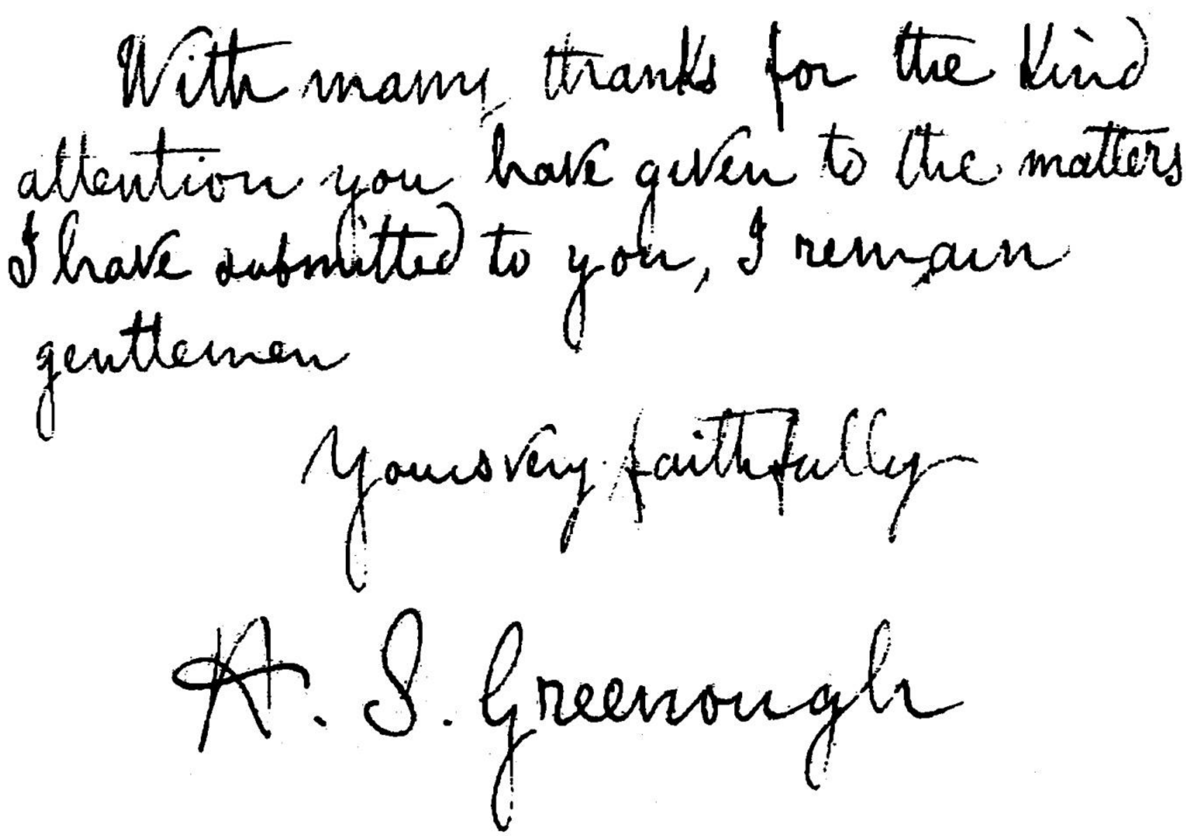
Stereo Microscope

Part 2b: Greenough Microscopes
3rd Edition

R. Jordan Kreindler (USA)



With many thanks for the kind attention you have given to the matters I have submitted to you, I remain gentlemen

Yours very faithfully

H. S. Greenough

Horatio S. Greenough signature, and last portion of one of his letters sent to Zeiss. c. 1890s
Courtesy of Herr Berndt-Joachim Lau, Carl Zeiss Microscopy GmbH (Lau, 2012).

Some Specialized Applications

Greenough stereo microscopes in addition to general use have also been designed as instruments for use in some specialized applications.

Ophthalmology

One type of stereo microscope used daily in clinical practice is found in slit lamp instruments, Fig. 33 and Fig. 34, seen in most ophthalmologist's and optometrist's offices. These instruments contain stereo Greenough microscopes, (e.g., Haag Streit, Topcon), or CMOs (to be discussed in Part 3), adjustable slit lamp illumination, usually a tonometer, a device for measuring intraocular pressure (IOP) in mm of mercury to test for glaucoma, a chin brace, and forehead rest on a single adjustable stand.

Figure 33. Topcon SL-2E Slit Lamp (Bryant, 2012)

As Manuel del Cerro explained to the author (del Cerro, 2012), the name *slit lamp* is perhaps inappropriate, as this assemblage is named for only one of its components, which it can be reasonably argued, is not as important as its microscope. This is likely the reason a slit lamp is sometimes referred to by a longer and more descriptive name, *slit-lamp biomicroscope*. Slit lamps are usually used in conjunction with a Hruby lens, typically -55/56 diopter (-55/56D), to allow examination of the retina.

Slit lamps are used to examine the eye's interior, iris, cornea, vitreous humor, and retina to allow for anatomical diagnosis. As they are built using high quality optical and mechanical components designed for continuous clinical use, slit lamps are expensive, but appear virtually indestructible and long functioning.

A slit lamp changed from a purely observational device to a measuring instrument with the inclusion of a tonometer to evaluate intraocular pressure (IOP). It was further extended as a measuring tool when additional capabilities were added to measure the distance from the cornea to the lens, and the thickness of the cornea.

Used functioning models, of relatively recent slit lamps, are usually on the market only a short time, as there is a constant demand from eye care specialists. Models from the major slit lamp manufacturers such as Zeiss (CMOs), the original manufacturer of the modern stereo microscope, and Haag Streit (Greenough), generally retain good resale values as used equipment. For example, a used Haag-Streit S350 slit lamp, depending upon condition and completeness, often sells for between USD $3,000 to $8,500. On trade-in for an improved Haag-Streit slit lamp, the BM 900 pictured here can reach $5,000.

Fig. 34 shows a Haag-Streit Greenough microscope from various angles. Fig. 35 shows an eye as seen through this instrument, and the slit lamp's illumination can be seen reflected by the eye (Ozment, 2012).

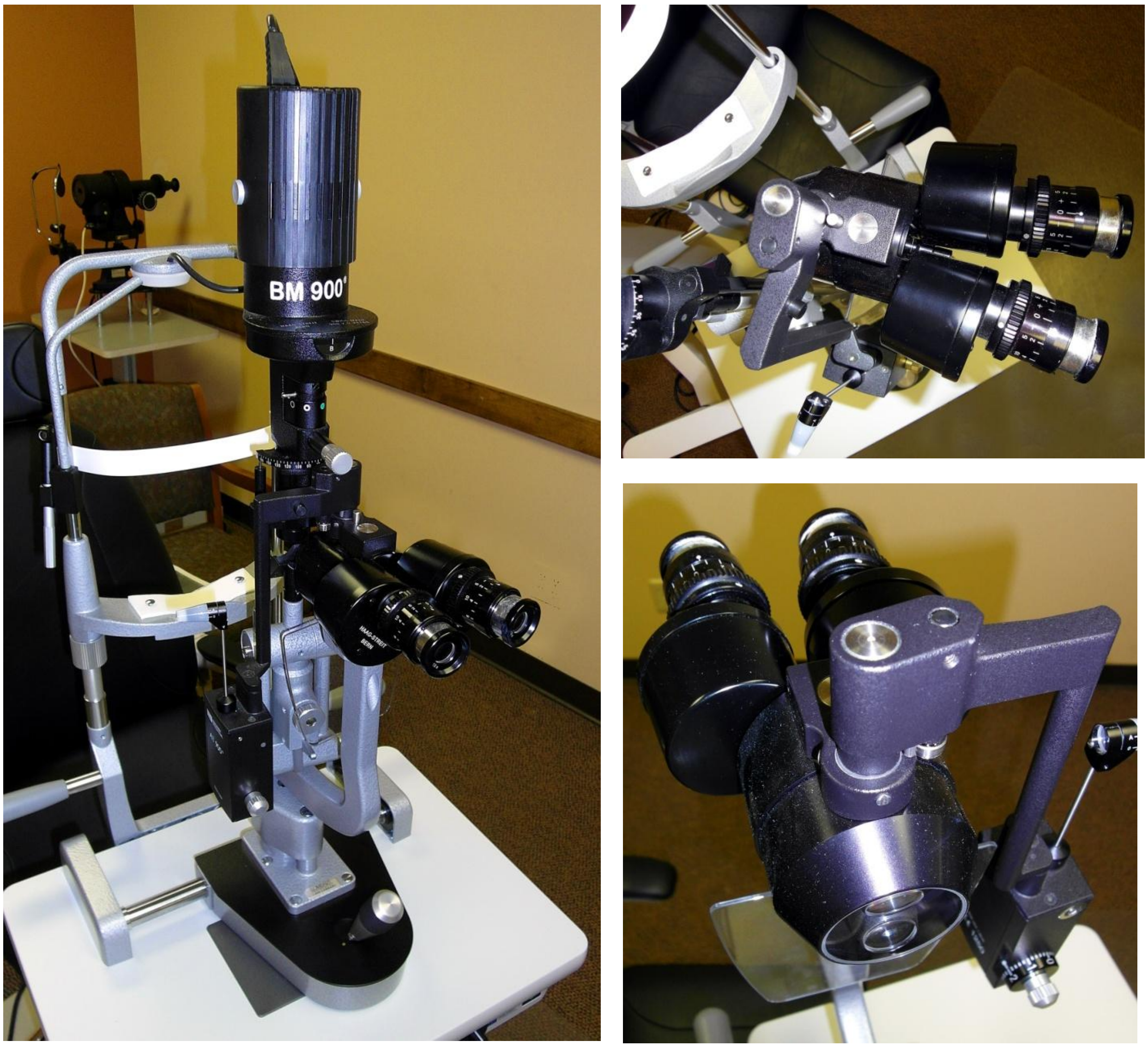


Figure 34. Haag-Streit slit lamp

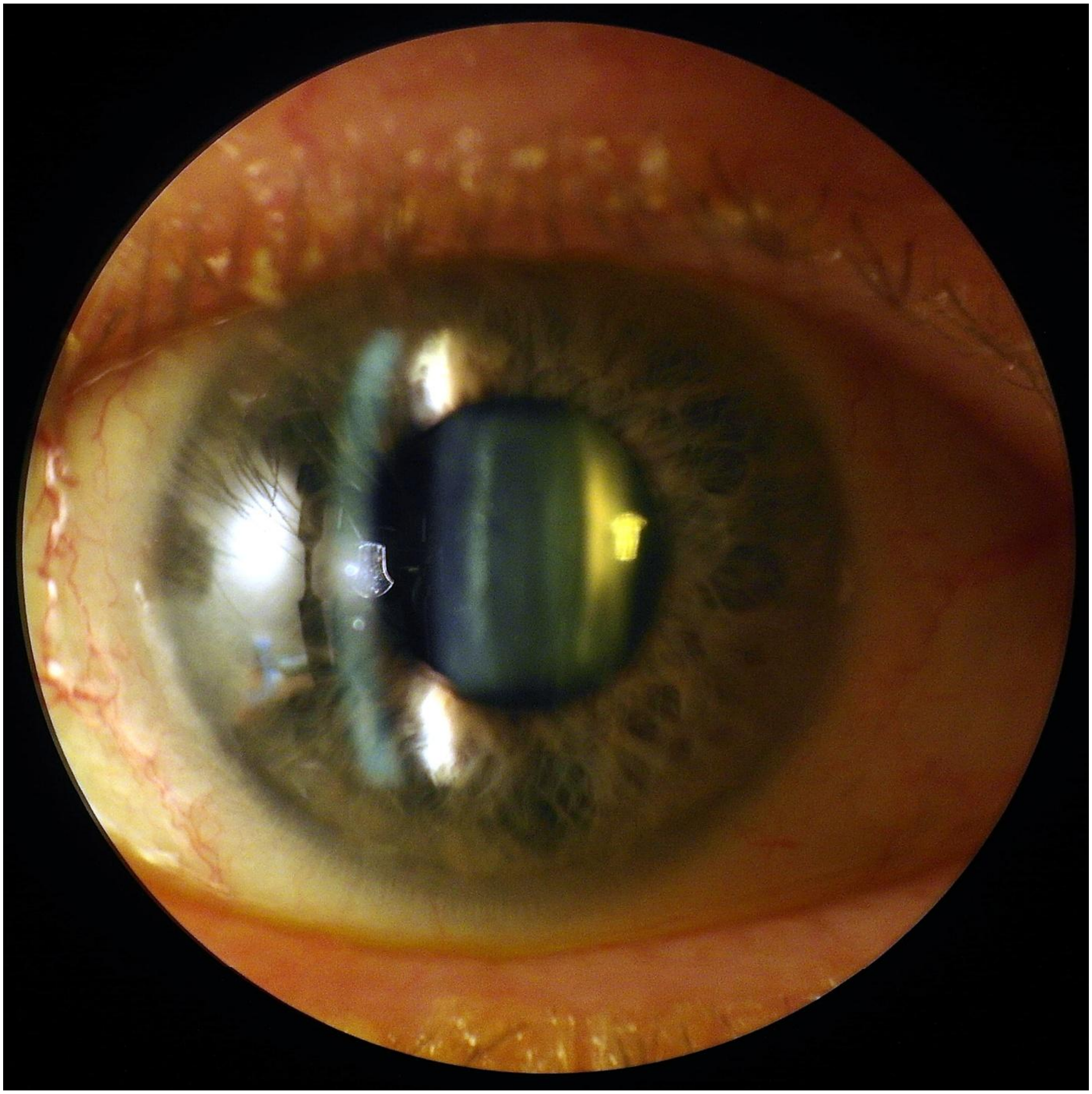


Figure 35. Human eye as seen through BM 900 Haag-Streit Greenough Microscope

Photoreconnaissance

Another specialized application was film photoreconnaissance analysis. One example of this is the Bausch & Lomb Greenough-style stereo zoom 240 photoreconnaissance microscope, c. 1970. This was used for photo interpretation of film from, often still classified, flights of Corona satellites, SR-71 Blackbirds, and other U.S. photoreconnaissance resources.

With the arrival of high-resolution digital imaging, this microscope was removed from use. However, during the early digital imaging age film still had higher resolution, so film photoreconnaissance analysis persisted. Only after the development of higher resolution digital imaging was film finally replaced. In spite of the availability of later optical instruments, while film continued in use this B&L microscope was still used, and often preferred, for the analysis of film images.

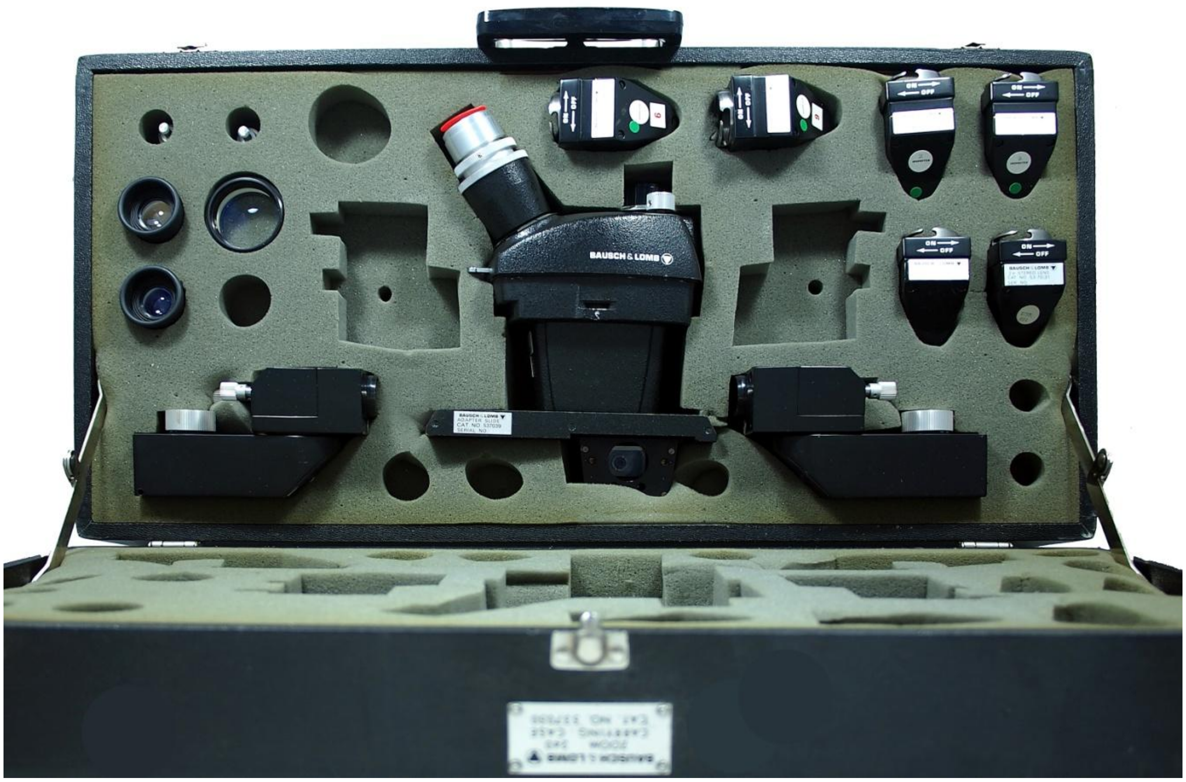


Figure 36. Bausch and Lomb 240 aerial photo interpretation stereo zoom microscope, in its laboratory storage case, with some accessories

The B&L 240 Aerial Photo Interpretation Stereo Zoom microscope, with some of its accessories, is shown in its storage case in Fig. 36, and assembled in Fig 37. The microscope has a maximum magnification of 120x and can resolve images up to 400 lines per mm. Although this microscope is c. 1970s, its resolution is greater than that of some modern high-quality camera lenses.

Figure 37. Assembled Bausch and Lomb 240 aerial photo interpretation stereo zoom microscope

The Stereozoom 240, shown here, has two rhomboid arms and stereo objective lenses that at the ends of these arms. When used for photoreconnaissance analysis, the B&L 240 pod with attached rhomboid arms and objectives was installed over a light table, typically made by Richards or Bausch and Lomb. The light intensity provided by different table models varied significantly, from a luminance of approximately 2,200 to 90,000 foot-Lamberts (about 700 to 28,650 candles/square foot).

The transmitted light, from most tables, followed the movement of the rhomboid arms either magnetically or mechanically, and so provided lighting where needed. Separate illumination for each stereo microscope objective had been introduced by Riddell over 100 years earlier.

Quality Control - Solid State Devices

Most semiconductor devices are fabricated onto a wafer typically made from silicon, although other compounds are also used. These semiconductor devices are made in relatively expensive facilities called "fabs".

Before the 1970s about 3/4 of stereomicroscope applications were in the life sciences. The 1970s saw the rapid growth of the semiconductor industry. Coincident with the growth of fabs was the acquisition and use of Greenough zoom stereo microscopes for the examination of thin sheets of semiconductor material. These sheets are called wafers and contain fabricated integrated circuits (ICs). These ICs are removed from the wafers and installed in packages. The rapid growth of the semiconductor industry lead to a concurrent and rapid growth in the production of Greenough microscopes. The new semiconductor industry was probably the single greatest impetus to growth that Greenough microscopes had ever experienced.

Fig. 38 shows a 3 inch wafer, typical of c. 1970s, containing many fabricated Motorola MC6800 chips. In general, the larger the chip the greater the chance for a flaw/damage and the lower the yield. Quality control using stereo microscopes was, and is, an important resource for identifying damaged chips

Wafers diameters were initially measured in inches, up to about 5 inches. For larger wafers, dimensions are measured in millimeters (mms). Today 300mm is considered to be the standard for state-of-the-art wafers, with the next standard expected to be 450mm.

Fig. 39 shows a Motorola MC 6900 microprocessor, an early 70,000 transistor microprocessor, shown mounted in its package, before the package is sealed. Fig. 40 shows a portion of a printed circuit board with some soldered components. Items such as those in Figs. 38, 39 and 40 were often viewed through a Greenough microscope for quality control.

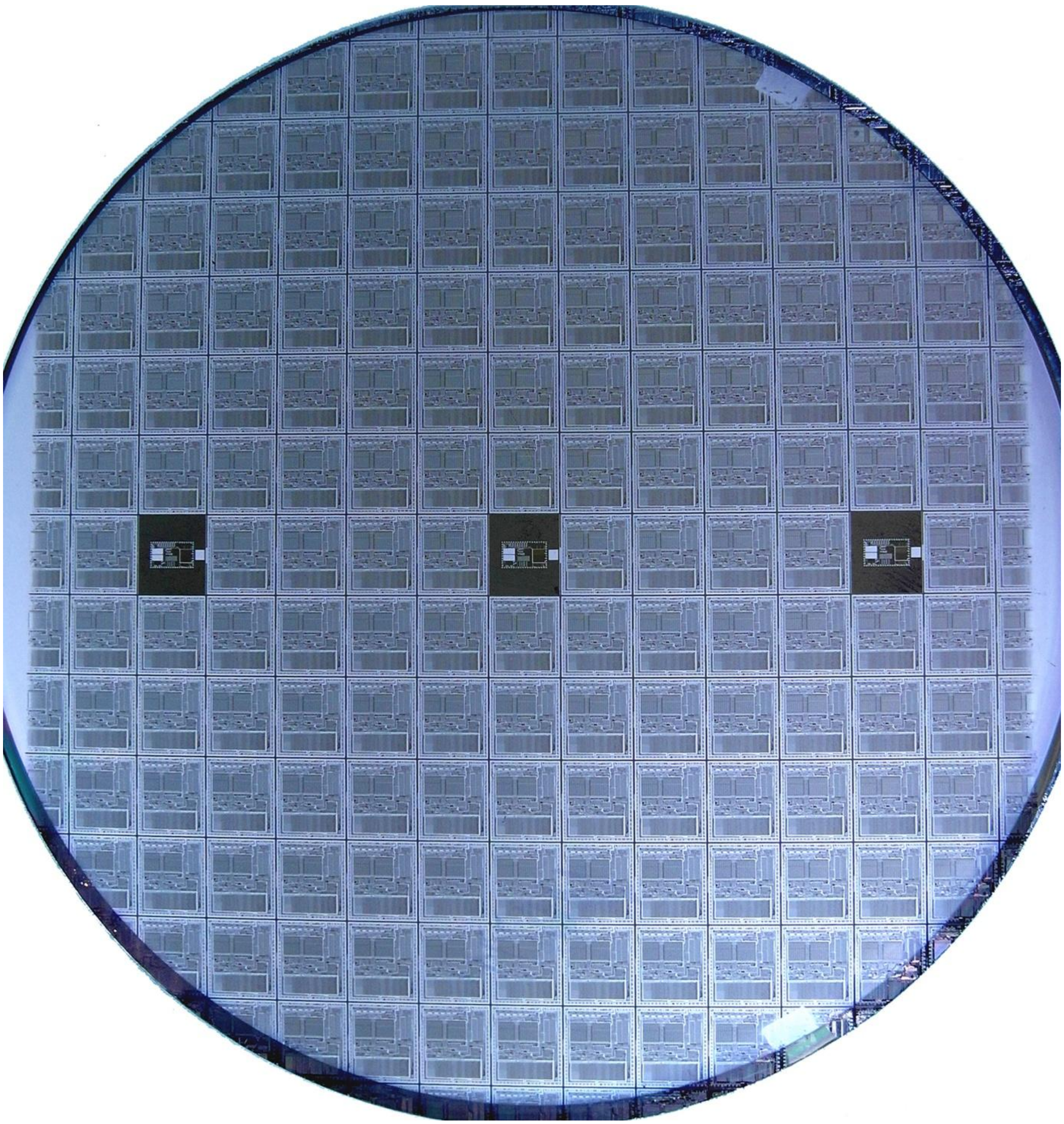


Figure 38. A wafer with Motorola 6800 ICs

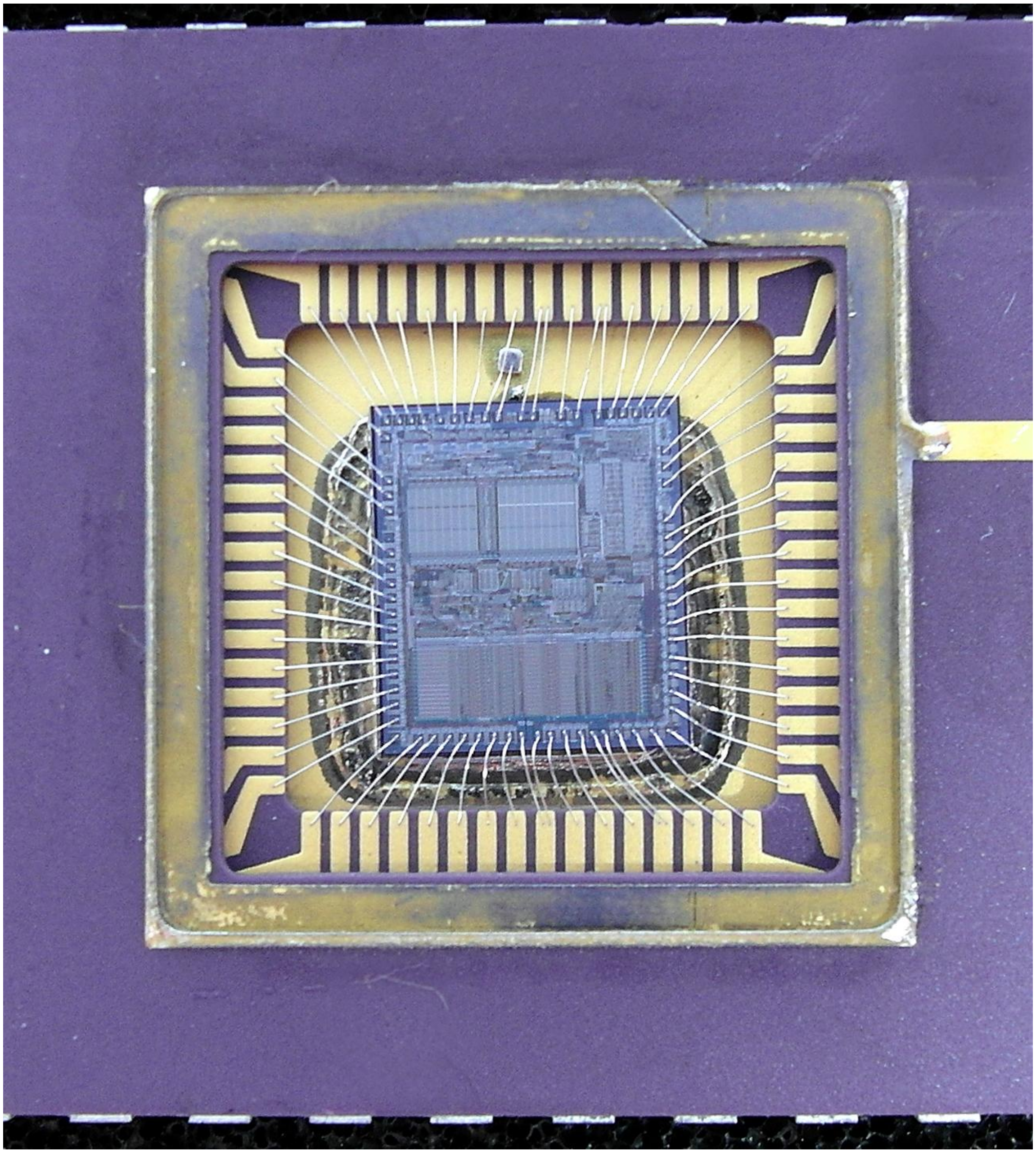


Figure 39. A mounted Motorola MC6800 microprocessor without top cover

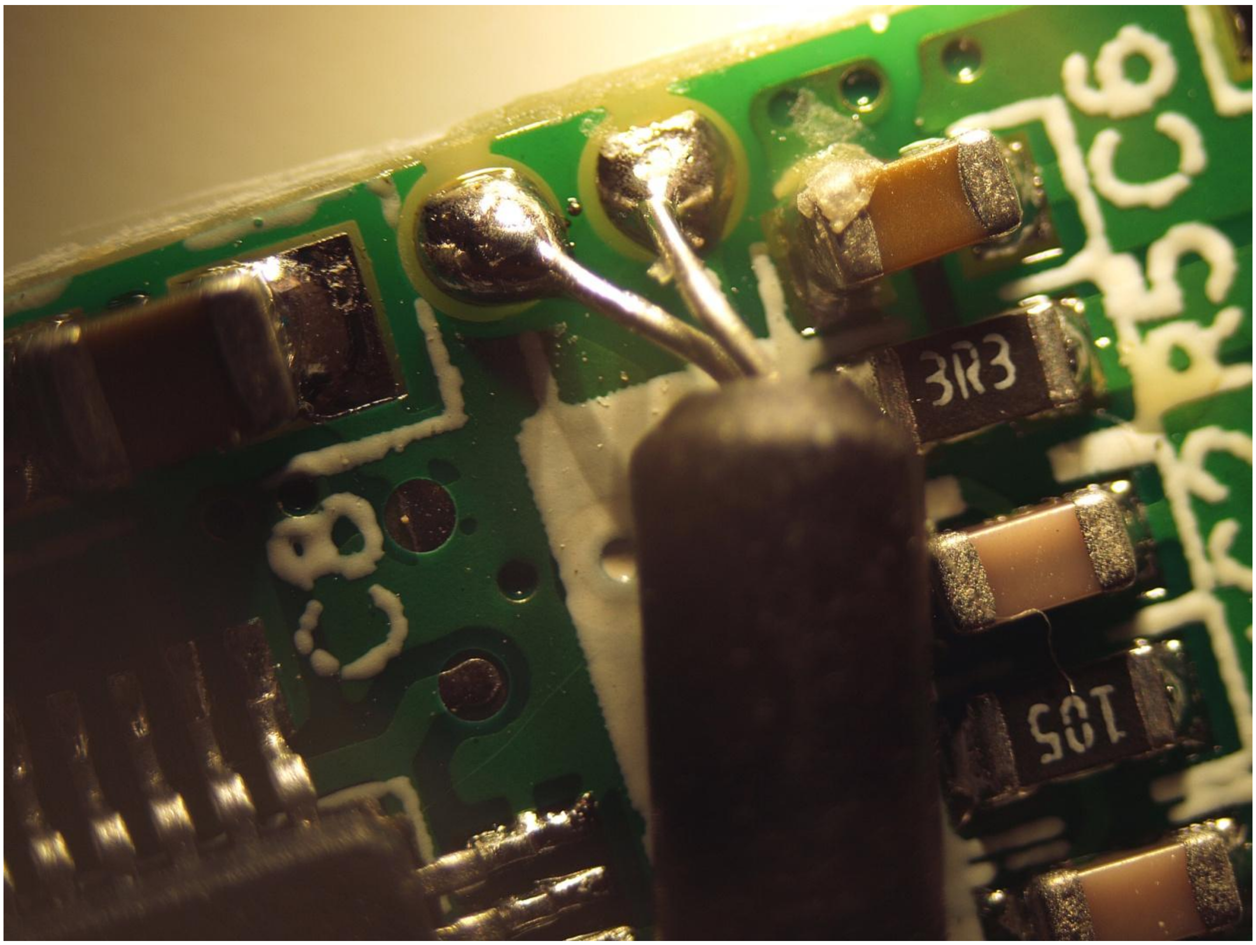


Figure 40. PC Board with soldered components as seen through a Greenough microscope

Most stereo quality control microscopes used by the semiconductor industry were Greenough-style zoom instruments. Bausch and Lomb StereoZooms, in particular, first introduced in 1959, became popular with the growing technology companies in Silicon Valley (Kreindler, 2012). Fig. 41 shows a later model B&L StereoZoom. B&L's StereoZoom entry was soon followed by AO's Stereo Star zoom series, Fig. 42.

StereoZooms were sold to the semiconductor industry in significant numbers and are still widely available, although their production stopped at the beginning of the 20th century. They can be seen for sale almost any week on eBay,

Figure 41. Bausch and Lomb StereoZoom 7, stand and microscope pod with coaxial lighting option

Fig. 20 shows a damaged integrated circuit as seen under a Greenough stereo microscope, as it would have appeared through a B&L StereoZoom or AO Stereo Star microscope.

Figure 42.. AO Stereo Star Zoom microscope "pod" (i.e., a microscope by itself for mounting on a variety of stands)

Today, higher zoom ratios are common. The first, double digit, 10:1 zoom stereo microscope was the Zeiss Citoval c. 1975 (Lau, 2012). Zoom ratios have continued to expand beyond this for many top-of-the-line instruments, e.g., the Nikon SMZ1500 with a 15:1 (0.75 - 11.25x) zoom.

The Bausch and Lomb Optical Systems Division and the American Optical (AO) company after a series of corporate acquisitions and mergers came together in one company. A company that also owned Reichert and Leica. This led to the rebranding of many stereo instruments. See Part 4 for a further discussion of stereo microscope rebranding.

Surgery

Operating room microscopes are usually stereoscopic and are often stable, floor standing instruments. Stereo microscopes are used for a variety of surgical procedures. The surgical applications are too numerous for a comprehensive list to be present here, but they include the medical specialties of cardiology, cardiac electrophysiology, dentistry, ENT (Ear, Nose and Throat), neurology, oncology, ophthalmology, orthopedics, plastic and reconstructive surgery, and urology.

Many operating room microscopes have straight or only slightly tilted binocular tubes. However, microscopes used for ophthalmologic and other specialized surgeries are often inclined at 45 degrees (although occasionally at other angles). Most high-quality operating room microscopes have electronic controls for focusing and positioning, which are usually foot or head-mounted. These microscopes are frequently equipped with dual or triple heads, and/or with a video output channel for simultaneous viewing of the surgical procedure by operating room personnel. However, the video is only two dimensional, while the images through the microscope are three dimensional. As these microscope are usually equipped with their own independent light sources, they can provide the spot illumination needed to see inside small openings.

Not all operating room microscopes are floor-standing. Zeiss makes surgical head-mounted loupes, in powers from about 4x to 8x. Leica now sells a head-mounted surgical microscope, model HM500. These head-mounted stereo microscopes allow surgeons greater mobility than possible with a floor standing unit.

The HM500 comes with zoom and autofocus capabilities, similar in many ways to modern digital cameras, and with from 2 - 9x magnification. The HM500 uses rechargeable batteries for mobility. It provides foot pedal controls for zooming and manual focusing if needed.

Most operating room microscopes are registered and/or certified. In the US registration is done by the Food and Drug Administration (FDA). In Europe Conformité Européenne (CE) certification, indicating compliance with EU regulations, is common. Unfortunately, some countries do not require registration or certification. In these countries surgical room microscopes are usually less expensive, but issues of optical and mechanical performance can arise. All surgical microscopes are relatively expensive, even head-mounted loupes.

A Small Sampling of Zeiss Greenough Microscopes

Introduction

After Zeiss' introduction of the Greenough stereo microscope at the end of the 19th century, other companies started manufacturing similar instruments. It would be very difficult, perhaps impossible, to list all Greenough microscopes manufactured, even if restricted to just modern times and "top" makers. With only modest descriptions, that list would likely exceed the length of this paper. Many previous Greenough microscope makers are no longer in business. Thus, confirming the accuracy of model designations and release dates would be difficult, and likely impossible. Even for companies I've contacted still in business, some manufacturing records are no longer available.

Therefore, rather than attempt to cover all the Greenoughs instruments manufactured, only a small sampling of general purpose instruments from the original Greenough developer, Zeiss, is presented here. This sampling serves to illustrate the evolution of Greenough microscopes. For competitive reasons, microscope makers often copied each other's "newest" concepts. Thus, the evolution presented here is somewhat synchronized with the evolution of Greenough microscopes by other makers.

Zeiss continued to produced Greenough microscopes after their first in 1897, and the company still manufactures and sells them today, e.g., the Stemi DV4, 2000/C/CS. Many of these Greenoughs are general purpose instruments, used for a variety of applications. The discussion that follows presents a few of these general purpose Zeiss models, spanning the interim from Zeiss' first Greenough to the present.

Some Zeiss Greenough Models

Fig. 43 shows a Zeiss Stand X, similar to that of Fig. 24. However, the Stand here has a triple turret, to allow easier magnification changes. This model had some of the earliest turrets made for Greenough microscopes. The turret here is thin and requires care in changing magnifications to avoid bending the assembly. This potential problem was eliminated by Zeiss in later models.

Figure 43. Zeiss 'Double tube X with revolving nosepiece', c. 1935.

A contemporary Zeiss catalog notes,

> *If the observer can always make do with as few as three paired objectives, a still more rapid exchange may be had by arming the double tube X with the triple revolving nose piece ... In this case, all that is necessary is to turn the disk of the nosepiece in order to swing any pair of objectives into line with the axes of the double tube.*
>
> *If the revolving nosepiece is to be employed, room must be provided for it by a recess in the prism body. The revolving nosepiece cannot be used with a double tube not having the recess.*
>
> (Zeiss, 1937).

Although the turret design is somewhat delicate, this model is fully functional and the arrangement provides exceptional images. The inserts in Fig. 43 show this turret from above and below, illustrating both its flexibility and fragility. The turret, in addition to providing magnification changes using the mounted lens sets, allowed the objective lens pairs on dovetail sliders to be inserted and removed, offering magnification options beyond those available in the installed sets. These objective pairs were similar to the objective sets in the single magnification Stand X of Fig. 24, so many magnification choices were available.

Below the stage, of Fig. 43 is a large circular rotating disk providing three backgrounds: a black background or white background for incident illumination, and a cylindrical opening for transmitted illumination. To reflect transmitted light the microscope has both plane and convex substage mirrors. The short, open cylinder for transmitted light allows for the insertion of a lens or condenser in the light path. This arrangement again demonstrates the heritage Stand X, and other relatively early Greenoughs, owe to the biological compound microscope.

This microscope could be used for dissecting with the attached hand rests, but with its multiple magnifications it was commonly used as a general purpose instrument. As noted in Part 2a, Stand X was manufactured from 1926 to 1942.

Fig. 44 shows a Zeiss Greenough Stereomicroscope III c. 1965 with magnifications of 1 - 4x and a working distance of 74mm (about 3 inches), that can be used for a variety of applications. It has the capability of seeing objects with either incident or transmitted light. A "stripped down" version of this stand was available with only incident light capabilities. It replaced the Zeiss Model II, and was itself replaced itself replaced by Zeiss' Model IVb. The model IVb, c 1976, had over double the magnification range, 0.8 - 5x, of the Stereomicroscope III. [If you're using the pictures in this article for model identification, please note that the Zeiss Greenough Stereomicroscopes I, III, and IV look almost identical. However, the toroid (doughnut-shaped ring) directly below the prisms on the Stereomicroscope III has a large black knob at its front center. This knob is not present on Stereomicroscope Models I and IV.]

Figure 44. Zeiss Greenough-style Stereomicroscope III, c. 1965, used for a variety of applications. Two extra eyepieces are shown on the bottom

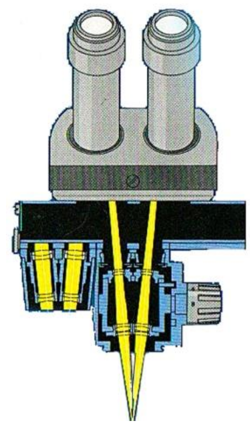


Figure 45. Zeiss DRC
-Left. Zeiss Stemi DRC, with Phototube, and stereo objective changer, Microscope c. mid-1980s
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-Top [Diagram of DRC light paths from Zeiss catalog, Courtesy and with permission of, Carl Zeiss Microscopy, LLC

Fig. 45 shows a later Zeiss Greenough Stemi DRC stereo microscope (C for camera) on Stand O, with stereo-lens changer D, and Phototube DRC for easy documentation, and dual 10x Br/25 wide-angle eyeglass compatible eyepieces. This Stemi has four magnification options 1.6x, 2x, 4x, and 8x. These magnification changes are obtained by a combination of dovetail slider, and a triple drum changer (stereo-lens changer D) for the three greater magnifications. This changer has a built-in double-iris diaphragm. Images can be sent to the camera port by using the slider on the underside of this port. Moving the slider, positions an internal mirror either in or out of the light path. If in the path it reflects light from one of the objectives to a second mirror that sends light upward to the camera port.

The combination of eyepieces and objectives provide magnification options of 16x, 20x, 40x, and 80x. Working distances, depending on lenses, of either 54mm (2.12"), 63mm (2.48"), and 88mm (3.46"). Although difficult to see in the picture, this microscope has a flat sustage slider to allow an opaque white background or a transparent opening against which to view objects. This microscope also comes with a Zeiss W 10x/25 Br eyepiece for the camera port. [Author's note: This microscope belongs with the "D" Zeiss Series Greenough stereomikroskops, where Ds have a fixed magnification, DRs have changeable fixed magnifications, and DV4s have zoom capabilities].

Fritz Schulze (Schulze, 2011, 2012) was kind enough to provide the prices for some DR options, in Canadian dollars, in 1976.

47 50 02	Stereotube DR	$268.00
47 50 32/33/34	Paired objectives	$76.00 ea
46 40 01-9903	Eyepiece 10x	$58.00 ea. (wide angle, $89.00 ea.)
43 51 05	Stand LO	$105.00

Zeiss continued to use essentially similar stands and other components, e.g., the same basic stand, and lighted stand with rheostat (in the Stemi SV6 series), as well as the same illuminator, photo tube, and occasionally the same style for binocular tubes for other Greenough Stemi microscopes. This style was also used by Zeiss for some of their CMO microscopes such as the SR, discussed in Part 3.

These microscopes and their close relatives were sold c. 1960s -1980s. Zeiss has continued to use the DR and DV4 designations [(DR 1040, 10x and 40x), (DR 1663, 16x and 63x), DV4 (8x to 32x zoom), and DV4 Spot (fiber-optic cold light illumination)] through more recent times. These designations are still used on Zeiss Stemi Greenough microscopes, although newer microscopes have significant design and color changes.

Fig. 46 shows some current versions of Zeiss' DV4.

Figure 46. Zeiss DV4 Greenough stereo microscopes (various current versions). Courtesy and with permission of, Carl Zeiss Microscopy, LLC

Zeiss 'aus Jena'

In 1945 the US Army (USA) occupied Jena before it was to be turned over to the Russians [part of what was to become the GDR (East Germany)] as reparations. So, in 1945 the US Army requested that many of Zeiss' top scientists and senior management move to what was to become West Germany. This relocated team built a new Zeiss company in West Germany using designs from many existing Zeiss microscopes (and other items) built in Jena. It became profitable sometime in the mid-1950s.

Some Zeiss personal not relocated to West Germany were sent to Russia to help the Russians start new technology businesses. The Zeiss Jena business restarted quickly in 1946, although without those personal sent to assist the Russians. When these specialists returned from Russia c. 1950/51 after being away about four years, the restarted Zeiss Jena enterprise was already in full operation. On June 1, 1948 the Zeiss Jena company became a VEB ("peoples owned enterprise") with the Zeiss foundation no longer Zeiss' owner. Sometime later it became the *Kombinat VEB Carl Zeiss Jena*, a conglomerate of companies.

This is from Zeiss on-line (it appears translated from original German text),

> *It was not until 1971 [that] an agreement [was reached] in London whereby ... For example, VEB Carl Zeiss JENA was permitted to offer its products in the Eastern Bloc countries, Syria, in the Lebanon and Kuwait using the agreed trademarks. Carl Zeiss Oberkochen, on the other hand, had the right to distribute the products bearing the name Carl Zeiss in West Germany, West Berlin, the Benelux countries, Italy, Greece and the USA.*
>
> -- *(Zeiss, undated History)*

As the Zeiss name in the West was to be used by Zeiss West Germany, microscopes sold in the West and built by the competitive East German Zeiss company carried the name 'aus Jena' (from Jena).

Berndt-Joachim Lau, Carl Zeiss Microscopy GmbH, a long time Zeiss employee who began work for VEB Carl Zeiss Jena in East Germany in 1973 (Lau, 2012), explained to the author that there are still strong and somewhat differing opinions about this time held by East and West German "Zeissians", making the whole truth somewhat difficult to find. From after WW II to the dissolution of the Soviet Union, the two Zeiss companies were competitors rather than partners. Mr. Lau was also kind enough to send the author a short account of this period in Zeiss history. That account is presented in Part 3.

Fig 47 presents an East German Zeiss (aus Jena) microscope from the time when there were competing products from the two Zeiss companies, and before the two companies merged after the Soviet Union ceased in 1989. In the late 1980s, VEB Carl Zeiss Jena had almost four times as many employees as Carl Zeiss Oberkochen.

The microscope in Fig. 47 can be approximately dated from a Zeiss East German publication, *GSM Stereo Microscopes,* # 30-735-1 (Zeiss 1984-GDR). GSM and GSZ microscopes were contemporary instruments of similar design (see the quote below from a Zeiss GSM/GSZ manual).

The GSM and GSZ are

> *largely standardized with regard to their mechanical and optical construction. They are mainly differing through the type of the magnification changer. While the magnification of the GSM is made by changeable objectives in fixed magnification steps, the GSZ is equipped with a pancratic, i.e., step-less magnification changer. In addition to this the GSZ had diopter adjusting rings for balancing accommodation and defective vision. Tripod, eyepieces as well as the lighting and almost all other supplementary equipment are interchangeable between the two microscopes.*
>
> (Zeiss, Undated GDR-2)

Figure 47. An aus Jena Greenough GSZ stereo microscope c. 1984
(The hard eyecup on the left eyepiece is original.)

Some Greenough Stereo Microscope Images

Fig. 48a is an "in context" picture of the distal area of a butterfly hind wing. Fig 48b is a higher magnification view of a colored scale patch from this area. It shows the "roof shingles" overlapping-style of butterfly scales. Both photographs were taken through Greenough trinocular microscopes. The actual view through these instruments shows greater sharpness and depth of field with direct visual observation than in these imbedded photographs.

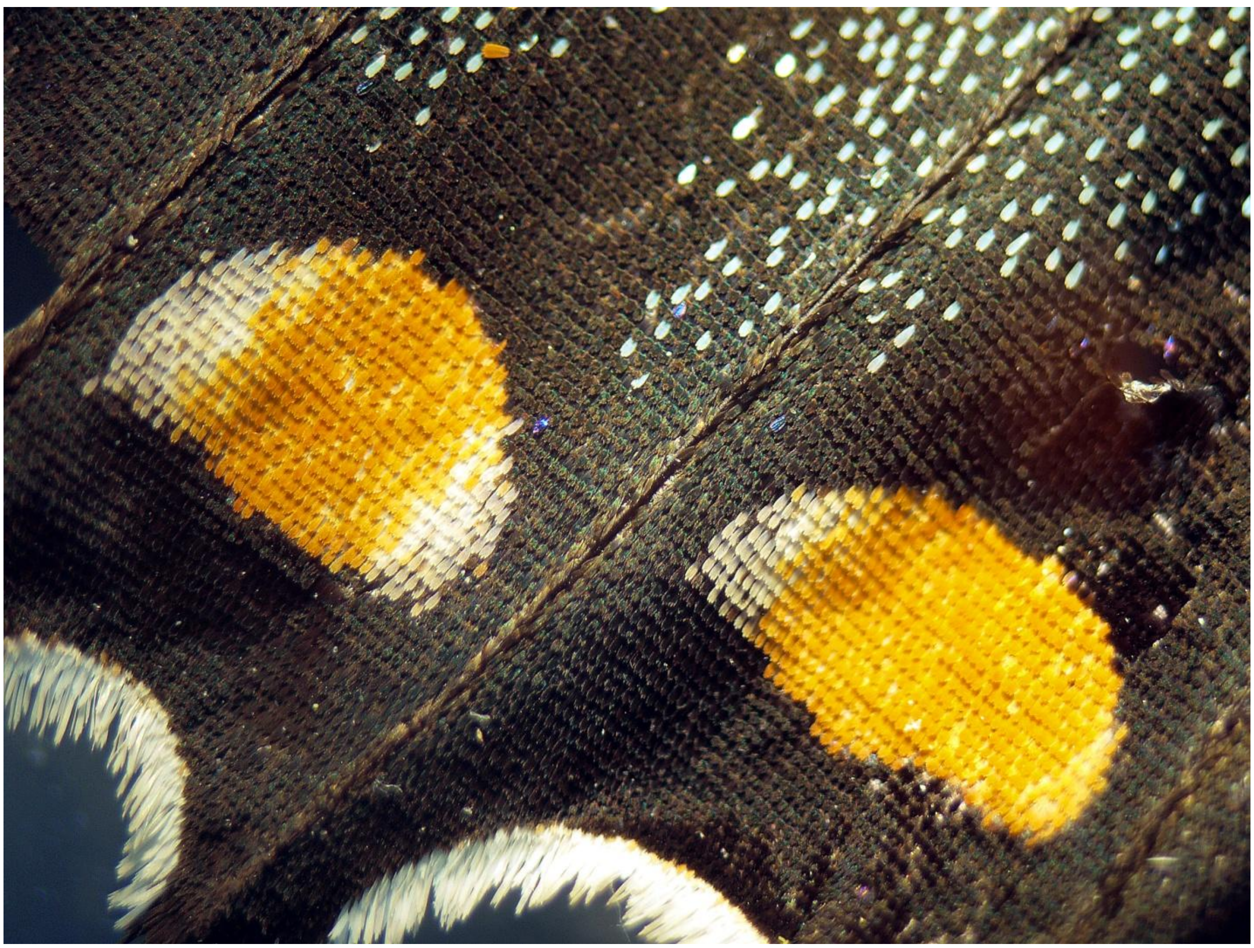

Figure 48a. Distal area for butterfly hind wing

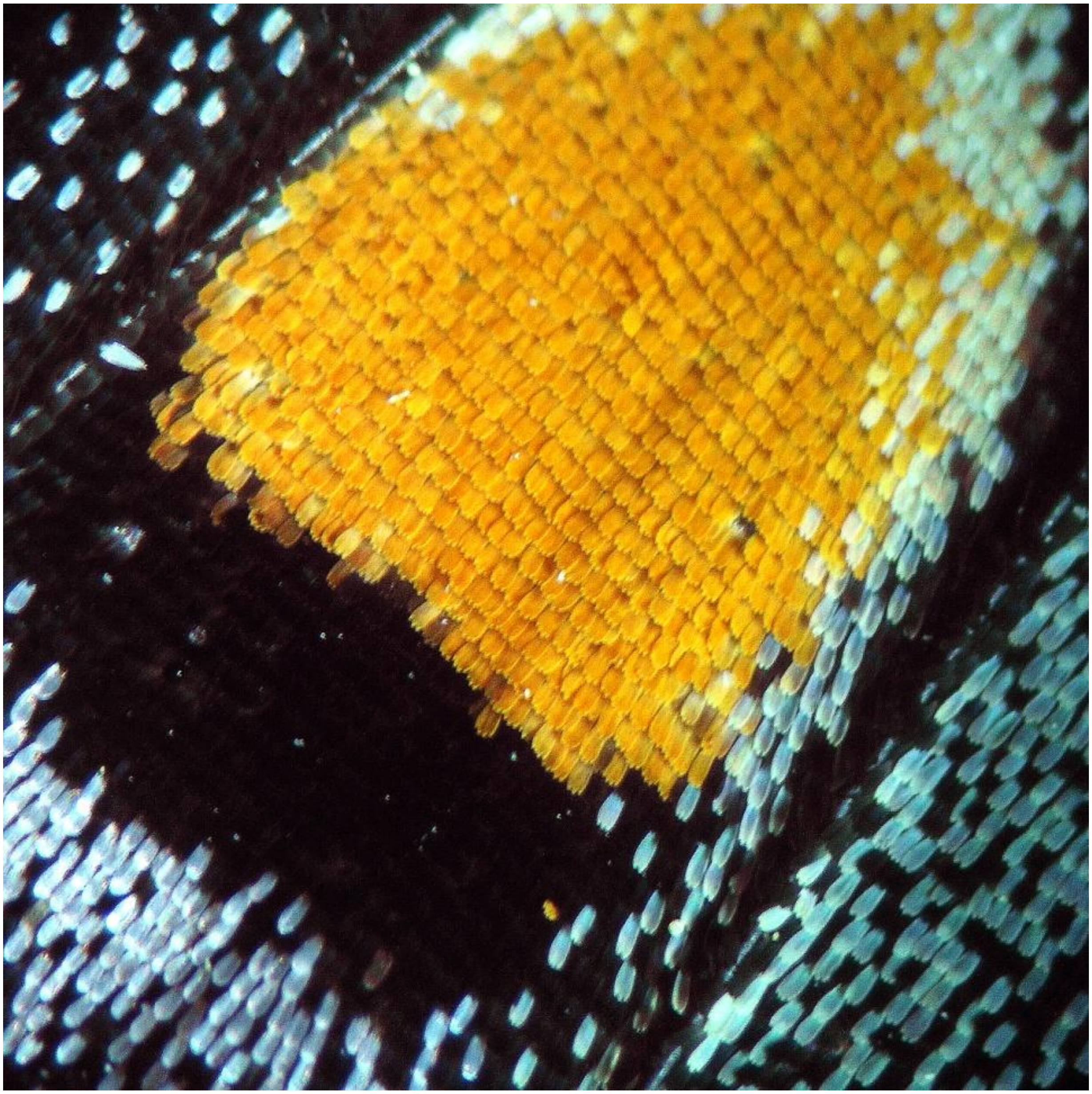

Figure 48b. Close-up of distal area of butterfly hind wing, showing "roof shingle" nature of scales.

Fig. 49 is a photograph of this same butterfly's left eye taken through another Greenough trinocular microscope. This butterfly was deceased and not killed by the author before being photographed, which explains the presence of post mortem changes and debris. These post mortem changes can be used to approximately date the earliest time of this butterfly's death.

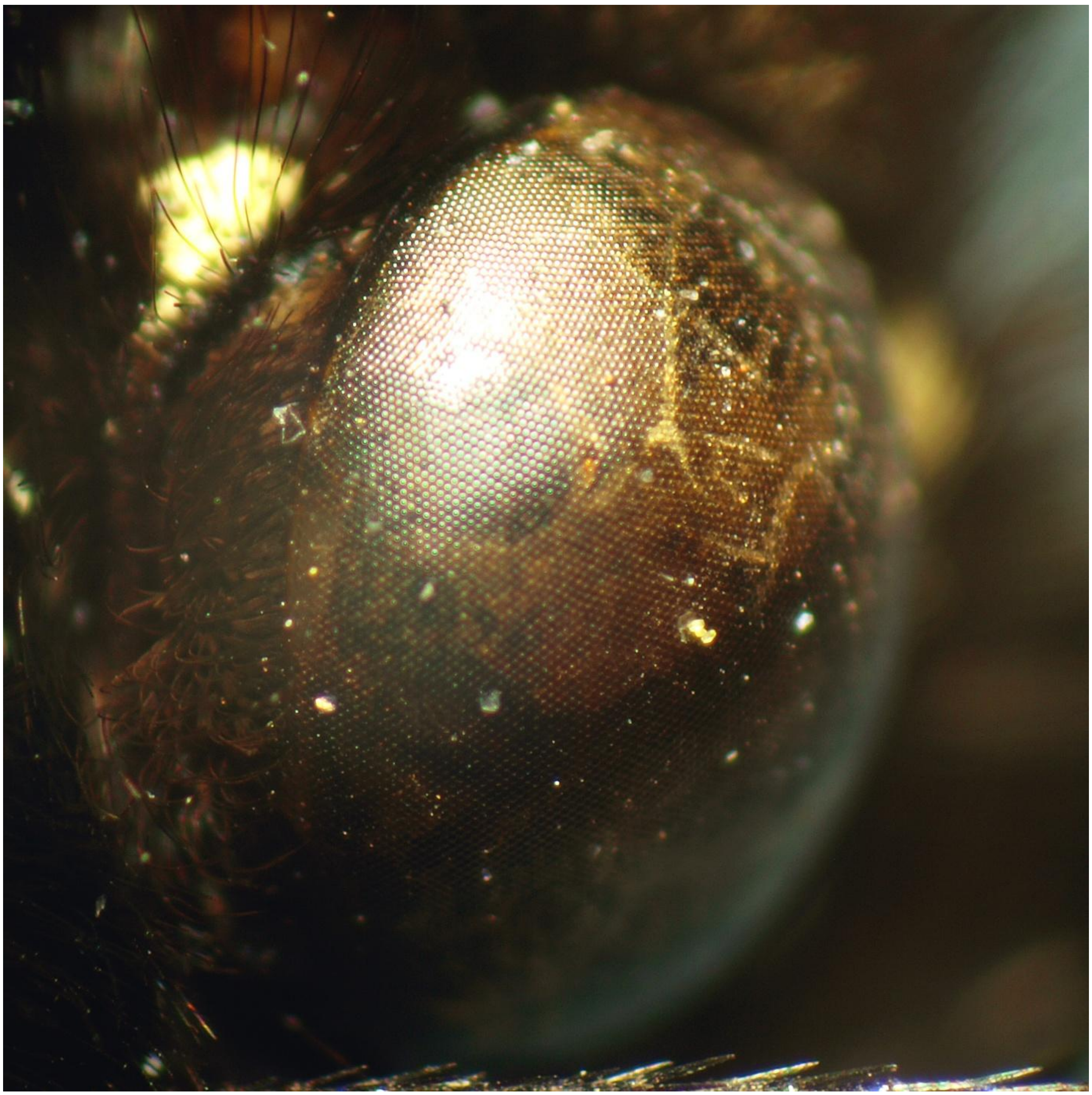

Figure 49. Post mortem. Butterfly eye taken with Greenough trinocular microscope

Figs. 50 and 51 show two Cretaceous Period fossils from Morocco photographed thorough Greenough microscopes. These fossils can probably be dated c. 100 million years ago. The coral was found in the Sahara Desert, and retains grains of angular windblown sand. The Ammonite fossil was found in the Atlas Mountain Range, in about the center of Morocco.

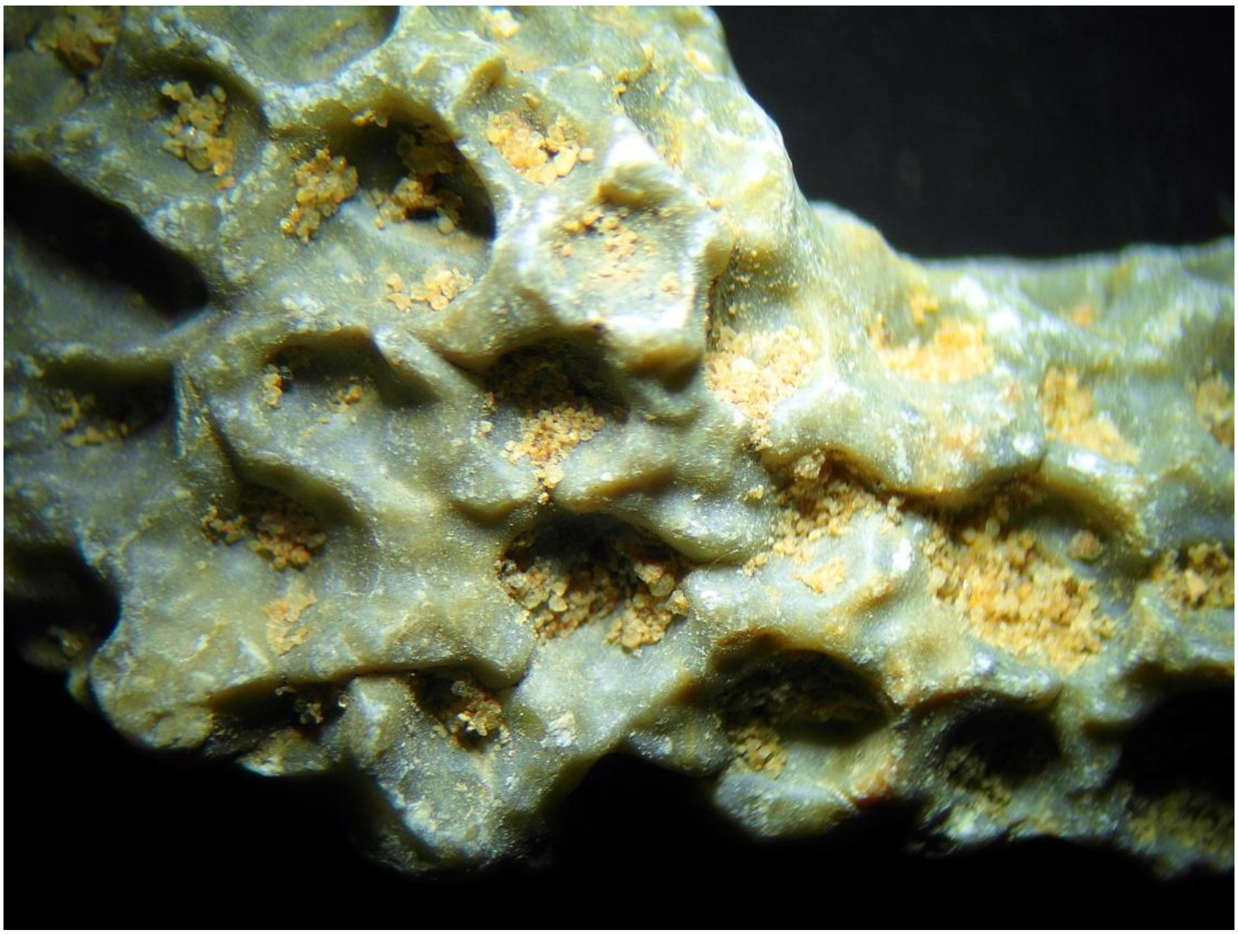

Figure 50. Cretaceous Period branch coral fossil

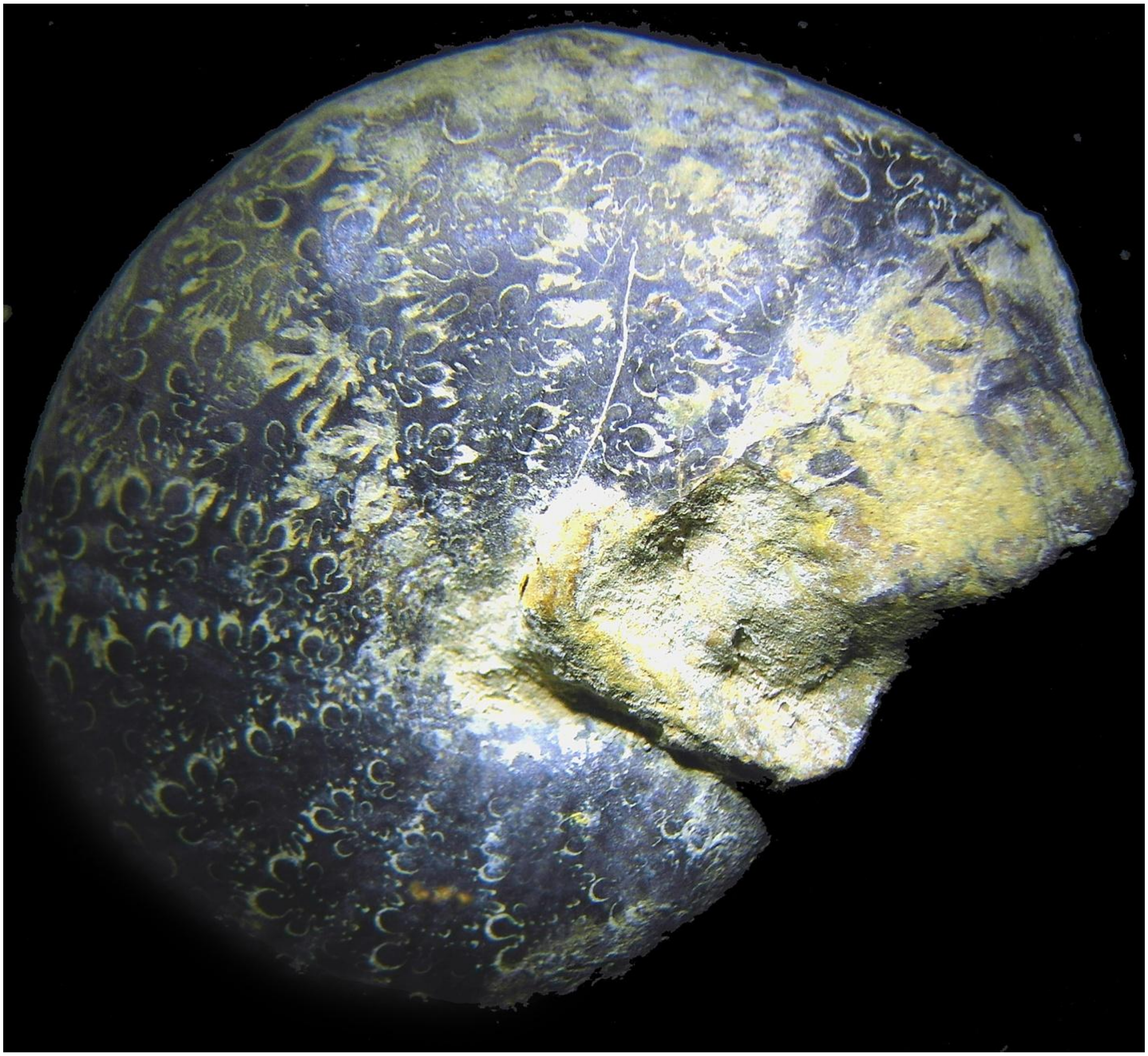

Figure 51. Cretaceous Period Ammonite fossil

Figure 52.White-spotted leaf beetle ventral view with post mortem changes (Family: Chrysomelida),

Fig. 52 shows an image of a small and colorful Asian white-spotted leaf beetle, captured through the photo port of a Greenough microscope. This leaf beetle is about mid-size (body length 10mm) in the family Chrysomelidae, where beetle size can range from about 1 to 20mm, although typically less than 12mm. This beetle has a weak clubbed (clavate) antennae, with the distal segments enlarged into small clubs. Only the proximal portion of the antennae is visible in this image. Fig. 52 shows the ventral side of this beetle with post mortem changes.

An interesting contrast is a similar-size leaf beetle, Fig. 53, with a dimpled iridescent body.

Figure 53. An iridescent leaf beetle, dorsal view

Fig. 54 shows a small portion of a U.S. 1852 silver 3 cent coin. This photograph was taken through the trinocular camera port of a Greenough stereo microscope using a mounted DSLR and 1.5x relay lens.

Figure 54. Portion of 1852 U.S. silver 3 cent coin

A comprehensive list of subjects and applications for Greenough stereo microscopes is impossible, as applications are extensive and new applications are frequently found. However, some Greenough microscope uses, in addition to those discussed above for some specialized applications, include arachnology, entomology, geology, gemology, horology, microarchaeology, micropaleontology, zoology, forensics science, materials science, numismatics, plastics, philately, safety, and textiles.

Zeiss Stereo Microscope Binocular Conversion Base

Zeiss Oberkoken c. 1980 offered a base stand to convert smaller Zeiss binoculars (i.e., the 6x by 20mm, 8x by 20mm or, 10x by 25mm binoculars) to a stereo microscope. As these binoculars use roof prisms, rather than Porro Prisms they differ slightly from the basic Greenough-design stereo microscopes. However, when converted to a stereo microscope, as in a Greenough, they use two eyepieces and two objective lenses as components of dual microscopes to obtain 3D results. Although larger binoculars will not work owing to the dimensions of the converter base, some similar size binoculars from other makers, e.g., Minolta, are also useable.

Since the acceptable binoculars have exit lenses that are relatively small, Zeiss was able to keep this stereo microscope adapter to a relatively small size. This adapter doubles the magnification of the binoculars resulting in 12x, 16x, or 20x magnification options, depending upon the Zeiss binoculars chosen. It's not possible to use binoculars with larger objectives lenses on these adapters, although other brands, e.g., Minolta's, small-size binoculars also work.

Because the adapter is relatively compact, if binoculars are already part of an excursion plan, this stereo adapter should also be considered. A picture of the Zeiss stereo stand adapter is shown in Fig. 55.

Figure 55. Zeiss binocular conversion base

The author welcomes any suggestions for corrections or improvement. He has a continuing interest in early and modern stereo microscopes from major manufacturers. He can be reached at:

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Combined References and End Notes

(This list includes references/notes for the full paper. However, additional references may be added in later Parts)

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