Happy New Year

Newsletter
Of the
New York Microscopical Society

1 Prospect Village Plaza
(66F Mt. Prospect Avenue)
Clifton, New Jersey 07013-1918
GPS: Latitude 40.8648N, Longitude 74.1540W

January 2015	**N.Y.M.S. (973) 470-8733**	**Volume 9 (29) Number 1**

New York Microscopical Society 2015 Lecture Series

Title: Glass, brass and a Lathe: Making opportunities for wonder

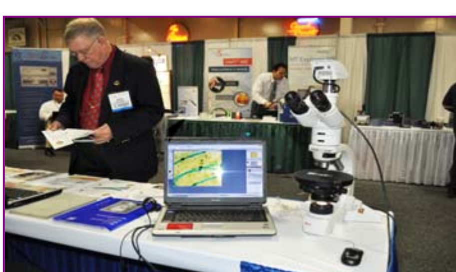
Speaker: Jay Holmes for the American Museum of Natural History
When: Sunday February 1st, 2015 at 2pm / Where: NYMS Building in Clifton, N.J.

Working at the American Museum of Natural History, and having an interest in the history of science and science education, I have been exposed to Darwin's story and the history of microscopy. I developed an interest in single lens microscopes along the way and Darwin's observations and experiences with 19th century microscopy. In this presentation I will share some stories that are the result of wanting to explore the world in some similar fashions and share that exploration with others. From collecting and using some single lens aquatic and botanical microscopes, to learning how to machine metal and make my own microscope and other tools this will be a story of learning, making and international community. The program will include some microscopes from the early 1800's and one that is just a few months old.

Jay Holmes is an educator at the American Museum of Natural History, where for 22 years he has had the opportunity to explore the world with learners of all ages. From the iconic exhibits, to Central Park to the Galapagos Islands, he enjoys thinking about the natural world, our interactions with it and our understanding of it. His fascination with microscopes and the microscopic world started in elementary school, and exploring pond life under the scope has never ceased to amaze him.

Doors will be open at Noon. Refreshments will be available. For additional information, please contact Mel Pollinger (pollingmel@optonline.net) or call (201)791-9826, between 9am & 9pm before the day of the meeting, or cell: (201) 314 - 1354 on the meeting day, from Noon to 1:30PM

NYMS Booth at EAS 2015



In Memoriam – Marge Walsh *(see page 3*

Save a Tree: Get The Extended Newsletter: By Email Only

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For additional information contact the Editor: Mel Pollinger at (201) 791-9826, or pollingmel@optonline.net

Dues and Addresses
Please remember to mail in your Dues to:
Mel Pollinger
Treasurer, NYMS
18-04 Hillery St.
Fair Lawn, NJ 07410-5207

Junior (under age 18) $10 Annually
Regular $30
Student (age 18 or above) $20 Annually
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Life $300 (payable within the year)
To avoid missing notices:
Notify Mel Pollinger if you have changed your address, phone or email.

Awards Given by the New York Microscopical Society
The New York microscopical Society takes great pleasure in recognizing and rewarding individuals who have contributed to either the activities of the society or to furthering microscopy. These awards are described in our website and in a pdf file for our email newsletter recipients. All members are eligible to nominate individuals for these various awards, and are encouraged to do so. John A. Reffner, Awards Committee Chairperson

Awards Committee
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To Order Your NYMS Lapel Pins
Send a check in the amount of $12.00 per pin to:
New York Microscopical Society
c/o Mel Pollinger, 18-04 Hillery Street, Fair Lawn, NJ 07410. To avoid shipping & handling charges, pins may be purchased directly at any NYMS meeting for $10.00.

The Mission of the New York Microscopical Society is the promotion of theoretical and applied microscopy and the promotion of education and interest in all phases of microscopy.

Alternate Meeting Notifications
Please note that due to time constraints in publishing, some meeting notices may be available by calling Mel Pollinger at 201-791-9826, or by visiting the NYMS website, or emailing: pollingmel@optonline.net

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Please remember to pay your dues

Buy and Read a Good Book on Microscopy.

Dr. Alexander Dazzi Receiving the Ernst Abbe Award at EAS from NYMS President, John Scott

Craig Prater / John Scott / Mikhail A. Belkin
Laurianne Robinet/Curtis Marcott/Alexandre Dazzi/John A. Reffner

From the Library:

The NYMS Library contains over 3,700 cataloged volumes, among these is a full set of McCrone's Particle Atlas and copies of Microbe Hunter Magazine.

Come on down and read!

Contact: Mel Pollinger (201) 791-9826, or email Mel at pollingmel@optonline. net

Be A Volunteer – There's *Always* Something to do and see at NYMS.

If you wish to contribute some of your time to NYMS, please contact me at (201) 791-9826 or by email at pollingmel@optonline.net

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Upcoming Events in 2015

Fossils in amber by Paul Nascimbene of the AMNH, to be presented at Clifton

Microscope Day – March at John Jay

In Memoriam

With a sad heart, I regret to inform you that Margaret L. Walsh died on Sunday November 9, 2014, she was 69 years old. Her life ended as result of respiratory arrest due to consequence of end stage COPD as due to injuries she sustained during the 9/11/01 attacks on the New York World Trade Center. She died in her sleep in bed in her Maplewood NJ home.

Margaret (Marge) Louise Walsh was born on March 21, 1945 to George Sr. and Louise Walsh and raised on Shelter Island.
She graduated from Shelter Island High School, where she played in the school band. For several years during high school and college, she worked as a lifeguard and manager at the Shelter Island Heights Beach Club.

Margaret went on to earn an associate degree from the Fashion Institute and then attended Hunter College.
Her professional career as a forensic scientist included working in textile technology for Better Fabrics in New York City and for U.S. Testing in Hoboken, New Jersey. She also worked in quality assurance for Frederick's Wholesale in New York and as a textile analyst for U.S Customs Services, also in Manhattan.

Marge joined the New York Microscopical Society in 1986, was a lifetime member and past president of NYMS. She was conferred the Ashby Award in 2003 for outstanding service to the Society.

Marge was a member of Marble Collegiate Church in New York. She enjoyed knitting, swimming and spending time in Fort Myers, Florida, where she had wintered since 2005. "She was a very caring person," her brother George said. She is survived by her partner of more than 30 years, Martin Youngberg, and her brothers, George Walsh of Shelter Island and Howard Walsh of Chandler, Arizona.

Donations may be made to Marble Collegiate Church, 1 West 29th Street, New York City 10001.

Martin N. Youngberg

Marge receiving the Ashby Award from NYMS President Peter Diaczuk at the 2003 Banquet.

Visitors Always Welcome to NYMS

Although most of our lecture meetings, workshops and classes are held in the NYMS Clifton facility on the last Sunday of the month, the building may be opened for special purposes at other times, by appointment only. For such an appointment, please contact Mel Pollinger by phone at (201) 791-9826, M-F noon to 9:30pm, or by email at pollingmel@optonline.net.

From The Editor...

if you have an email address: Getting the newsletter by email means you can receive an **extended pdf version** that cannot be sent by "snail mail." Even if you only continue your USPS delivery of the newsletter, NYMS needs your email address for reporting priority events and special news. Being able to contact you quickly by email means better communication between you & NYMS■■ Mel

Need to use a Microscope?

The various microscopes that are presently set up on the main floor of the New York Microscopical Society building in Clifton, N.J. are there for the use of its members.

From Gary Mayer: In need of parts for older Olympus Microscopes? Contact J.C. Ricky in Ohio at (740) 862-9252

Microscope Cleaning Kit

A complete set of tools and accessories to keep your microscope in optimum operating condition. The kit is put together by our previous Curator/Educational Chairman, Don O'Leary, and available directly from NYMS, while they last, for only $35.00 plus shipping & handling, or may be purchased at a meeting. Call or email Mel Pollinger for details (see page two for contact numbers).

NYMS Meeting Dates

Most meetings of NYMS are usually held in Clifton on the last Sunday of the months of Jan., Feb., Mar., May, Sep., Oct. Exceptions will be noted in the Newsletter.

NYMS microscope slide collections are available for study at meetings and by appointment.

Please note that our website is presently under repair.

Answer to Mystery Photo for Nov-Dec 2014

This parrot is in fact a female model who posed for Johannes Stötter, a fine art body painter. The model's arm forms the parrot's head and beak, and her legs form the wing and tail feathers. Sent in by Joan Mokray

Did you guess correctly? Judy Megerle did! Things are not always what they seem. If you have a Mystery Photo and would like to tweak our brains, please email it to me at pollingmel@optonline.net

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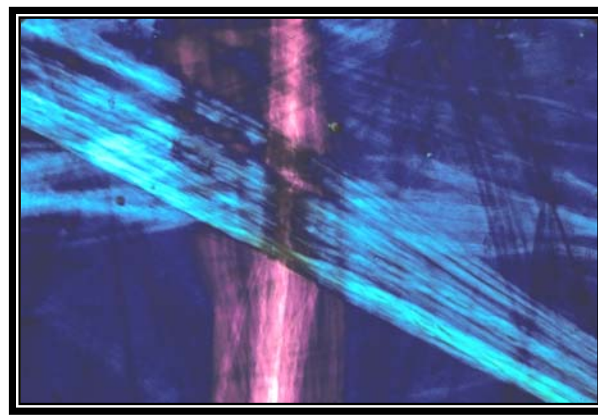
Mystery Photo for January 2015



Want to take a guess? Send it to me by email or call me: pollingmel@optonline.net, (201) 791-9826

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Additional Historical NYMS Supplements

Email Newsletter recipients will also be getting copies of NYMS Newsletter pdf back-Issues from 2007. Copies of older newsletters will be sent as I convert them.

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Attention NYMS Members

Got something to sell? Article to publish? Pictures for the newsletter? Looking to buy something? Want to use the library? Want to use a NYMS microscope?
For any of the above, contact the Editor, Mel Pollinger.

EASTERN ANALYTICAL SYMPOSIUM & EXPOSITION

Supporting Member

NYMS Extended Newsletter Section
January 2015

Directions to NYMS Headquarters

One Prospect Village Plaza
(66F Mount Prospect Avenue)
Clifton, NJ 07013

GPS: Intersection of Colfax & Mt. Prospect:
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GPS: Our building: Latitude 40.8648 N,
Longitude 74.1540 W

In This Section:

From George Washington Bridge:
Take Interstate Route 80 west to Exit 57A, Route 19 South. Take Route 19 to Broad Street and continue two lights to Van Houten Avenue. Turn Left. Go to second light, Mount Prospect Avenue and turn left. Building 66F is on the left side , one and a half blocks from Van Houton.

From Lincoln Tunnel:
Follow exit road to NJ route three west. Continue to Bloomfield Avenue exit. Turn right to Circle and go three quarters to Allwood Road West. Mount Prospect Avenue is a few blocks on the right (a small street) Turn right and go to first light (Van Houton) continue. Building 66F is on the left side , one and a half blocks from Van Houton.

From North:
Take Garden state Parkway South to Route 46 Clifton Exit. On 46 Make second exit to Van Houton Ave. Continue to third light Mount Prospect Avenue and turn left. Building 66F is on the left side , one and a half blocks from Van Houten.

From Route 46 coming from west:
Take Broad Street Exit in Clifton and follow Directions above from GW Bridge.

From route 46 coming from East: Take Paulson Avenue Exit in Clifton and follow to Second light, Clifton Ave turn right. Go to next light, Colfax, turn left, go three blocks and turn right on Mount Prospect Ave.. Building 66F is half block on right.

Public transportation from NY:
Take NJ Transit train from Penn Station to Secaucus Transfer Station. Change trains to Bergen Line to Clifton (call NJ Transit for schedules). From Clifton Station cross under tracks to first street and go left one block to Mount
Prospect Street, turn right and Building 66F is one half block on Right.

If you plan to come by bus or train, please copy the links below into your browser:
http://www.njtransit.com/sf/sf_servlet.srv?hdnPageAction=TripPlannerItineraryTo
http://www.njtransit.com/sf/sf_servlet.srv?hdnPageAction=BusSchedulesP2PTo
http://www.njtransit.com/sf/sf_servlet.srv?hdnPageAction=TrainTo

New York Microscopical Society Ernst Abbe Award Symposium on Atomic Force Microscopy Infrared Spectroscopy, *organized with the New York Conservation Foundation* Honoring Dr. Alexandre Dazzi, University of Paris-Sud Chair: John Reffner, John Jay College Program

287 How Photoacoustic and Nanomechanics Combine to Perform IR Spectroscopy at the Nanoscale, Alexandre Dazzi, University of Paris-Sud
288 Extending AFM-Based Infrared Spectroscopy to a Wide Range of Applications, Craig Prater, Anasys Instruments

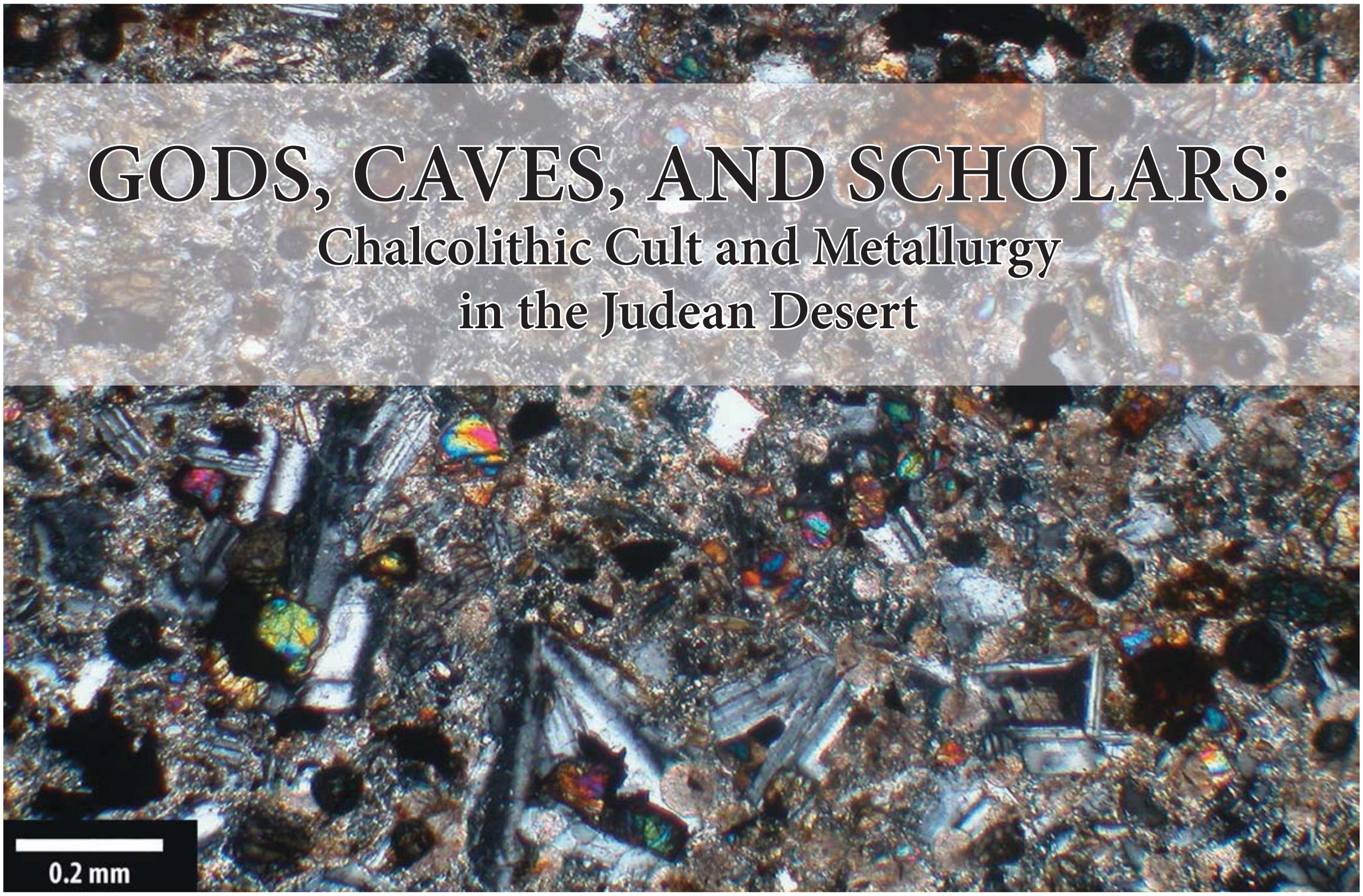
289 AFM-IR: Nanoscale IR Spectroscopy for the Materials and Life Sciences, Curtis Marcott, Light Light Solutions, Craig Prater, Qichi Hu, Michael Lo, Kevin Kjoller, Anasys Instruments

290 Tip-Enhanced Infrared Nanospectroscopy via Molecular Expansion Force Detection, Mikhail A. Belkin, Feng Lu, Mingzhou Jin, University of Texas-Austin

291 NanoIR to Investigate Parchment and its Degradation, Laurianne Robinet, Center of Research for Conservation, Gaël Latour, Ariane Deniset-Besseau, Alexandre Dazzi, University of Paris-Sud, Marie-Claire Schanne-Klein, Laboratory for Optics and Biosciences

Craig Prater / John Scott / Mikhail A. Belkin
Laurianne Robinet/Curtis Marcott/Alexandre Dazzi/John A. Reffner

GODS, CAVES, AND SCHOLARS:
Chalcolithic Cult and Metallurgy in the Judean Desert



A mixture of functionally-graded materials in the casting mold remains of a Chalcolithic copper macehead from Nahal Mishmar (IAA 61-189) seen under the petrographic microscope between crossed polarizers. The fine background pearl-white material (matrix) is calcitic lime plaster. The coarse, sharp-edged crystalline bodies is crushed basalt containing plagioclase feldspar (striped white, gray, and black elongated crystals), pyroxene-augite (smaller colorful crystals), and olivine (larger colorful crystals). Photograph and graphics by Y. Goren.

Yuval Goren

The cultural interpretation of the southern Levant during the Chalcolithic period (ca. 4500–3700 cal B.C.E.) has been one of the most dynamic fields for nearly a century of archaeological research in this region. Since the discovery of Chalcolithic remains at Teleilat Ghassul in Jordan in the 1920s–30s, our understanding of Ghassulian culture (named after the site) has undergone numerous radical revolutions. Always highly-debated, its overall and internal chronology, social and economic configuration, settlement patterns, regionalization, cultic and religious manifestations, and technological innovations have all been subject to "extreme makeovers." The ever-growing accumulation of data has led to the rejection of the majority of the initial interpretations proposed by scholars in the 1950s and 1960s, with lively debates concerning major topics continuing from the 1980s up until today (for recent reviews and references, see Rowan and Golden 2009; Lovell and Rowan 2011: 1-11). Consequently, some of the major scholars of the period have repeatedly altered their views in an attempt to catch-up with the records. Above all, simplistic explanations and ungrounded theories of the past are now being met with skepticism in light of the obvious complexity depicted by the present state of research.

This reality is demonstrated in relation to three primary topics: cult, burial practices, and craft specialization. Although the chronology of the period is generally understood now due to the abundance of radiocarbon dates and stratigraphic and typological records from numerous sites (e.g., Gilead 2009 for the beginning and Braun et al. 2013 for the end of the period), the role played by metallurgy is still widely debated. Our understanding of the cult – particularly in prehistoric hunter-gatherer or early farming societies – has always been hampered by the difficulty in discerning the "prehistoric mindset." Over the past two decades, several – frequently conflicting – attempts have been made to interpret it on the basis of finds at Teleilat Ghassul, Ein Gedi, and Gilat (Bourke 2001; Gilead 2002; Levy 1995, 2006). Although the advances of scientific methods in archaeology have deepened our understanding of the technological aspects of Chalcolithic metallurgy, this circumstance has merely increased the confusion and divergence among scholars, and consensus on these matters remains as distant as before.

Chalcolithic Metal Production

The discovery of the Nahal Mishmar hoard (Bar-Adon 1980) constituted a turning point in the study of the Chalcolithic period. It quickly became evident that most of the artifacts found were made of copper or copper alloys demonstrating skillful craftsmanship and technology. Together with lesser numbers of similar artifacts from other sites, this evidence constitutes a major database for the copper industry of the southern Levant.

Typological and metallurgical examinations of copper artifacts from Nahal Mishmar and elsewhere indicate a relatively clear dichotomy between simple working tools (i.e., axes, adzes, awls), made of nearly-pure copper by open casting, and elaborate "prestigious" items (maceheads, standards, crowns, etc.) made by the "lost-wax" casting technique of copper alloys with arsenic, antimony, and sometimes nickel and bismuth (e.g., Key 1980; Shalev and Northover 1993; Shalev 1995; Tadmor et al. 1995; Golden et al. 2001; Namdar et al. 2004). The two different technologies frequently being assumed to reflect two distinct production traditions, scholars generally considered the simple working tools to have been produced locally in the northern Negev sites and the elaborate prestige objects to originate from an as-yet-unknown center – possibly near the remote sources of arsenic-antimony copper (in the Caucasus or eastern Anatolia) or somewhere in the southern Levant.

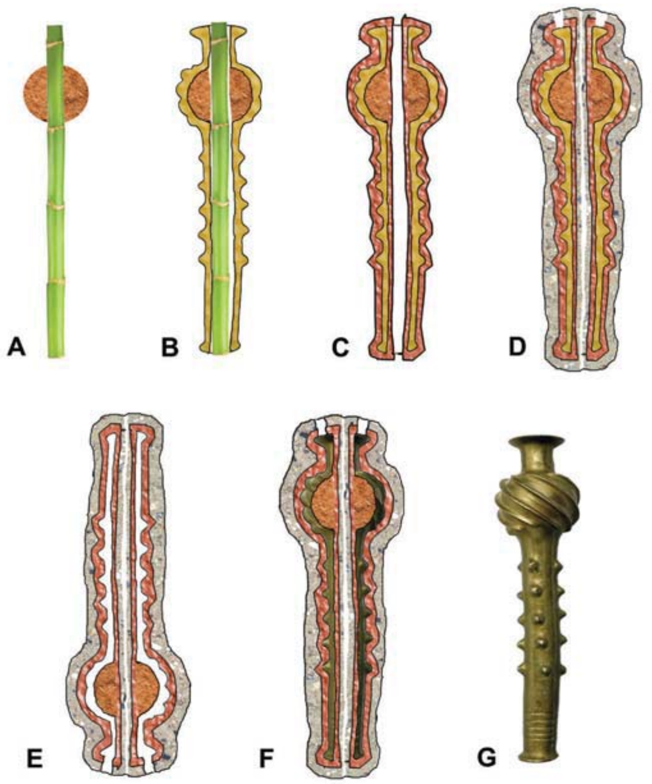


Figure 1a–g. Production process of a copper alloy artifact by the lost-wax casting technique (refer to the text for details). Graphics by Y. Goren.

Various studies of elaborate Chalcolithic artifacts lead to the conclusion, widely accepted now but not agreed by all, that these items must have been of local production. On the basis of the spatial distribution and broad chemical variability between the artifacts, Tadmor et al. (1995) suggested that several production centers existed. If this theory is correct, arsenic-antimony-rich ores or ingots were brought to the southern Levant by long-distance exchange – most likely from Anatolia or the Caucasus, where such ores are prevalent – and used locally to produce objects in a highly-specialized workshop. Alternatively, the imported alloying minerals were mixed with local copper in order to create the desired alloy. Both these possibilities raise numerous questions regarding the development of such complex technology at a formative stage in an area where arsenic and antimony minerals do not occur. Interestingly, this type of metallurgy was subsequently abandoned during the Early Bronze Age, and only the simpler techniques were preserved (Shalev 1994).

Although similar artifacts were already found at other sites, this immense gathering of items has inspired speculation about the circumstances that caused the hiding of this hoard in such a remote location. Based on its relative proximity to Ein Gedi, 15 km to the north, and a visionary narrative attempting to explain the contrast between the assumed function of the site as a major temple and the material culture found in it, mainly pottery fragments and animal bones thrown into the pits within the main structure, Ussishkin (1971, 1980, 2014) suggested that the hoard, being the cultic furniture of the temple, was hidden in the inaccessible cave in times of trouble, never to be recovered. The lack of any radiocarbon date from the reported organic materials at Ein Gedi – such as the burnt twigs, carbonized wood, palm fronds, and reeds (Ussishkin 1980: 15–16, 28) – however, precludes any conclusive determination in this regard, as the hoard quite plausibly could date to a century or two before or after the short-lived single phase of the supposed temple (ibid: 29).

In reality, Chalcolithic metal artifacts were always found in indisputable habitation sites (Abu Matar, Bir es-Safadi, Giv'at Ha-Oranim, Shiqmim), burial caves (Palmahim, Nahal Qana, Peqi'in), and caves in the Judean Desert (Nahal Ze'elim, the Sandal Cave, Nahal Lahat). In the majority of cases, the implements (whether "mundane" or "prestigious") were found as caches in pits or as concentrations on floors. Recent research has shown that metal artifacts were used during the Chalcolithic over a longer timespan than previously thought (Shugar and Gohm 2011). Despite the allegedly long period of occupation and abundance of apparently cultic artifacts at Gilat (ibid: 841), no metal object or waste has been found at any Ghassulian cultic site – neither Ein Gedi nor the "sanctuaries" at Teleilat Ghassul (Bourke 2001: 130–33) and Gilat (Levy 2006: 95–212),

This inconsistency seriously challenges the above interpretation – or at least calls for its grounding upon a firmer basis. This fact, combined with the new archaeological knowledge obtained over the past half century, has been the background of my studies during the past thirty years with a view to produce explanations that have a more rigorous scientific basis.

The Lost Wax Technique

While Chalcolithic copper objects represent the earliest use of the lost wax technique known thus far, the technology has been used for thousands of years in many cultures to produce objects in metal that, due to their complex shape and the need to preserve undercut outlines, could not be made by other methods. The traditional application of this technique, became almost extinct before and during the twentieth century. However, it is carried on in the manufacture of small pieces by Hindu metalworkers in India (Kochhar 2001; Levy et al. 2008). Tribes in West

Bengal, known as the Dhokra, also use this technique, and the items made in this tradition are sometimes called Dokhra after their producers. During the last decades these industries have undergone significant changes due to the increase of tourism interest, and new methods and materials are being introduced (Smith and Kochhar 2003). Therefore, only traditional methods and materials, still recorded by some anthropologists, remain relevant to the present discussion.

In the traditional process, a figure is first roughly modeled in clay mixed with finely sieved vegetal matter to form a ceramic core, over which the desired shape is to be applied (fig. 1a). Next, a model of the planned metal artifact is formed using beeswax mixed with tree resin over the core (fig. 1b). Then a mold can be created over the wax model by various means. In the basic construction, the wax model is first coated with a thin layer of fine clay in order to preserve its delicate patterns (fig. 1c). Coarser layers are then added in order to build up a mold that can be handled and into which the molten metal can be poured (fig. 1d). When it has dried, the mold is heated until the wax melts and can be poured out (fig. 1e). The molten metal is then poured into the mold (fig. 1f) using a crucible. The crucibles can be obviated, however, by melting scrap metal in a special chamber in the mold (Capers 1989). When the latter mold is carefully chiseled off, it reproduces each detail of the original wax (fig. 1g).

This technology leaves no visible evidence except for small fragments of the outer mold layers (not preserving the imprints of the wax model) and small crumbs of the inner layer carefully chipped off the final metal product (fig. 4h). If the smelting of copper from ores was done somewhere else and the production relied solely on scrap or metal ingots with no tuyères (ceramic bellow nozzles) being used to protect the bellow pipes, the only evidence for the furnace would be a stone-lined hearth and some fired clay crumbs. Archaeological evidence for the activity can therefore only be adduced if the site deposits are subjected to scientific analyses.

In modern workshops, the mold construction method is called "ceramic shell" or "investment casting." Instead of the traditional clay and grass or dung, silicaceous clay, lime, or gypsum plasters are used to cover the wax model by dipping or pouring. Special refractory sand is then applied to the wet pattern, covering the wet areas until no more will adhere. When the coated pattern has dried, another layer of wet material and sand is applied. This is repeated using coarser aggregate on the outermost layers until the mold is sufficiently thick to hold together through the burnout and pouring. Finally, the mold is broken off the metal after cooling.

The Study of Ceramic Remains on Chalcolithic Copper Objects

The conclusions I have drawn from my research – spanning over 30 years with a continuous buildup of data (contra Ussishkin 2014: 23–24) – have inevitably undergone various evolutions. Based on the limited petrographic examination of pottery from Ein Gedi in 1985 for my MA thesis, I observed an unexplained fabric that the scanty data at hand at the time suggested to have originated in the eastern Jordan Valley (Gilead and Goren 1989: 7).

At that point in time, Varda Sussman, curator of the storehouses at the Israeli Department of Antiquities and Museums, allowed limited extraction of very small samples. After the establishment of the Israel Antiquities Authority, this policy changed, with the new head – Baruch Brandl – permitting more extensive sampling. Taking numerous samples and comparative sediments from many sites for my Ph.D., I was able to relate this group to the Moza formation of the Judean and Samarian Mountains, providing the logic and supportive data for the shift of interpretation in detail in a following publication (Goren 1995: 300–03). At the same time, I was allowed to take tiny crumbs from what were thought to be the ceramic cores of ten copper implements from the Nahal Mishmar hoard. Together with three samples from other sites, the materials observed in these 13 objects were presented as a brief appendix to that work, combined with a preliminary interpretation (ibid: 304–05).

It was not until a decade later that I was allowed to take sufficient samples from the ceramic fragments attached to numerous copper implements from Nahal Mishmar and elsewhere by the new curator in charge at the Israel Museum in Jerusalem, Osnat Misch-Brandl. With the better sampling of previous items and

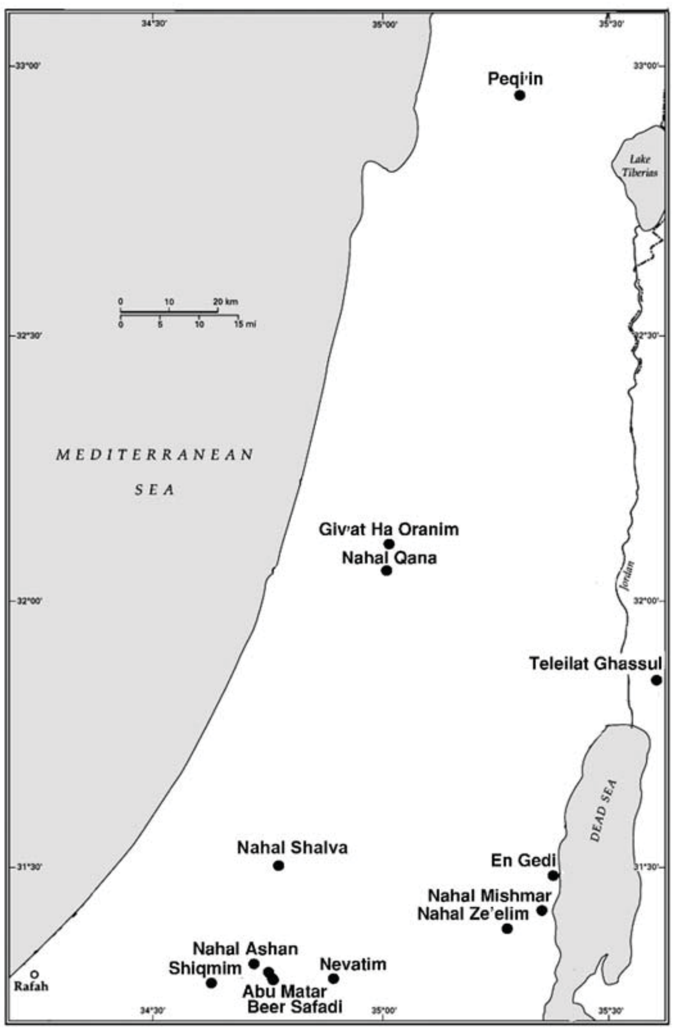


Figure 2. Map of the southern Levant with the find sites of the Chalcolithic copper artifacts included in this study. Graphics by Y. Goren.

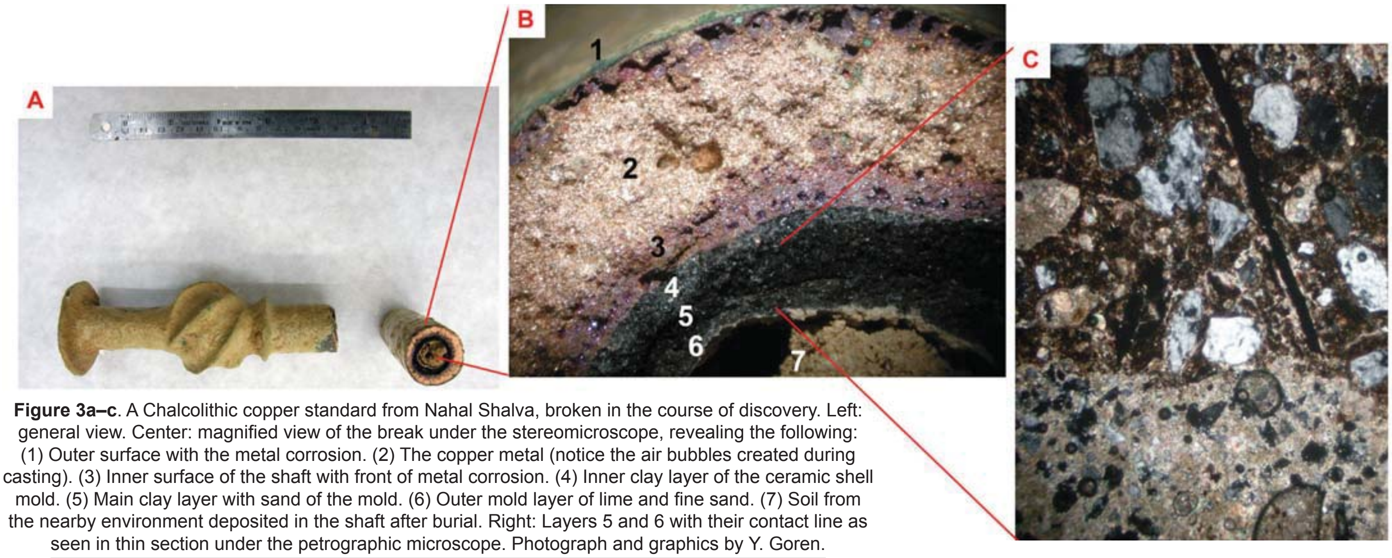


Figure 3a–c. A Chalcolithic copper standard from Nahal Shalva, broken in the course of discovery. Left: general view. Center: magnified view of the break under the stereomicroscope, revealing the following: (1) Outer surface with the metal corrosion. (2) The copper metal (notice the air bubbles created during casting). (3) Inner surface of the shaft with front of metal corrosion. (4) Inner clay layer of the ceramic shell mold. (5) Main clay layer with sand of the mold. (6) Outer mold layer of lime and fine sand. (7) Soil from the nearby environment deposited in the shaft after burial. Right: Layers 5 and 6 with their contact line as seen in thin section under the petrographic microscope. Photograph and graphics by Y. Goren.

62 additional artifacts, it became clear that the ceramic fragments were in most cases multilayered casting molds constructed out of composite materials. This new interpretation was discussed and explained in detail in my 2008 publication (Goren 2008: 383–90, footnote 2). Based on this new data, a revised overview has been suggested. This is the normal process of a long-term research project where new data offer new explanations. Rather than being embarrassed by such revision of my views, as opposed to those maintaining their unsupported hypotheses for half a century, I take pride in endeavoring to ensure that my conclusions are dictated by the latest evidence and research as this is the way science advances.

The petrographic analysis of ceramic components of 76 Chalcolithic copper implements from eight sites spread all over the country (fig. 2) revealed three principal classes of materials: clay from the Moza Formation mixed with grass, ferruginous clay mixed with quartz sand, and lime plaster mixed with crushed basalt or quartz. Significantly, on many occasions two of these classes formed layers within the same artifact – attesting to the fact that they constitute the remains of casting molds not completely removed after casting. In most cases, these leftovers mainly remained in the inaccessible inner crevices, as represented par excellence by a copper standard found at Nahal Shalva – a site on the southern fringe of the modern city of Kiryat Gat – where salvage excavation unearthed a set of pits, two of which were connected by a tunnel (Y. Israel, personal communication). A broken copper standard was found at the site during a test trench dug by backhoe prior to the excavation (fig. 3a). The layers of the ceramic shell mold and their composition can be clearly seen in the cross-section and under the petrographic microscope (fig. 3b–c). This technology indicates that Chalcolithic mold construction using the lost wax technique was well-established and performed by specialists. The striking standardization of the technique also precludes the possibility that such objects were produced by itinerant craftsmen, suggesting on the contrary that the items were all produced by a single workshop cluster.

Simulation of the Technique

In an attempt to reconstruct the technology as revealed by this study, the process was simulated with the collaboration of Ilan Shoshani and his team at Esh Casting workshop in Beit Nekofa, Israel, who specialize in producing artistic casts using the lost wax technique. Wax copies were made of the Nahal Shalva standard (fig. 4a) and then soaked in a mixture of Moza clay, goat dung, and water (fig. 4b). After drying, the process was repeated several times to form a layer several millimeters thick (fig. 4c). Finally, the copies were immersed in lime mixed with quartz sand and water (fig. 4d). After this, another shell was applied to create a thicker mold (fig. 4e). When this had dried, the wax was removed by heating (fig. 4f). Molten copper with added antimony was then cast into the mold (fig. 4g) and left to cool, after which the mold was broken (fig. 4h) to reveal the final product (fig. 4i).

Back to Ein Gedi

The results of this study make it clear that although Chalcolithic production techniques may be compared with contemporary traditional crafts to a certain degree, they are far more sophisticated and thus more analogous with the mold construction techniques used by modern workshops. This is reflected in the fact that functionally graded materials and mixtures were combined to make the inner and outer shells of the mold, as in modern ceramic shell technology. This technique creates thin-walled, multilayered molds in which each layer is composed of a different material. Clearly, these materials have been selected for their refractory properties, as they do not necessarily represent the geology of the immediate surroundings of the workshop. Still, refractory clays, quartz sands, and basalts not being scarce in the southern Levant, they are likely to have come from locations in fairly close proximity to the workshop.

Because the main concentration of copper artifacts was found in the Judean desert, the raw materials forming the molds (Moza clay, ferruginous shales, quartzitic sandstones, basalts) are found in the lower Jordan Valley, and many of the motifs depicted by the items (ibexes, vultures) relate to local desert fauna, I suggested that this was likely to have been the production area – a thesis that immediately calls to mind the fenced complex of buildings and installations on a remote platform found at Ein Gedi (fig. 5). Ritualization of metallurgy is a phenomenon commonly encountered

Figure 4a–i. Modern simulation of the casting process of the Chalcolithic standard shown in fig. 3 (refer to the text for details). Photographs and graphics by Y. Goren.

in anthropological studies of recent aboriginal societies (Eliade 1978). Ethnographic data from metal-producing societies indicates that metallurgy was frequently performed by small groups of men in isolated locations, often being associated with shamanism and magic (for a recent overview, see Gošić 2013: 183–235). The limited data from Ein Gedi (below) and the general archaeological invisibility of the technique led me to tentatively propose that it may be related with such activities (Goren 2008: 390–93).

Interpreting the Chalcolithic site at Ein Gedi is not an easy task. While cultic practices are attested during the Chalcolithic period, cultic activity in early farming societies was most likely not established by formal institutions such as temples and priests, a reality that belongs to later (late fourth millennium and later) urban and state cultures (Gilead 2002). Although cultic objects such as ceramic, ivory, and stone figurines have been found at Chalcolithic habitation sites, burial caves, and cultic areas within settlements (i.e., Gilat and Teleilat Ghassul), Ein Gedi contains no cultic material culture. Ibex horns in refuse pits (dubbed "favissae" by Ussishkin 1980) do not reflect cultic activity at a site where, even today, ibexes roam daily. While the abnormal frequency of cornets in the pottery assemblage is unusual, it exhibits strikingly similar features to the markedly domestic assemblage from the nearby Moringa Cave, a few minutes' walk away (Porath et al. 2007).

Combined with our current knowledge of Ghassulian culture, which has changed so drastically over the last half century, these data make an interpretation of the site at Ein Gedi even more challenging, especially since the site has been excavated in its entirety, without leaving any remnant for further research. The excavation

Figure 5. The Chalcolithic site at Ein Gedi. Photograph by Y. Goren.

report gives us no stratigraphic section nor detailed drawing of any so-called favissa to permit differentiation between these and the pits so prevalent at other sites from this period. Ein Gedi is in fact the only major Chalcolithic site excavated before and after 1960 whose final report contains no stratigraphic section whatsoever. Similarly, the only explanation of material culture offered is for pottery, some flint, and fragmentary information regarding other finds.

Since most Chalcolithic habitation sites contain numerous pits, often filled with successive layers of sediments and fragmented finds, the stratigraphy of the pits, the floors above them, and the overlaying debris could supply some evidence for the nature and use of the complex. A good example of such a case is an earlier report by Perrot (1955: 23–40), which discusses the function and sequence of the various features at Abu Matar (Beer Sheva) on the basis of detailed stratigraphic cross-sections. The size of the main building at Ein Gedi does not, per se, necessarily indicate cultic practice, since an equally large building was found in the evidently domestic village at Bir es-Safadi (Perrot 1984).

Much of the interpretation of Chalcolithic sites rests on studies of faunal and floral remains – as in the northern Negev sites, whose function and socio-economic aspects have been based on such studies (Perrot 1955: 83–84; Grigson 1995a, b, 2006 with more references therein). The rich faunal remains from the main structure at Ein Gedi were unfortunately lost before publication; all my attempts to locate them in four departments of two universities ended in failure. We therefore cannot conclusively determine whether the site was used for cultic, domestic, or other functions. The reference to the flint assemblage is scanty, though flint implements can be found around the site and in the dump – an unfortunate circumstance given the importance of flint assemblages for assessing the economic nature of contemporaneous sites (Gilead et al. 2010 with more references therein). These facts, together with the lack of absolute chronology, make it very difficult to establish any linkage between Ein Gedi and the Nahal Mishmar hoard solely on the grounds of their alleged cultic function.

Research into the Chalcolithic period of the southern Levant is undoubtedly one of the most challenging, intriguing, and rewarding tasks for archaeologists of this region. With diminishing returns from the process of trial and error, an ever-growing body of data, and a seemingly endless store of surprising discoveries, this field has witnessed numerous "paradigm shifts" over the years. In my opinion, this is precisely what makes archaeology such a fascinating enterprise.

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ABOUT THE AUTHOR

Yuval Goren is professor of archaeology at Tel Aviv University where he has been teaching for twenty years. He joined the faculty of Tel Aviv University after graduating from the Hebrew University of Jerusalem and working for several years as a researcher in the IAA. He served as the Head of the Department of Archaeology and Ancient Near Eastern Cultures and as Vice Dean of the Faculty of Humanities at Tel Aviv University. Goren was the initiator and head of the graduate program in Archaeology and Archaeomterials and the Laboratory for Comparative Microarchaeology at Tel Aviv University. His research focuses on early technology and provenance of ceramics using petrographic and geochemical methods. Goren co-directed the excavations of Chalcolithic sites at Nahal Sekher and Kissufim cemetery. Recently he is directing the excavation at Tel Sochoh.

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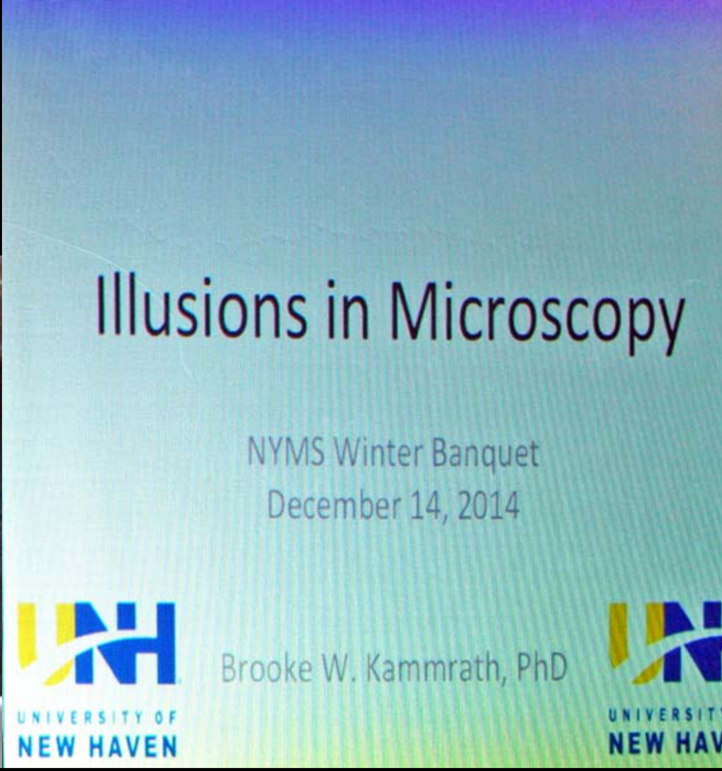

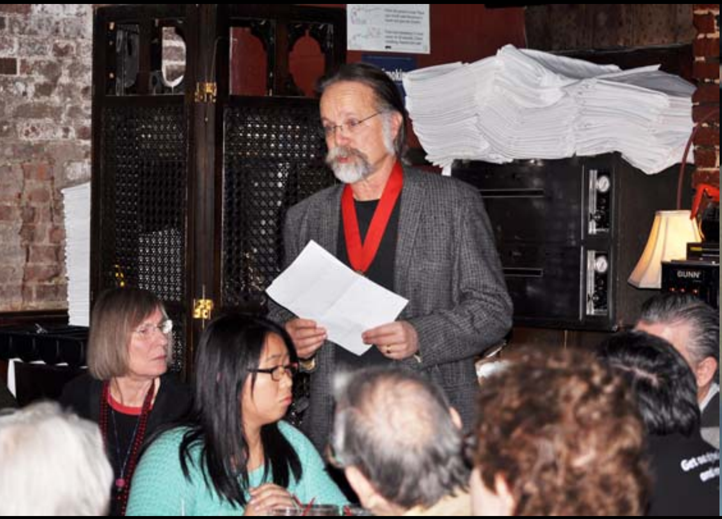

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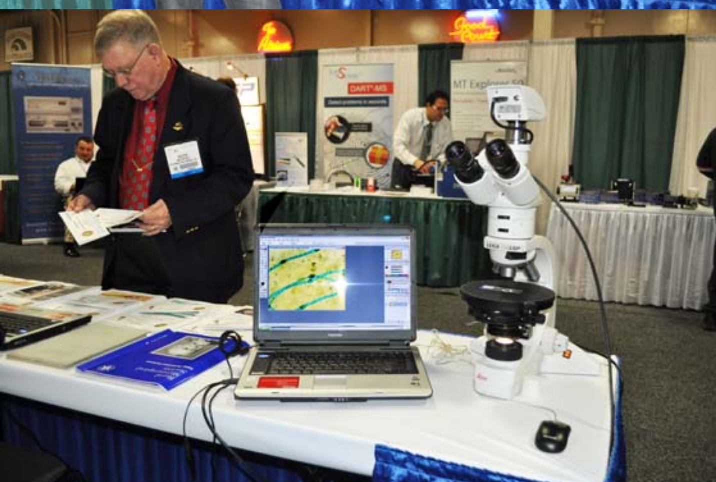

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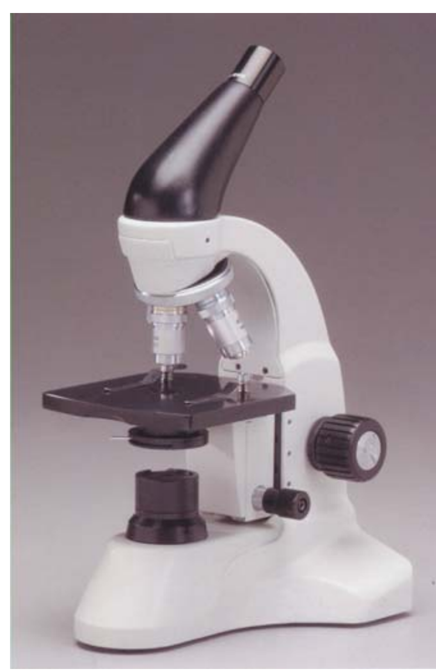

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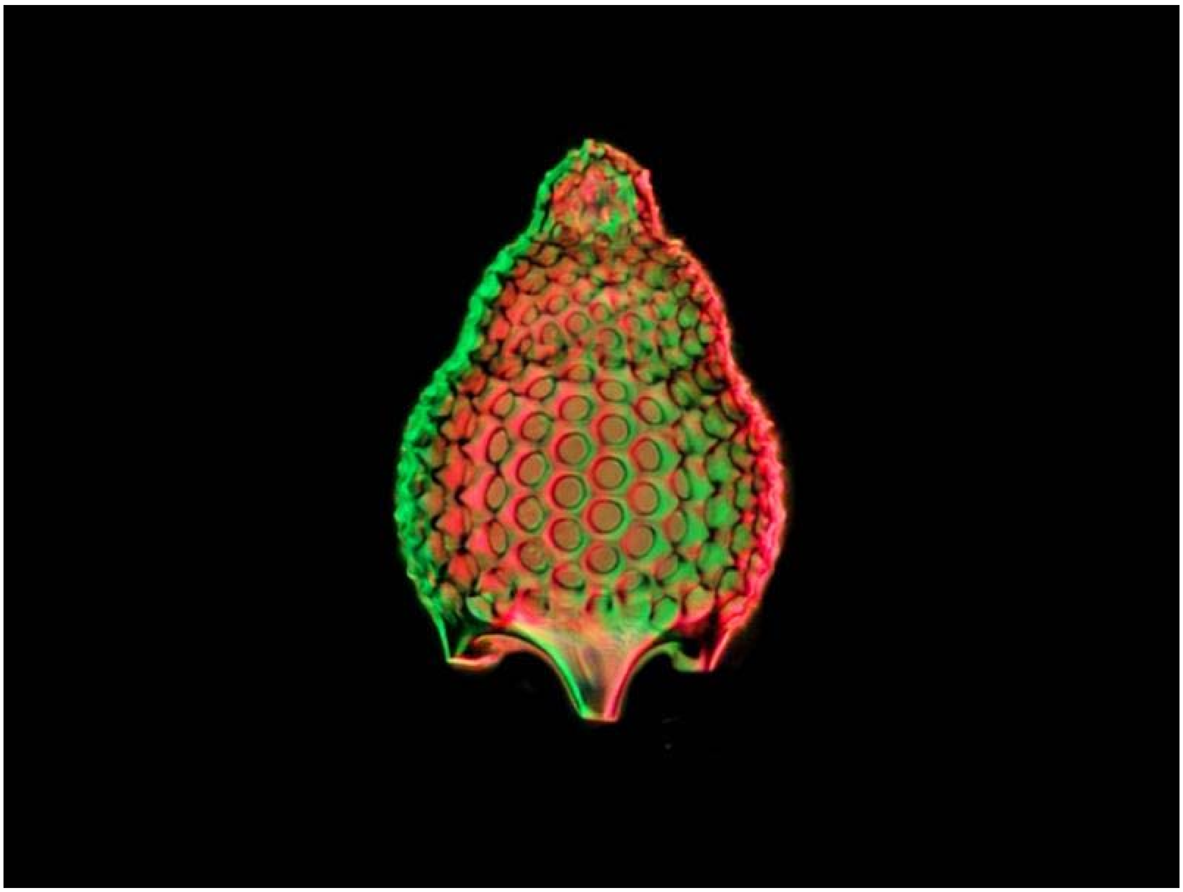

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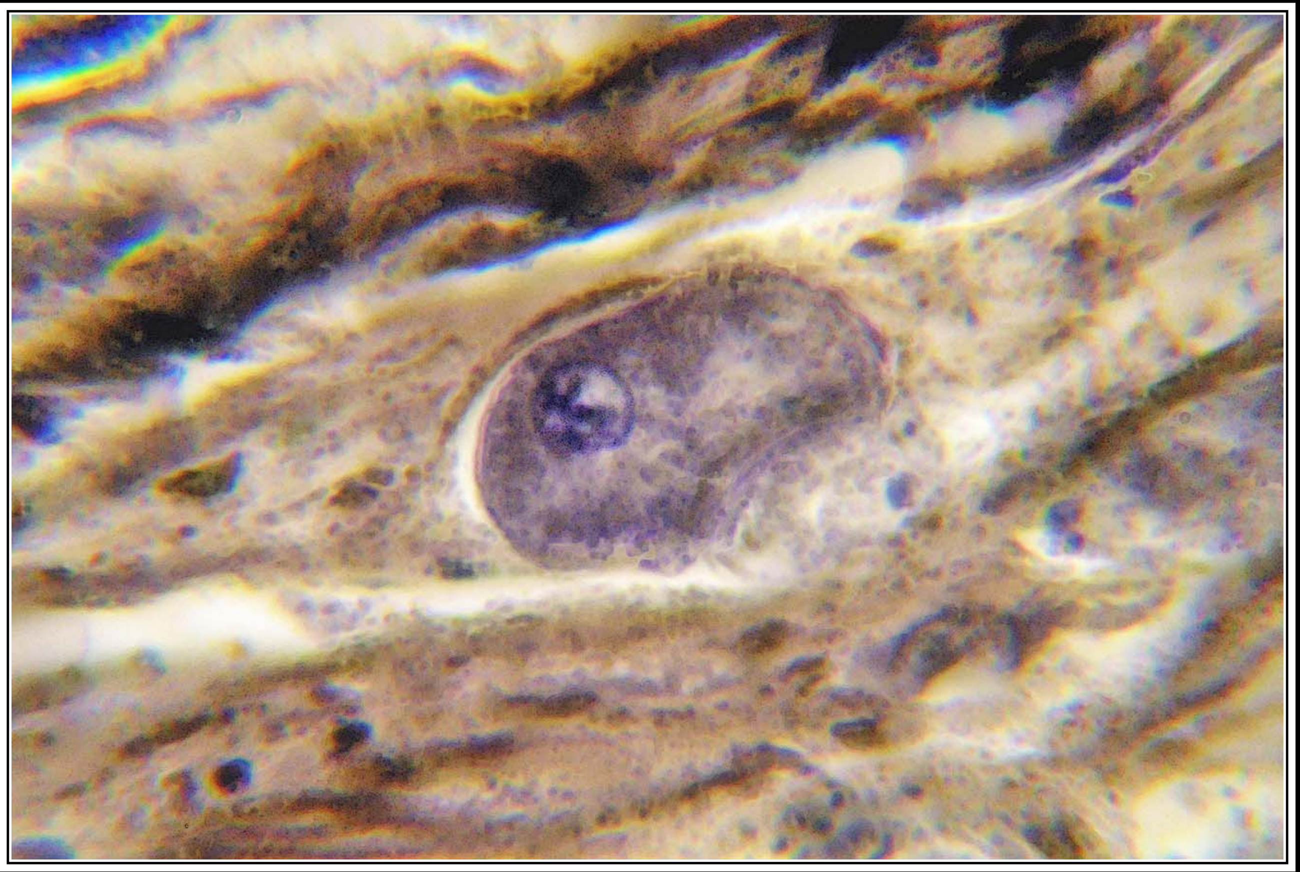

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