Coffeen *(Tesseract)* Brian Ford Tom Grill James Solliday

Stuart Warter Donald Wing Allan Wissner George Vitt

Some instruments depicted have been illustrated in one or more issues of the *Journal of the Microscopical Society of Southern California.*

Some instruments depicted are not the exact ones mentioned, but nonetheless are accurate representations.

END