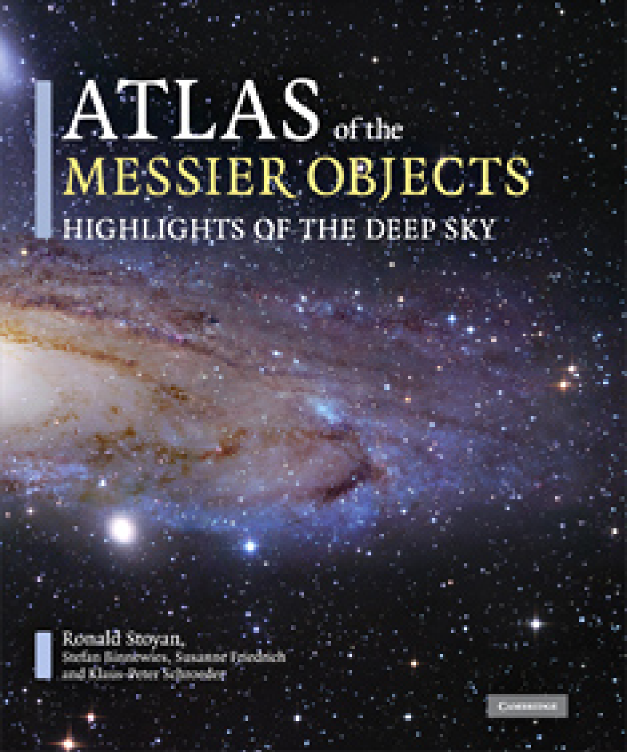

ATLAS of the MESSIER OBJECTS

HIGHLIGHTS OF THE DEEP SKY

Ronald Stoyan,
Stefan Binnewies, Susanne Friedrich
and Klaus-Peter Schröder

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Atlas of the Messier Objects
Highlights of the Deep Sky

The 110 star clusters, nebulae and galaxies of Messier's catalog are among the most popular of all the deep sky objects and are beautiful targets for amateur observers of all abilities. This new atlas presents a complete account of all of the Messier objects, detailing, for each object:

- its astrophysical significance
- well-researched background on its discovery
- clear observational descriptions from naked eye through to large telescopes
- observations and anecdotes from Messier himself and other famous observers from the past

In addition, this atlas has some of the world's finest color astrophotos, inverted photos that have been labeled to point to hidden details and neighboring objects, and historical sketches alongside new deep sky drawings, helping to bring the Messier objects to life.

Painting an engaging portrait of Charles Messier's life and observations, this is the most far-reaching and beautiful reference on the Messier objects there has ever been, and one that no observer should be without!

RONALD STOYAN is editor-in-chief of *interstellarum*, one of Germany's main astronomy magazines. He was the founding director of the German deep sky organization 'Fachgruppe Deep-Sky', and has authored and coauthored six books on practical astronomy.

STEFAN BINNEWIES is a leading astrophotographer and travels around the world to get the best shots. He has worked on several amateur observatory projects, including helping to establish the Capella Observatory near Windhoek, Namibia.

SUSANNE FRIEDRICH is an editor for *interstellarum* and a visiting scientist at Max-Planck-Institute for extraterrestrial physics. A trained astrophysicist, she has been observing the sky both visually and photographically for more than 25 years.

KLAUS-PETER SCHROEDER is Professor of Astronomy at the University of Guanajauto, Mexico. An avid amateur astronomer and photographer since youth, he has published several books on astrophotography and is a regular contributor writing for amateur astronomy magazines.

Cover illustration: A majestic view of M 31, M 32, and M 110, our intergalactic neighbors. This image was taken by Robert Gendler in September and November, 2005. A 20-inch reflector was used at 4000mm focal length, total exposure was 90 hours with a SBIG CCD camera STL-11000XM, from Nighthawk Observatory, New Mexico, USA.

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Dedicated to the memory of my brother Norman Stoyan (1975–2003)

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Foreword

David H. Levy

Why yet another Messier catalog book? With Kenneth Glyn-Jones, Stephen James O'Meara, and Ken Graun, haven't we had enough? No, I say! And especially no when the latest addition to the canon is Ronald Stoyan's scholarly, historical, astrophysical, and superb look at the great comet hunter and the list of objects he compiled during his lifetime.

This book is the first scholarly look at the catalog since Glyn-Jones, and that effort is almost half a century old. Stoyan explores the latest astrophysical research concerning each of Messier's 110 deep sky objects. Stoyan could well devote his entire book to the astrophysics of Messier's first object, the Crab Nebula, and I still subscribe to the belief that I read years ago that astronomy has two parts: that of the Crab and that of everything else. From the first time I looked at M 1 on September 1, 1963, I've been fascinated by the ghostly luminescence of the Crab, but never more so than when it seemed ablaze again not with a new supernova, but with nearby Saturn visiting at nearly the same spot from which the original star first became visible on July 4, 1054.

Next comes the historical view: I cannot get enough of the life of Charles Messier, who lived, observed, searched, and suffered some two hundred years ago. This observer's life story is compelling, and Stoyan's retelling adds new material. Although he was not the first person to discover a comet with a telescope, Messier was most likely the first to organize a successful survey program specifically devoted to the search for comets. For that accomplishment he certainly deserves a place with the greats like William Herschel, Kaoru Ikeya, and Leslie Peltier. In Stoyan's biographical summary we learn a little more about Messier's famous accident, in which he fell into a pit. Although he recovered enough to resume his work, we know for the first time that he never *completely* got well again, and he finished his life with a continuing limp. A fortunate fall, to be sure, for he is lucky to have survived it in the first place.

What if Messier were to return to our time? He would be amazed at the ease by which visual comet hunting can be done, as well as the increased difficulty in finding a comet when well-funded electronic searches compete with amateur astronomers. With a computer star chart riding with my telescope, I know instantly what my telescope is showing at any particular moment. On the morning of October 2, 2006, for example, the chart showed a rich field of stars with the planet Saturn in the field center; it did not display, however, the faint fuzzy spot that turned out to be my 22nd comet discovery, a new comet that will make a close approach to the Earth when it returns at the end of 2011. Messier obviously did not have such technology at his disposal; he used his telescope and a printed star atlas, trusted friends that remained the classic way to search the sky until just a few years ago.

For all of Messier's brilliance, his famous catalog was primarily an observing tool, and Stoyan's writing confirms this crucial footnote to history: by keeping a record of the objects that could be mistaken for comets, Messier provides himself and posterity an invaluable resource. The pages you are about to read delve further into what his list looks like after 200 years, and particularly the astrophysics that lies behind each of the clusters, nebulae, and remote galaxies that constitute it. Stoyan does not take a position on one of the questions of our time – should the double cluster in Perseus be added to the list?

Yes, there is a need for "yet another" Messier catalog book. Stoyan has done a masterful job giving his readers a modern look at Messier's greatest accomplishment. May this book inspire you to learn about the man and his project, and more importantly, may it encourage you to don a coat, grab a telescope, and enjoy this window into the deep sky for yourself.

Preface

The catalog gathered by the French astronomer Charles Messier (1730–1817) has been the most popular compilation of astronomical objects beyond our Solar System for more than 200 years. It contains 110 star clusters, nebulae, and galaxies, among them most of the brightest and finest deep sky highlights that are visible from northern skies.

Amateur and professional astronomers alike have turned their telescopes time and again to the Messier objects. Numerous books have covered them, and numerous websites attest to their unwavering popularity. However, a current overall picture of the catalog and its objects was missing, as much information currently disseminated is actually outdated. So, for the first time since Robert Burnham's famous *Celestial Handbook*, a thoroughly investigated new account with historical, astrophysical, and observational information on all the objects had to be conducted.

Many discrete tasks were associated with this book. Historical information on Charles Messier, his observations and his catalog had to be compared to latest level of knowledge. In addition to our own research, the biography published by Jean-Paul Philbert in the French language proved especially helpful. The main task was the compilation of recent astrophysical information on all of the objects. More than 500 scientific papers were compiled and evaluated. These texts are complemented by extensive observational notes, which incorporate the visual use of large modern reflectors.

A major part of the book is the more than 150 fantastic photos by leading amateur astrophotographers from all over the world. Occasionally, these images are accompanied by photographs from the Hubble Space Telescope, where this adds value. In addition, an extensive collection of visual drawings is shown, both from the classical era of the nineteenth century, as well as modern sketches drawn by the author himself.

The compilation of this book took much effort over the past five years. Many of the images were prepared exclusively from such exotic spots as Greece, Chile, and Namibia. They combine more than 5000 minutes of photographical exposure and 150 hours of visual observation. From the original German edition, which was released in 2006, information and photos have been updated and improved.

I owe a very personal thank you to the co-authors of this book. Stefan Binnewies, the well-known German astrophotographer, conducted the orchestra of his colleagues. Susanne Friedrich, professional astronomer and amateur alike, ensured the quality of the astrophysical information. Finally, Prof. Klaus-Peter Schroeder, also a professional astronomer, who has worked in the United Kingdom and the United States for decades, translated and updated the texts.

A deeply felt thank you goes to the astrophotographers who contributed so much to this book, especially to the teams of Volker Wendel and Bernd Flach-Wilken, Josef Pöpsel and Dietmar Böcker, and Robert Gendler and Jim Misti. I would also like to thank Lutz Clausnitzer, Klaus Wenzel, Arndt Latusseck, Wolfgang Steinicke and Matthias Juchert, who helped in many respects on the German edition.

The fact that this book appears in an English language edition is almost a miracle. Among the many people who have helped that this dream became reality are Owen Brazell, David Eicher, Phil Harrington, Yann Pothier, and Stewart Moore. Additionally, I am greatly indebted to Sue French, who proofread the manuscripts and supported this project to a very great extent, and David Levy, who authored the foreword in his unparalleled manner. Finally, I would like to thank Vince Higgs and the team at Cambridge University Press for their support, work, and faith.

May this book give you new insights into your favorite deep sky highlights.

Erlangen, Germany
Ronald Stoyan

User guide

The data files

Degree of difficulty: rating of the observational difficulty:
1 object easily visible to the naked eye
2 object difficult to see with the naked eye
3 object easily visible in 8×30 binoculars
4 object easily visible in 10×50 binoculars
5 object difficult to see with 10×50 binoculars
For more information about visual and photographic difficulty, see page 63.

Minimum Aperture: minimum aperture required to see the object under a dark mountain sky, according to the personal experience of the first author. There are four categories:

- naked eye
- 15mm
- 30mm
- 50mm

Designation: catalog number in the NGC (New General Catalogue) or the IC (Index Catalogue).

Type: Object type. For a more detailed introduction to the different types, see page 53.

Class: Classification of the object, specific to its type:

- Galactic nebulae: distinction between emission nebula and reflection nebula, see page 53
- Open clusters: Trümpler classification, see page 55
- Globular clusters: concentration class, see page 56
- Galaxies: Hubble classification scheme, see page 61

Distance: Distance from Earth in light-years. As far as possible, uniform sources have been used, i.e.:

- galactic nebulae and open clusters: K2005 (Kharchenko, N.V., et al.: “Astrophysical parameters of galactic open clusters,” Astronomy and Astrophysics 438, 1163 (2005)
- globular clusters: Rww2005 (Recio-Blanco, A., et al.: “Distance of 72 galactic globular clusters,” Astronomy and Astrophysics 432, 851 (2005)
- galaxies: H2000 (multiple authors: “The Hubble Space Telescope Key Project on the Extragalactic Distance Scale,” Astrophysical Journal 529, 698, 745, 786 (2000)
- Virgo cluster galaxies: V2004 (Sanchis, T., et al.: “The origin of HI-deficiency in galaxies on the outskirts of the Virgo cluster. II. Companions and uncertainties in distances and deficiencies,” Astronomy and Astrophysics 418, 393 (2004)
- Virgo cluster galaxies: V2002 (Solanes, J.M., et al.: “The Three-dimensional Structure of the Virgo Cluster Region from Tully-Fisher and HI data,” Astronomical Journal 124, 2440 (2002)
- extragalactic HII regions: HK83 (Hodge, P.W., Kennicutt, R.C., Jr.: “An atlas of HII regions in 125 galaxies,” Astronomical Journal 88, pp. 296 (1983)

In addition, alternative results have been quoted, in order to demonstrate the uncertainty of the distances given. If available, the distance measurement method is indicated.

Size: physical diameter of the object, as calculated from its actual distance and angular diameter. The resulting values may differ from the ones stated by original sources. Spiral galaxies seen under some inclination may be underestimated.

Constellation: Latin name of the constellation in which the object is located

R.A.: Ascension for the equinox 2000.0

Decl.: Declination for the equinox 2000.0

Magnitude: apparent total visual brightness

Surface brightness: mean visual brightness in magnitudes per square arcsecond (not given for star clusters)

Apparent diameter: apparent (angular) photographic diameter

The texts

History

The historical sections include translations from the original quotations of historic observers from the seventeenth to the early twentieth century. In part, these have been translated from the original. Where not available, they had to be taken as quotes from secondary literature. English quotations are given, as far as available, in their original wording.

Frequently, the term "resolution" (of an object) is used in historic texts – not just for star clusters, but for galaxies and nebulae as well. In the nineteenth century, that did not necessarily mean the resolution into individual stars, as we use the term today, but rather resolution of any kind of detail.

A short introduction to every historic observer quoted in this book can be found on page 28.

Astrophysics

Ever since the publication of the famous "Burnham's Celestial Handbook" in the 1970s, amateur astronomers have been waiting for a new, up-to-date compilation of astrophysical data on all Messier objects. A lot of literature, internet sources in particular, refers to outdated values.

For this book, the content of over 500 professional, up-to-date publications was researched. This was made possible by the use of the Internet and the free NASA service known as the Astrophysical Data System (ADS), which is an on-line collection of almost all scientific publications in astronomy. The exact citations are given in the Appendix.

Where possible, no sources older than 10 years were used, but a few objects have received little attention in modern references. Other objects (M 1, M 31, M 42) catch a lot of professional attention, and the vast amount of literature dealing with them would easily permit a much more detailed treatment. However, space restrictions limited this book to the most relevant information.

In many cases, the research presents surprises: modern scientific results often disagree completely with what is commonly believed as the result of outdated literature. This trend will continue, as there is a steady stream of new observations and their astrophysical interpretation. Hence, the statements made in this book must be regarded as only a momentary picture of our knowledge from the years before 2007. Many questions remain unanswered, and we expect new insight into topics such as dark matter, black holes or the age of the Universe. This may affect how some aspects of the Messier objects will be explained in the future.

Another common problem is the disagreement of modern sources from one another. Different authors have different opinions, and different methods yield different results. Generally accepted knowledge grows out of long debate and testing. This is part of the lively nature of a quickly developing science such as modern astrophysics.

Observation

The information and advice given for the visual observation of each object is based on the personal experience and observation of the first author, using telescopes of different apertures. Each object has been observed on several occasions, some more than a dozen times. The instrumentation used consisted of:

- 3.5×15 opera glass, "Theatis" made by Carl Zeiss Jena
- 8×30 binoculars, "Deltrintem" made by Zeiss Jena
- 10×50 binoculars, "Dekarem" made by Carl Zeiss Jena
- 20×100 binoculars, made by Miyauchi
- 120/1020mm (4.7-inch) refractor "Star 12ED," made by Astro-Physics, magnifications from 25× to 255×, in exceptional cases 340× and more
- 360/1780mm (14-inch) Newtonian on a Dobsonian mount, magnifications from 45× to 593×, entirely manual operation, observing sites in the German countryside (Kreben, naked-eye limiting magnitude 6.5, sky surface brightness 21.0 mag/arcsecond^2) and Austrian Alps (Tiefenbachferner, naked-eye limiting magnitude 7.0 mag, sky surface brightness 21.6 mag/arcsecond^2)
- 500/2500mm (20-inch) Newtonian on a Dobsonian mount, magnifications from 63× to 625×, Farm Tivoli, Namibia (naked-eye limiting magnitude 7.5, sky surface brightness 21.8 mag/arcsecond^2)

Observing comments refer to a very experienced observer and excellent observing sites with a dark, moonless sky. We have purposely omitted star charts and all advice on finding the objects, since there is already a vast literature on these aspects, useful even to the first-time observer. However, we recommend a versatile software-based approach, "Eye & Telescope." It produces star charts and visibility information based on actual sky conditions and the instrument used.

The pictures

Selected images showcase the fantastic results of the amateur astrophotographer's community. To document astrophysical aspects beyond the reach of amateur photos, we have complemented the material with NASA pictures of many Messier objects, obtained by the Hubble Space Telescope (HST).

Some Messier objects are particularly popular with amateurs, and good images are abundant. Others grab almost no attention and only a few pictures of lower quality are available. It's virtually impossible to get photos of uniform quality for all 110 objects. For this reason, the scale and depth (i.e., limiting magnitude) of the photos vary from object to object.

The photos printed in this book were taken in the years between 1995 and 2007. The most common technique is tri-color (red, green, blue) photography with a cooled CCD camera and (L)RGB filter wheel. With a few exceptions, traditional film-based photography can no longer compete, while the new era of digital cameras and DSLRs is just about to begin. For accurate technical information on each picture, refer to the picture credits in the appendix section.

The color reproduction is neither uniform, nor should it be regarded as quantitatively correct. Color-balance and saturation depend on a number of factors, such as chip-characteristics, filter-transmission, software and personal judgment during image processing. The result is often subjective, perhaps aimed at reproducing the colors of professional photos. After all, techniques of absolute color calibration are time-consuming and do not apply to some types of astronomical objects, most notably the emission nebulae.

The techniques used by amateur astronomers for their image-processing work differ a lot from person to person, and there are no general standards. Some photographers would remove traces of planetoids, satellites or ghost-images by hand, on a pixel-to-pixel basis, others accept them as part of the authentic picture. Composite images made from several different exposures change the perception of the intensity range. This technique is used to accommodate large intensity variations and to avoid "burnt-out" central regions. But it may make stars on bright nebulous background appear significantly less brilliant than they are in reality. A good example is the Trapezium in the Orion Nebula. Hence, a quantitative interpretation of such a photo is impossible, but amateur astrophotographers are happy to accept that, in order to produce the most appealing image of an object.

Together with the photographs, historical and modern drawings have been reproduced here. The manual sketch of an object as perceived through the telescope eyepiece was the only scientific method of recording until the late nineteenth century, after which photography finally took over. This book shows a large number of fine sketches from the pre-photographic era. Differentiating real physical changes in the objects from artistically diverse sketching styles and personal

A photo in the works: M 42. At left is a single image taken with the green filter, in the middle a raw tri-color image, at right the fully processed LRGB composite.

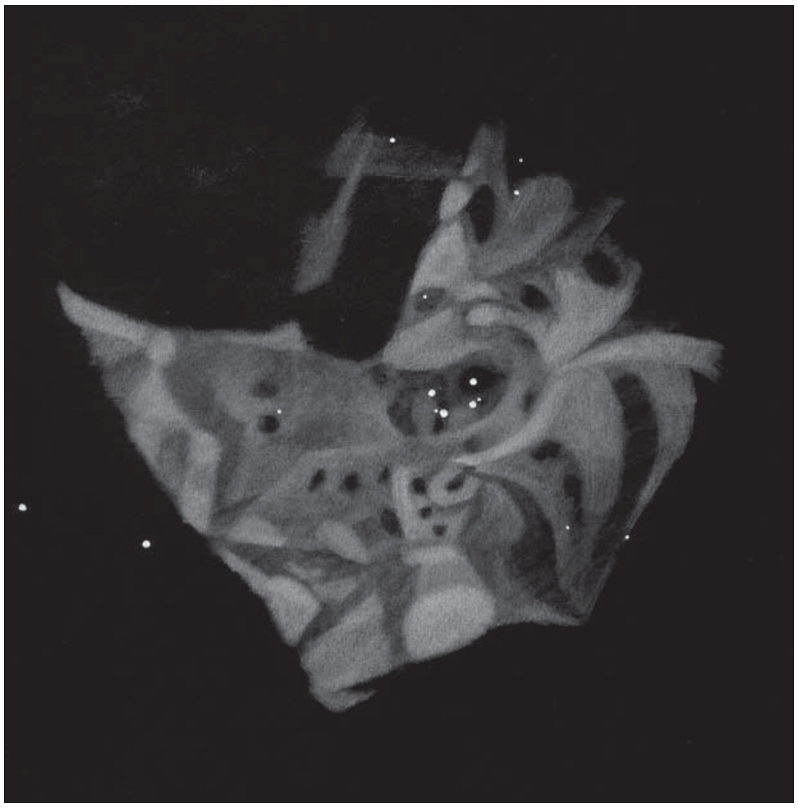
perceptions had been a continual problem. Today, amateurs keep the tradition of astronomical drawings alive, in order to sketch their visual impression of a specific object.

Drawings are subjective and contain erroneous perceptions. Nevertheless, this method is an independent recording technique, complementary to the capabilities of photography. Before criticizing historical drawings for their misconceptions, we should keep in mind that it is always easier to verify a known feature than to discover it. In that sense, the historic drawings must be regarded as more "honest" than their modern counterparts. Even the most critical modern observer cannot avoid the subconscious knowledge of an object by modern photography and its influence on his or her perception of it.

Drawings differ from photographs in a number of ways. For one, the eye can not accumulate light over a long time, as a photographic emulsion or chip can. Furthermore, the visual response to a large brightness range is much more logarithmic than the photographic response. And finally, the spectral response of the eye also differs from that of photographic emulsions or chips. With emission nebulae, in particular, visual and photographic views emphasize different features.

The author's drawings were specifically made for this book. The objects were observed several times with different apertures. Frequently, several attempts were required before an acceptable result was achieved. All the sketches are of a cumulative nature: each drawing summarizes the visual impressions of an object collected over many hours or even nights under a dark sky in the countryside, in the mountains or in the Namibian desert. The results are not to be confused with a quick sketch made by the eyepiece! The observing time involved was at least an hour, as for a simple elliptical galaxy, and up to three nights for large objects with a lot of detail.

The original sketches are drawn with pencil, black on white. So are the proper drawings, using in addition an eraser and a smudging tool. For an inversion to white on black, the drawing is scanned and the tonal range adjusted, but no further digital manipulations are made. Subtle contrasts are over-pronounced by the drawings, as they would otherwise be lost in print.



A drawing in its work-stages: M 42. Above is the original pencil sketch, below the properly redrawn and then inverted result.

Charles Messier

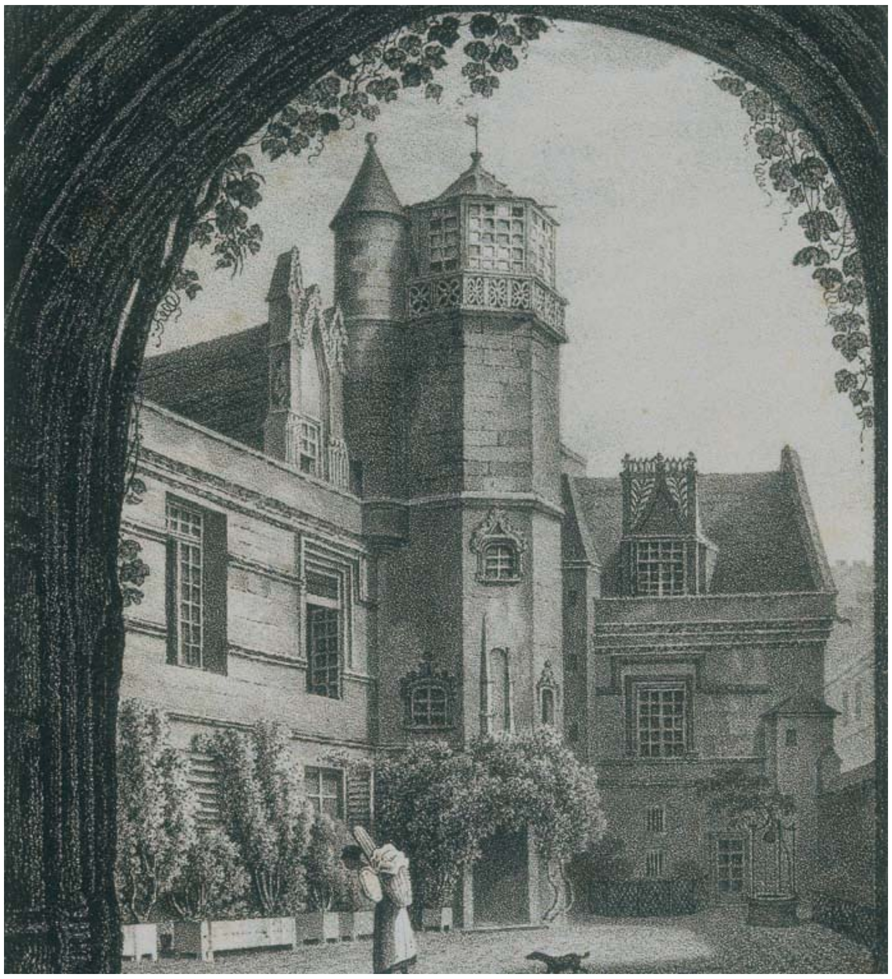
1730 to 1751: Childhood and adolescence

Charles Messier was born on the 26th of June 1730 in Badonviller, as the tenth child of the court bailiff Nicolas Messier (1682–1741) and his wife Françoise (maiden name Grandblaise, deceased 1765). His home village lies near the former German–French language border in the western part of the Vosges Mountains in Lorraine. In Messier's days, that region did not belong to France but to the independent dukedom of Salm. The Messier family was one of the richest in the little state, with high-ranking positions and excellent connections, which would later be very helpful to the young Charles.

He grew up in a house opposite the evangelic church of Badonviller, by a square which today bears his name. Six of his siblings died in their early childhood. An important role in Charles' life was played by his eldest brother Hyacinthe, who was older by 13 years. Hyacinthe started his professional career as an auctioneer and, eventually, became the highest financial officer of the dukedom. When their father died in 1741 – Charles was only 11 years old then – Hyacinthe was already able to take care of the Messier family. He gave Charles an apprenticeship in his office, mostly involving paper work. That helped develop the boy's good writing and drawing skills, and the accuracy required for finance and business. His first interest in astronomy was sparked by the large, six-tailed comet of 1744, discovered by the Swiss de Chéseaux, and the annular solar eclipse of 1748.

The year 1751 brought important changes to the life of the Messiers. The dukedom of Salm lost its independence by becoming part of Lorraine, which later fell to France by annexation. Only the former residence of the dukes of Salm, the village Senones, a few kilometers from Badonviller, retained its independence and was to become the new home of the Messier family. Now at the age of 21, it was time for Charles to seek a life of his own. With the help of a good family friend, who had contacts in important circles in Paris, an assistantship at the new Naval Observatory in Paris became available to Charles Messier. It was not really his interest in astronomy which got him the offer, but his good skills as an office assistant. He left Badonviller on the 23rd of September 1751.

Charles Messier at the age of 40, painted by Ansiaume. Messier commented that his portrait was most appropriate but made him look younger than he really was.



Drawing of the Hôtel de Cluny, from the beginning of the nineteenth century. The octagonal sheltered platform of the tower is Messier's observatory.

Today, the Hôtel de Cluny is one of the most beautiful medieval buildings of central Paris. It hosts the National Medieval Museum, but there is no commemoration of the work of Charles Messier.

1751 to 1757: Assistant of the Naval Observatory

Joseph-Nicolas Delisle (1688–1768), who taught mathematics and astronomy at the Collège Royal in Paris (later to be the Collège de France), built a private observatory on the stair-tower of the Hôtel de Cluny in 1747, opposite to the Collège Royal. Originally, the Hôtel de Cluny was the Parisian residence of the Benedictine monks from the great abbey in Burgundy. Later, it became the property of the French Navy. In 1754, the aged Delisle made a deal: he signed over the observatory to the Navy and in return, he received the custom-tailored title "Astronomer of the Navy."

Delisle's humble observatory stood in the shadow of the established Royal Observatory of Paris, which was well known as a leading European institution for astronomers like Huygens, Cassini, and Maraldi. Delisle, by contrast, was not part of the French astronomy establishment. Hence, Messier entered a professional environment which allowed him to pursue his astronomical interests without any scientific obligations, but which also branded him from the outset as an outsider to professional astronomy.

The childless Delisle couple received and hosted Messier as though he were their own son, and he lived with them in their apartment in the Collège. Delisle's assistant Libour introduced Messier to the basics of astronomy, and the young Messier's first tasks were to make hand-drawn copies of maps and to write the observing logs.

Delisle had been in personal contact with the late, famous English scientists Newton and Halley. The latter had pointed out in his famous work of 1705 that the comet apparitions of 1456, 1531, 1607, and 1682 were due to the same physical comet, which would reappear in 1758. Delisle made an independent calculation of the comet's orbit and derived April 1759 for the perihelion passage. Based on his master's work, Messier drew a map of the comet's path among the stars and had orders to watch for it from the summer of 1758 onward. That comet hunt was the first real astronomical task given to the 28-year-old, who so far had carried out only basic observations. Messier understood that this was the chance of a lifetime; he wanted to be the first to prove Halley's milestone work.

But life took a different course. While Messier did rediscover the comet on the 21st of January 1759, he soon had to learn that a farmer in Saxony had beaten him by about a month: the previously unknown amateur astronomer Johann Georg Palitzsch (1723–1788) from Prohlis near Dresden had already spotted Halley's Comet on Christmas night 1758. Messier had confined his search to Delisle's orbital path for too long. And to his great dismay, Messier could not even get his master's permission to publish his independent discovery, since Delisle did not believe that he'd made a mistake in his calculations. He thought the comet was an unrelated object. Messier bowed to the wishes of his master and host and withheld his obser-

City map of Paris from the year 1771. The Hôtel de Cluny (1) and the Royal Observatory of Paris (2) are circled.

Custos Messium – a constellation for the comet hunter

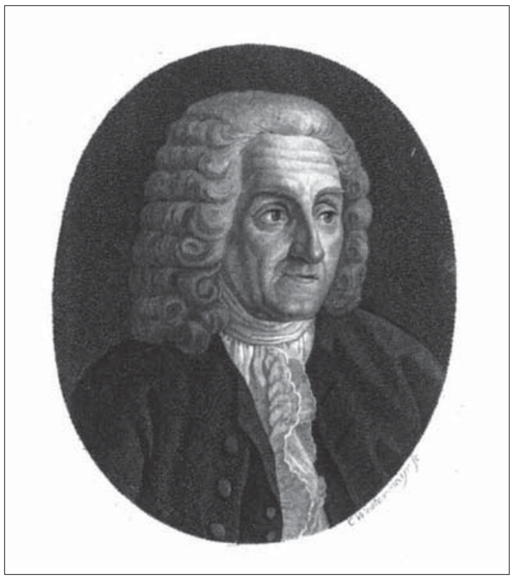
In 1775, the first version of the now enormously popular Messier catalog of 110 nebulae had been out for one year, with then only 45 objects. However it was his achievements as a record-breaking comet discoverer that made Charles Messier the publicly best-known astronomer of his country. In fact, Messier had discovered practically all the comets of the past 15 years. He had been a member of the elite circle of the French Academy of Sciences since 1770. But now, a very special honor was awarded to him, unprecedented in the history of astronomy.
Jerôme de Lalande (1732-1807), a famous author, professor and colleague of Messier, created a new constellation on his freshly published stellar globe: "Custos Messium" (lat.), the "Harvest Guardian." Concerning his motives, Lalande wrote: "This name will remind future astronomers of the courage and diligence of our industrious observer Messier, who since 1757 appears occupied with the sole task of patrolling the sky to discover comets." Contemporary French star charts happily included the new constellation under its French name "Messier," picturing a guardian who watched over a cornfield.
The "Harvest Guardian" had its place north of Cepheus, Cassiopeia, and Camelopardalis. Today, its space has become part of these three constellations. Messier's constellation held only one noticeable star, 40 Cas, and no remarkable deep-sky objects. As Messier related, Lalande chose that particular part of the sky, because it once hosted the comet of 1774, discovered by Montaigne. It was the only one of 14 comets that, following the death of his wife, Messier failed to discover himself. These were two big losses, which Messier could not bear – and Lalande must have been aware of that.
Lalande created two other new constellations: "Felis," the cat (between Hydra and Antlia), in memory of his favorite pet, and "Globus Aerostaticus" (between Capricornus and Piscis Austrinus) to commemorate the invention of the hot-air balloon by the brothers Montgolfier and their first air-borne voyage in 1799. All three constellations were included in J.E. Bode's Prussian star atlases – despite, certainly, some national rivalry. But in return, Lalande would include in his atlases the "Brandenburg Scepter," "Frederick's Honor," and the "Mural Quadrant," which Bode had invented. Nevertheless, all these new constellations fell out of use only 80 years later.

The constellation Custos Messium (Harvest Guardian), pictured in Johann Elert Bode's "Vorstellung der Gestirne" (1782).


Joseph Jérôme le Français de Lalande, colleague and friend of Messier. Engraving by André Pujos.

vations for three months, until it was finally clear that Delisle was wrong. However, the long-delayed publication aroused suspicion and skepticism among the royal astronomers in Paris. His independent discovery was not acknowledged – a disappointment that Messier would not forget for a long time.

In hindsight, we know that the by-products of Messier's diligent comet hunt were much more rewarding. In August 1758, when he was observing the comet discovered by de la Nux, Messier came across a yet unknown nebula which looked exactly like the comet. This discovery sparked the idea for his catalog, which retains Messier's name to this day. Hence, Messier made good use of that chance of a lifetime, after all – albeit in quite a different way than he, the comet enthusiast, had anticipated.



Johann Georg Palitzsch succeeded in what Messier tried in vain: he was the first to rediscover Halley's comet on its return in 1758.

1759 to 1770: Comet discoveries and recognition

Comet hunting became an obsession for Charles Messier. Between 1758 and 1804, he spent more than 1100 nights on this task. He became the first real "comet hunter" in history, with a prototypical character: a most diligent observer with humble equipment but much enthusiasm, who would search for new comets with systematic endurance. He observed 44 comets altogether, more than were known to science before him. He discovered 21 comets, 6 of which are regarded today as co-discoveries. Messier was, in fact, the first observer who systematically used the telescope for comet hunting. Before him, comets were usually discovered with the naked eye. But he did not leave it with the discovery of a comet. He would observe every comet for as much and as long as possible; his record was 71 nights over a period of 6 months. Furthermore, Messier measured comet positions to make orbit calculations possible. He never did that himself, though, as he was entirely devoted to observation. None of his many publications would contain a single bit of math or theoretical work.

In that respect, Messier's close friendship with Jean Baptiste Gaspard Borchart de Saron (1730–1794) was most beneficial. Saron came from an established, noble family and was soon to become the royal state-attorney, and later even president of the parliament. Theoretical astronomy was one of his hobbies – a perfect match: Saron's quick calculations were essential to Messier's success, because these allowed him to find a comet again, even after a long period of bad weather.

Joseph Nicolas Delisle, teacher and benefactor of Messier. Engraving by Konrad Westermayr.

For the discovery of the great comet of 1760, Messier was still a day late. But only a few days later, on the 26th of January 1760, he discovered the first comet named after him. In the following years, Messier nearly achieved a monopoly on comet discoveries: all eight known comets between 1763 and 1771 were discovered by him!

Messier was active in other respects, too. Between 1752 and 1770, he observed 93 lunar occultations and 400 eclipses of Jupiter's satellites, he watched 5 solar eclipses, 9 lunar eclipses, and he measured 400 stellar positions. Over the course of his lifetime, Messier followed four Mercury and two Venus transits, and he did a lot of planetary observing, especially on Saturn. In 1767, he made a three-month-long sea cruise to test astronomical clocks on the coasts of the Netherlands and Belgium.

Recognition by the international science community was soon to follow. In 1764, he became elected a fellow of the English and Dutch scientific academies. Such academies were of crucial importance in the eighteenth century. Only their membership made it possible to exchange correspondence with the leading scientists of the time and gave access to the accumulated knowledge of their libraries. Messier had to wait a long time for admission to the French academy of the sciences – in Paris, the skepticism aroused by his long withheld observations of Halley's comet were still not forgotten. But, at least, his salary was raised in 1765, after the retirement of Delisle from active research. Messier's breakthrough with the French astronomy establishment came with his discovery of the great comet of the year 1769. That comet was a spectacular sight, and it made its discoverer's name so popular with the general public that the king would personally receive a map drawn for him by Messier. The king nicknamed Messier "the comet nest-robber," because for many years not a single comet "slipped out of its egg" that hadn't already been discovered by Messier. This idea then developed into the popular nickname "the comet-ferret."

The role-model: Nicolas-Louis de Lacaille

Nicolas-Louis de Lacaille (1713–1762) was born on the 15th of May 1713 in Rumingy near Reims. As a son of noble parents, he began to study theology in Paris. He was 26 when he made his first recorded astronomical observations. Soon, he became professor at the Collège Mazarin in Paris, where in 1746 he constructed an observatory, and finally in 1741 he was admitted to the French Academy of Sciences, with the support of the Duke of Bourbon.

Lacaille was well known for his accurate observations and an over-eagerness to work – in fact, he died of overwork on March 21st, 1762. Hence, in 1751, the French academy chose him for a longer stay at the Cape of Good Hope, in order to accurately measure geographic longitudes and the positions of southern stars. Meanwhile, his scholar Lalande was his counterpart in Berlin for a program of simultaneous observations, which led to improved distance measurements of the planets and the Moon.

Abbé Nicolas-Louis de Lacaille, painted by Melle Le Jeuneux, 1762

Lacaille arrived in South Africa in April 1751. At the foot of Table Mountain, which he honored with the constellation "Mensa," he began the observations for a southern star catalog in August 1751. For that work, Lacaille used a mural quadrant, equipped with a very small telescope of only ½-inch (12.5mm) aperture and a magnification of 8×. A year later, in July 1752, this catalog contained the positions of 9776 stars.

While cataloging the heavens, Lacaille made a list of the nebulous objects he came across, which he published in 1755. It was the first of its kind, and it is appended to Messier's third and final catalog.

Thirteen new southern constellations were created by Lacaille as a by-product of his work: Antlia, Caelum, Circinus, Fornax, Horologium, Mensa, Microscopium, Norma, Octans, Pictor, Reticulum, Sculptor, and Telescopium. With these, Lacaille filled in the coarser pattern of southern constellations created 150 years earlier by Keyzer. In addition, Lacaille changed the name of the constellation Abies into Musca – not to be confused with a lost northern constellation of that name – and he suggested splitting the huge constellation Argo Navis into Carina, Vela, Pyxis, and Puppis. About 100 years later, these suggestions became widely accepted as astronomical conventions.

The next year (1770), Messier discovered a comet, which was identified by the Swedish observer Lexell as a periodic comet. Two weeks after that discovery, Messier was finally admitted to the French Academy of Sciences, followed by membership in nearly all of the remaining foreign scientific associations. In addition, he received another pay rise and, in 1771, he inherited the title invented for Delisle, "Astronomer of the Navy."

1770 to 1789: Changing private fortunes and observational successes

On the 26th of November 1779, Messier married the daughter of a noble professor, Marie-Madeleine Dordolot de Vermauchampt, who was three years his junior. For 15 years, they had lived under the same roof in the Collége Royal. But in the absolutistic France of that time, a marriage between a bourgeois and a noble lady would have been impossible. Only the recent great success of Charles Messier changed their fortunes. In 1771, they moved into an apartment of their own in the Hôtel de Cluny – it was then only a few steps from Charles' bedroom to the observatory.

1771 must have been one of the best years in Messier's life. Besides his personal good fortune, he discovered two comets and completed the first version of his catalog, then totalling 45 nebulous objects, although Messier considered the latter a mere by-product of his searches, as he just wanted to avoid confusion when he was comet-hunting.

On the 15th of March 1772, there was another reason for Messier to rejoice: his wife gave birth to a son, Antoine-Charles. But then his fortunes changed dramatically: a week later, Marie-Madeleine Messier died of puerperal fever, and the little baby followed her on the 26th of March. Messier's reaction to this heavy double-blow to his private life is difficult to assess. The fact is, however, that he started a four-day observing campaign on comet Montaigne – the first comet in almost 10 years which had not been discovered by him – the very night his son died.

In August 1772, Messier travelled to the dukedom of Salm, which in his own words he regarded as his "Fatherland." He stayed some time with his eldest brother in Senones, following earlier visits in the years 1758, 1762, and 1770. Not surprisingly, Messier continued an intense observing schedule during that family visit. On his return to Paris, he was accompanied by his nephew Joseph-Hyacinthe and by his sister Barbe, who would take care of her brother until her death in 1797.

The following years were characterized by continued comet observations. In 1780, Messier published the second version of his catalog, which contained 68 nebulous objects. The first new objects were found soon after his original catalog was printed. But Messier did not keep looking systematically for new objects, he just recorded accidental findings during his comet observations. Nevertheless, the third version of his catalog, with 103 objects, came out in 1781. This was mostly due to the wealth of input from his new colleague Pierre Méchain (1744–1804). Despite more such discoveries by Méchain after 1781, there were no further catalog versions.

Table: 44 comets, observed by Charles Messier

Popular name	Old designation	Messier's first observation	Messier's last observation	Number of nights observed	Date of discovery	Discoverer
		Aug 14,1758	Nov 2,1758	31	May 26, 1758	de la Nux
P/Halley	1759I	Jan 21, 1759	May 1, 1759	47	Dec 25, 1758	Palitzsch
Great Comet	1759III	Jan 8, 1760	Jan 30, 1760	6	Jan 7, 1760	Chevalier
Messier	1759II	Jan 26, 1760	Mar 18, 1760	22	Jan 26, 1760	Messier
		May 28, 1762	Jul 5, 1762	20	May 17, 1762	Klinkenberg
Messier	1763	Sep 28, 1763	Nov 24, 1763	29	Sep 28, 1763	Messier
Messier	1764	Jan 3, 1764	Feb 11, 1764	16	Jan 3, 1764	Messier
Messier	1766I	Mar 8, 1766	Mar 15, 1766	8	Mar 8, 1766	Messier
P/Helfenzrieder	1766II	Apr 8, 1766	Apr 12, 1766	5	Apr 8, 1766	Helfenzrieder
Messier	1769	Aug 8, 1769	Dec 1, 1769	42	Aug 8, 1769	Messier
P/Lexell	1770I	Jun 14, 1770	Oct 3, 1760	47	Jun 14, 1770	Messier
Great Comet	1770II	Jan 10, 1771	Jan 20, 1771	4	Jan 10, 1771	Messier
Messier	1771	Apr 1, 1771	Jun 15, 1771	48	Apr 1, 1771	Messier
		Mar 26, 1772	Apr 3, 1772	4	Apr 8, 1772	Montaigne
Messier	1773	Oct 12, 1773	Apr 14, 1774	71	Oct 12, 1773	Messier
		Aug 18, 1774	Oct 25, 1774	41	Aug 11, 1774	Montaigne
Bode	1779	Jan 19, 1779	May 19, 1779	63	Jan 6, 1779	Bode
Messier	1780I	Oct 27, 1780	Nov 28, 1780	13	Oct 27, 1780	Messier
Méchain	1781I	Jun 30, 1781	Jul 16, 1781	14	Jun 28, 1781	Méchain
Méchain	1781II	Oct10, 1781	Nov 5, 1781	12	Oct 9, 1781	Méchain
		Nov 27, 1783	Dec 21, 1783	13	Nov 19, 1783	Pigott
		Feb 3, 1784	May 25, 1784	13	Jan 24, 1784	Cassini
Messier	1785I	Jan 7, 1785	Jan 16, 1785	6	Jan 7, 1785	Messier
Méchain	1785II	Mar 13, 1785	Apr 16, 1785	14	Mar 11, 1785	Méchain
P/Encke	1786I	Jan 19, 1786		1	Jan 17, 1786	Méchain
		Aug 1, 1786	Oct 26, 1786	43		C. Herschel
Méchain	1787	Apr 11, 1787	May 20, 1787	6	Apr 10, 1787	Méchain
Messier	1788I	Nov 25, 1788	Dec 29, 1788	20	Nov 25, 1788	Messier
		Jan 3, 1789	Jan 6, 1789	2	Dec 21, 1788	C. Herschel
		Jan 19, 1790		1	Jan 7, 1790	C. Herschel
P/Tuttle	1790II	Jan 10, 1790	?	7	Jan 9, 1790	Méchain
		May 1, 1790	Jun 9, 1790	45	Apr 17, 1790	C. Herschel
		Dec 26, 1791	Jan 28, 1792	12	Dec 15, 1791	C. Herschel
		Feb 1, 1793	Feb 14, 1793	6	Jan 10, 1793	Gregory, Méchain
		Sep 27, 1793	Dec 8, 1793	25	Sep 24, 1793	Perny
Messier	1793I	Sep 27, 1793	Jan 7, 1794		Sep 27, 1793	Messier
		Aug 16, 1797	Aug 30, 1797	13	Aug 14, 1797	Bouvard
Messier	1798I	Apr 12, 1798	May 24, 1798	27	Apr 12, 1798	Messier
		Dec 7, 1798	Dec 12, 1798	4	Dec 6, 1798	Bouvard
Méchain	1799I	Aug 10, 1799	Oct 25, 1799	44	Aug 7, 1799	Méchain
Méchain	1799II	Dec 28, 1799	Jan 6, 1800	5	Dec 26, 1799	Méchain
Pons	1801	Jul 12,1801	Jul 21, 1801	5	Jul 12, 1801	Pons, Messier, Méchain, Bouvard
		Aug 30, 1802	Sep 5, 1802	7	Aug 26. 1802	Pons
		Mar 11, 1804	Mar 17, 1804	6	Mar 7. 3. 1804	Pons

adopted from: Philbert, J.P.: Charles Messier – le furet des comètes

The competitor: Johann Elert Bode

Messier not only reinvented comet hunting, he also sparked new interest with his contemporaries in the observation of nebulae and star clusters. The German astronomer Johann Elert Bode (1747–1826), who like Messier published an annual almanac, entered into a direct competition with the French astronomer in 1777, by presenting his own catalog of nebulous objects. Bode developed an interest in astronomy at a young age. He observed the night sky from a hatch in the roof of his parents' house in Hamburg. By chance, a math professor saw Bode's notes and encouraged him to write a popular astronomy book. In 1768 at just 21 years old, Bode published the guidebook "Deutliche Anleitung zur Kenntnis des gestirnten Himmels" ("Concise manual to the knowledge of the starry sky"), which was received very well and reprinted several times. A later edition was used to publish the formula for the distances of the planets, which was soon known as the "Titius-Bode-Law." Still an amateur astronomer, Bode observed the Venus transit of 1769. But in 1772, he began to work at the royal observatory of Berlin, and a few years later, in 1779, Bode discovered his first comet. Much like Messier, that discovery gave him recognition. He eventually became the director of Berlin Observatory in 1787 and kept that office for 38 years. Bode gained some fame as the founder of the "Berliner Astronomisches Jahrbuch" ("Berlin Astronomical Almanac") and with his book "Vorstellung der Gestirne" ("Introduction to the Constellations," 1782) and the monumental celestial atlas "Uranographia" (1801). By contrast to Messier, Bode was well connected in scientific circles. The name "Uranus" for the new planet discovered by William Herschel was his suggestion. And as director of the Berlin Observatory, he had excellent contacts all over Europe. In 1774, three years after the publication of Messier's first catalog of 45 nebulae, Bode started his own search for new nebulae and star clusters. He succeeded with some genuine discoveries (M 81, M 82, M 53, M 92) and a larger number of independent findings. In 1777, he compiled his "Complete Catalog of all Observed Nebulae and Star Clusters," based on his own observations as well as on all references he could find in the literature. At its time the largest deep-sky catalog, this included 75 objects. Bode continued to observe, and he always encouraged other observers to publish their data in his almanac. The 1779 volume contains a listing of objects found by Köhler from Dresden, and other editions reproduced the notes of Oriani and a translation of Messier's catalog.

Johann Elert Bode

An updated and enlarged list of contemporary observations of nebulae, still without knowledge of Messier's third catalog version but including the 68 objects of his second, was published by Bode in 1782 within the "Vorstellung der Gestirne." This list not only included several new discoveries, presumably made by Bode himself, but also the objects IC 4665 (already mentioned by Al Sufi) and h & χ Persei. Despite the substantial work of Bode in this field, his name is hardly known today, by contrast to popular Messier. One good reason may be that Bode did not check the positions of objects contributed from other observers. That caused many errors in his list. His listing of 1782, for example, contains three different entries for M 8, because Bode did not realize that the different positions from Messier, Le Gentil, and Köhler all referred to the same object. Hence, despite Bode's strive for completeness, Messier's final catalog of 1781 was, at its time, second to none in terms of quality.

The 13th of March in that same year saw the discovery of the planet Uranus by William Herschel in England. At first, Herschel took his new object for a possible comet and asked Charles Messier for his opinion. The same day he received Herschel's letter, Messier observed Uranus. Messier passed his positional measurements down to de Saron to calculate the orbit. His mathematical friend was quick to realize that Uranus was not a comet but a new planet.

After 1781, Herschel would find over 2000 new nebulous objects with his much better telescopes. However it was not only this superior competition that stopped Messier working on nebulae, but also another blow of fate: on the 6th of November 1781, Messier was on a walk with his family in the Park Monceaux. His curiosity led him to inspect the entrance to a basement, when he slipped and fell 8 m (24 feet) into a deep ice-storage cellar. Messier was seriously injured, and had broken his upper leg, upper arm, two ribs and the wrist of his hand. He lost a lot of blood from an open wound over his eye. It took him the better part of 1782 to recover from this bad accident. His leg had to be broken again, after the bones had healed at an angle. Messier was bed-bound for a long time, and he always limped thereafter. Herschel, who paid him a personal visit in Paris 20 years later, remarked that Messier never fully recovered from that injury. It was a full year after that accident before Messier was back in his observatory, on the occasion of the Mercury transit of the 12th of November 1782.

1789 to 1804: In the turmoil of the French Revolution

The French Revolution began with the storming of the Bastille in Paris on the 14th of July 1789. As for so many, the following years brought chaos and insecurity to Messier. The structures of the French Navy were dissolved and maintenance of the observatory ceased. Frequently, Messier had to borrow oil for his observing lamp from his good colleague Lalande. The latter was now director of the former Royal Observatory of Paris, and they knew each other well from the days when they both taught at the Collège Royal. In 1793, by decree of the revolutionary directorate, all academies were dissolved, with serious consequences for Messier. A further tragic event for Messier was to follow on the 20th of April 1794 when his good friend and benefactor de Saron was guillotined under the reign of terror. Already in prison, he calculated his last comet orbit for Messier.

Fundamental changes were also imposed upon Lorraine. In 1793, the dukedom of Salm became part of revolutionized France by annexation, with significant consequences for the Messier family, which was closely involved with the local nobility. Some family members emigrated from France to Germany, following the dukes of Salm.

In 1795, a new astronomical institute was founded in Paris: the Bureau des Longitudes. Its original purpose was to outstrip the superiority of the English clocks. Messier was not among its founding members, like Méchain or Cassini, but he replaced the latter in the next year.

In 1798, still living in the Hôtel de Cluny, Messier was on his own again, after the death of his sister in the previous year. From Senones, his younger brother and his niece Josephine now came to live with him. Josephine would take care of Charles Messier until his death.

In 1801, Messier made his last comet discovery at the age of 71. Thereafter, he just lived off his past fame, which was finally recognized by the new regime. Napoleon personally bestowed him with the Cross of the Legion of Honour. This led Messier to make, in 1808, a connection between his discovery of the great comet of 1769 and the simultaneous birth of "the Napoleon the Great." This idea was so close to astrology that it did not go over well with most contemporary astronomers.

The colleague: Pierre Méchain

Thirty of the now so-called "Messier objects" were, in fact, discovered by Pierre Méchain (1744–1804). He was a close collaborator of Messier and helped complete his final catalog in the years 1779 to 1781.

Pierre Méchain was born in Laon. He planned to become an architect, but lack of finances forced him to abandon his studies. Rumour has it that he even had to sell his telescope, which he had bought as an amateur astronomer, and that the buyer turned out to be Jérôme de Lalande, later (1794) to become the director of Paris observatory.

Lalande had been astronomy professor at the Collège Royal from 1760 to 1767, as the successor of Delisle, and from 1794 to 1807 he was also editor-in-chief of the Connaissance des Temps. In 1772, he managed to get Méchain a job at the treasury of the French Navy in Versailles. Two years later, Méchain obtained the official position of a "calculator." The connection with Messier's friend Lalande initiated Méchain's contribution to the Messier catalog.

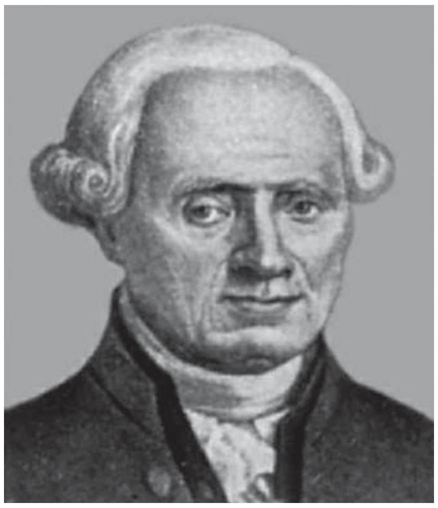
In 1781, Méchain found two new comets – eventually, his total score grew to eight discoveries. Unlike Messier, he was able to calculate his own orbits. His most famous discovery was the comet of 1786, which was proved by Encke's orbital calculations to be the second-known periodic comet (after Comet Halley).

From 1786 on, Méchain was engaged in longitude measurements. This work requires clocks much more accurate than those available at the time – a big problem for offshore navigation, as well as for geodesy on land. Hence, in 1791, the French Academy of Sciences started a project to define the French prime meridian from Dunkirk in the north to Barcelona in the south.

After the project finished in 1795, Méchain found an error of 3" in the calculated latitude of Barcelona (about 90 meters on the ground). We know now that this was due to a combination of instrumental inaccuracies and some deviation of the globe from a perfect sphere – but Méchain expended considerable effort trying to further increase the accuracy of the calculations.

In 1798, he succeeded Lalande as director of the Observatory of Paris. In 1804, during field work in Spain to revise the measurements along the French prime meridian, Méchain contracted yellow fever and died on the 20th of September 1804.

Pierre Méchain, painted by Hurle.



Portrait of the comet hunter from 1801, at the age of 71, drawn by Cless from Weimar. Messier was reasonably tall for his time, measuring 1.68m (5 feet 6 inches), a little chubby, and his hair turned white around the age of 60.

The last comet that Messier was able to observe was the great comet of 1807. Thereafter, he suffered from failing eyesight. After 1808, he could no longer read or write. In 1812, he became paralyzed on one side, and dropsy set in around 1815. Messier finally died on the 11th of April 1817 at the age of 87 years. Three days later, he was buried in the cemetery of Père Lachaise.

The speech at Messier's grave was given by Delambre, secretary of the reconstituted Royal Academy of Sciences. He commemorated the comet hunter with the words: "He did not write a single book, nor any treatise in general or in particular, but his observations will for a long time enrich the collection of the Academy. His famous colleague Lalande has created a constellation in his honor, the only one bearing the name of an astronomer. It will keep the memory of him alive, but his name will remain with science, independent of this honouring act of friendship: in terms of the catalog of comets, in which the name Messier has been recorded as often as honestly."

William Herschel continued with Messier's work. Painting by Contel, from an engraving.

The Observations

Work on the catalog

M 1 and M 2: Beginnings and motivation

Charles Messier's first encounter with a nebulous object occurred during his preparations for the return of Comet Halley. When he observed Comet de la Nux for that purpose in August 1758, he came across an object in Taurus, which looked very similar to the comet, but it did not move. It was the 28th of August 1758 when Messier discovered the Crab Nebula, now known as M 1. He obtained the position of this apparently new nebula two weeks later (12th of September). Messier did not know then that M 1 had already been found by Charles Bevis in England in 1731, and so took his observation for a new discovery. That kindled an interest that would eventually lead to his famous catalog. As he described it in 1801:

> *What made me produce this catalog was the nebula which I had seen in Taurus, September 12, 1758, while I was observing the comet of that year. The shape and brightness of that nebula reminded me so much of a comet, that I undertook to find more of its kind, to save astronomers from confusing these nebulae with comets. I continued to observe with telescopes suitable for the discovery of comets, which was the purpose I had in mind when producing this catalog.*

Messier did not start a systematic search straight away. However, it was two years before he found M 2, with a Gregorian reflector of 30-inch focal length and a power of 104×. Only later was he to learn, during a search for comet observations from other astronomers, that this object had already been discovered in 1746 by Jean-Dominique Maraldi (1709–1788). Again, Messier was not the original discoverer.

M 3 to M 40: Systematic search for nebulae

In May 1764, Messier finally started systematic work on the catalog of nebulae. He began with the "nebulosae" in the lists and literature known to him, in particular those from Hevelius, Huygens, Derham, Halley, de Chéseaux (of which, apparently, he had only an incomplete knowledge), Lacaille, and Le Gentil. In addition, he discovered new objects of his own; some of these, like M 39 and M 40, while trying to verify entries from old catalogs. In only five months, Messier observed and measured the positions of M 3 to M 40, including 19 genuine first discoveries. Hence, the first version of his catalog was more or less accomplished within half a year of work, from spring to fall 1764. That time must be considered the most productive phase in the life of Charles Messier as a "deep-sky observer," as we would put it today, and it laid the foundation for his lasting popularity.

M 41 to M 45: Completion of the first catalog

Early in 1765, Messier found the open cluster M 41. For a long time, this was the last entry in his observing log. The subsequent pause of four years saw his boat journey to the Netherlands in 1767 and further comet discoveries – apparently, Messier was pondering whether to publish his list of nebulae or not. In March 1769, he finally made up his mind and completed the catalog with the inclusion of several well-known objects as his entries M 42, M 43, M 44, and M 45, listed under the date of the 4th of March 1769. All of these objects are impossible to confuse with a comet, and it remains a matter of speculation why he added them. Perhaps having a catalog with 41 objects did not satisfy Messier's sense of symmetry, and he wanted to exceed the 42 entries in the catalog of his role-model, Lacaille. In his foreword, Messier mentioned the motivation for making a list of all nebulous patches in the sky, rather than just those which look like a comet. However, he did not include other significant objects in that respect, e.g., the double cluster h & χ Persei, which apparently did not bother him much. There simply were not enough such objects left to round the number up to an even better sounding total of 50 entries.

The manuscript for the first catalog was finally completed on the 16th of February 1771. It was printed in that same year for the 1774 edition of the Mémoires de l'Académie Royale des Sciences.

M 46 to M 52: Further discoveries

Only three nights after the manuscript of the first catalog was finalized (19th of February 1771), Messier discovered four more objects: three more star clusters (M 46 to M 48) and the first galaxy of the Virgo cluster, M 49. Later that same year, on the 6th of June an object was discovered but its position not measured until 1779, which gave it a much later entry as number 62. Instead, on the 5th of April 1772, Messier finally found a nebula from a note of Cassini, for which he had been looking since 1764, now his M 50 – not much more than a week after his wife and newborn child had died.

During an observation of the Andromeda Galaxy on the 10th of August 1773, Messier discovered the companion galaxy M 110. But for reasons that are not known, he did not include this object in his catalog. The observation and a drawing were finally published in 1798 – for this, M 110 was accepted as a Messier object in the twentieth century. Also in 1773, Messier came across M 51, while he was following the comet of that year which he had discovered himself. He saw only the central part of the main galaxy. The double-nature of this object was noticed later by Méchain, whom he got to know in that year (1773). M 52 in 1774 was then for some time Messier's last discovery; he did not engage himself again with nebulous objects until 1777.

M 53 to M 70: Completion of the second catalog version

In February 1777, Messier found M 53 and the faint M 54, and M 55 followed on the 24th of July 1778, while he was looking again for an object described by Lacaille (M 55), which he had failed to find in the night of the 29th of July 1764. Meanwhile, in 1777, Bode had entered into a direct competition with Messier with his catalog of 75 nebulous objects. Then in 1779, the 6th of January, the German challenged Messier in his very domain: Bode discovered his first comet. Messier saw it only 13 nights later. The comet then happened to pass near M 56, which Messier happily added to his list. Further nebulous objects were soon found along the path of Bode's comet by different observers: M 57 on the 31st of January 1779 by Darquier, the Virgo galaxies M 59 and M 60 on the 11th of April by Köhler (four days later independently discovered by Messier, together with M 58), and M 61 by Oriani, on the 5th of May. The latter galaxy was seen by Messier the same night, but confused with the comet; he noticed his mistake six nights later. The other galaxies of the Virgo cluster had not yet been observed.

June 1779 saw the first contribution to the Messier catalog by a discovery of Méchain: M 63. In March and April 1780, Messier had a very productive phase again: he discovered M 64, M 65, M 66, M 67, and M 68. The much grown number now motivated him to publish a second version of his catalog. It was printed in the 1783 edition of the French Almanac, the Connaissance des Temps. Two more objects (M 69 and M 70) found by Messier on the 31st of August 1780, and making a pleasantly round number, were added on in the annex of the same edition.

M 71 to M 103: Méchain's discoveries and the final catalog version

Again, new discoveries were made immediately after the publication of the catalog. More than 32 new objects were observed between October 1780 and March 1781. The personal discoveries achieved by Messier were M 73 (when he was looking for M 72 of Méchain), M 84, M 86, and M 87 to M 93

Observations of nebulae before Messier

For the earliest astronomers, non-stellar (fixed) objects had little importance and hardly any attention was paid to them. The only exception was the easily resolved and bright star cluster of the Pleiades, which played an important role in astronomical calendars and mythology. For example, the tradition of All Saints Day and Halloween is based on the culmination time of the Pleiades. Nebulae were not noticed by the ancient Greek scholars, only Hipparchus mentioned, apart from the Pleiades, the other two cloud-like objects, M 44 and h & χ Persei.

The great star catalog of the second century AD, the Almagest produced by Ptolemy (83–161), already contained seven objects characterized as "cloud-like" or "nebulous." But apart from M 7, M 44, and h & χ Persei, they are not real but rather chance alignments of stars that remain unresolved and therefore appear nebulous to the naked eye. Not even the two most obvious of the real nebulae, M 31 and M 42, are mentioned in the Almagest, nor elsewhere in antiquity. This demonstrates the lack of interest in such objects. The first note on M 31 came from the Persian scholar Al Sufi in the tenth century, when he worked on a revision of the Almagest. And the discovery of M 42 had to wait until the first telescopic observations in the early seventeenth century. In 1611, several astronomers discovered the Orion Nebula almost at the same time – the very first of them was Nicholas Peiresc.

The first telescopes were also used for several other non-stellar objects. Galileo found that M 44 was not a nebula but a cluster of faint stars. About the same time, Simon Marius discovered M 31, which was still unknown in Europe. After him, Giovanni Batista Hodierna (1597–1660) made a series of discoveries. His list of 19 observed objects contains nine genuine discoveries (including M 6, M 36, M 37, M 38, M 41, M 47, and perhaps M 33, and M 34), but his notes were lost and remained entirely unknown until their rediscovery in the twentieth century.

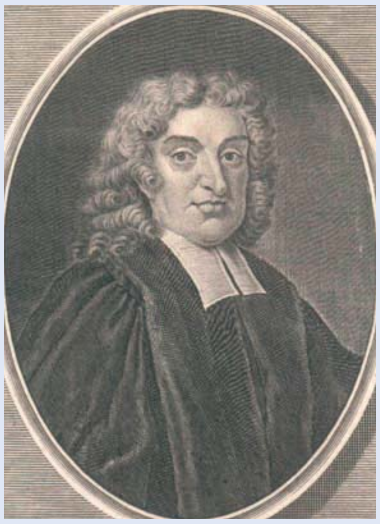
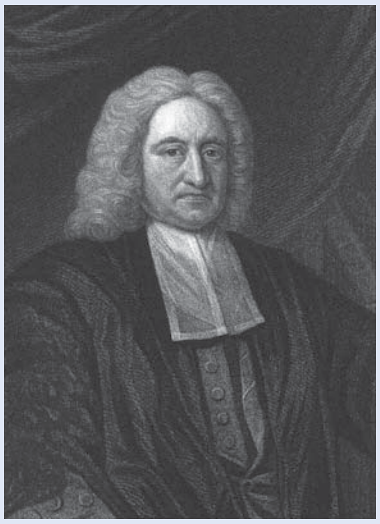
For quite some time not much progress was made; nebulae were still objects of little interest. In 1647, Johannes Hevelius published one of the last large star catalogs achieved without the use of a telescope, he therein mentioned 14 "nebulous" objects, mostly taken from Ptolemy. As in the Almagest, these "nebulae" are mostly accidental stellar patterns, which are not resolved by the naked eye. However, with the advent of this widely known publication, nebulous objects gained a bit more attention for the next hundred years. In 1733, Hevelius' original listing of 14 objects was translated from Latin into English by William Derham and supplemented with M 7 and NGC 6231. In this form, it came to Charles Messier, who tried to verify these 16 objects in 1764. Since most of them were not real, they could not be identified as a nebula through the telescope. Only Hevelius No. 14 survived as M 40, as Messier included it in his catalog, although he only saw a faint double star and no nebulous object.

Not long after the work of Hevelius, M 22 (Ihle, 1665) and M 11 (Kirch, 1681) were found by telescopic observation, the first discoveries made from Germany. In England, meanwhile, Edmond Halley was quite active. Best known for his long-period comet, he had already discovered ω Cen in the southern sky in 1677. From home, he found M 13 in 1714. In a 1715 publication, he also described M 42, M 31, M 22, and M 11.

But it wasn't until Messier's time, when the quality of telescopes had improved sufficiently, that more progress could be made. In 1746, the Swiss aristocrat de Chéseaux (1718–1751) listed 21 observed nebulae, which include eight genuine discoveries. But as in the case of Hodierna, his notes were not published, because de Chéseaux was not a member of any important scientific society, so he was not accepted by the scientific establishment.

This was different with Nicolas Louis de Lacaille (1713–1762), who presented a list of 42 nebulous objects in 1755 as a by-product of his star survey of the southern sky. Despite the very small aperture he had used, this first real nebula catalog contained a significant number of genuine discoveries and was of very good quality, especially in terms of positional information. Certainly, it was the best example for Messier, who reprinted Lacaille's list as an annex to his 1771 catalog.

Hence, many southern objects were known before Messier's work, while the northern sky was still almost untouched. Concurrently with Messier, Guillaume Le Gentil (1725–1792) made a few discoveries. Like Messier, he once was a student of Delisle in the Collège de France. In his publication, submitted in 1749 but not printed until 1755, Le Gentil mentioned M 32, M 8, M 41, M 36, and M 38.


Some astronomers who paved the way for Messier: Hevelius, Flamsteed, Halley, Peiresc, de Mairan, Huygens.

Hevelius "Nebulosae," 1647

Derham's number	Constellation	Derham's description	Modern identification
1	Andromeda	In Andromeda's girdle	M 31
2	Cancer	Praesepe	M 44
3	Capricornus	In the forehead of Capricorn	σ Cap
4	Capricornus	Another, preceding the eye of Capricorn	π Cap
5	Capricornus	Another following it	o Cap
6	Cygnus	Preceding above the Swan's tail and last in its northern foot	ω Cyg
7	Cygnus	One of two following the Swan's tail, outside the constellation	?
8	Hercules	At the tip of Hercules' left foot	88 Her
9	Hercules	In the left leg of Hercules	90 Her
10	Hercules	In the head of Hercules	32, 33, 34 Oph
11	Libra	Under the beam of the western scale	ζ, 17, 18 Lib
12	Pegasus	Following the ear of Pegasus	34, 35, 37 Peg
13	Scutum	Below the western border of the shield	?
14	Ursa Major	Above the back of Ursa Major	?

Visual observers after Messier

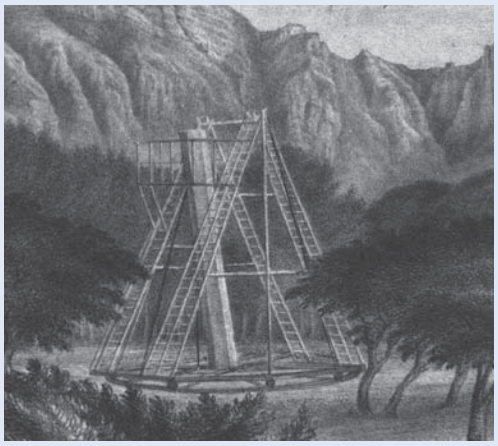
From the seventeenth to the nineteenth century, visual observation at the telescope's eyepiece was the common scientific means of documentation in astronomy. The observers would produce drawings and descriptions, which were then reproduced in professional publications. It was not until the end of the nineteenth century that emerging photographic techniques evidently became the more accurate and less subjective form of recording positions and intensities than visual observation.
Nevertheless, descriptions from the great historic visual observers are still most valuable for the modern amateur for comparison with his or her own visual observations. We have to keep in mind that those historic observers could not "cheat" and look at a photograph to get some help; they depended entirely on the capabilities of their eyesight.

Frederick William Herschel (1738–1822)

William Herschel was a musician, born in the German town of Hanover, who had emigrated to England. He became the first observer to undertake a systematic search for nebulae for their own sake. Most likely, he was inspired by Messier's catalog. Within 20 years, he compiled a huge catalog of 2500 nebulae and star clusters.
Herschel had produced home-made telescopes and mirrors since 1774, for himself as well as for other astronomers. For his nebula observations, which he started in 1782, he used a very large, modified Newtonian telescope with 18 inches (475mm) of aperture and 20-feet (6m) focal length. His standard magnification was 157× with a field of view of 15', with which he was systematically scanning the sky. He combed through a zone of 4 minutes to 5 minutes in right ascension with a length of 12° to 14° in declination and noted all newly found objects for a later, accurate position measurement. This procedure was then repeated in a band of right ascension adjacent to the preceding field. Wanting a larger objective for this project, Herschel finished building the then largest telescope in the world in 1789, with a huge 47-inch (1.2m) metal mirror of 40-feet (12m) focal length, but it proved too bulky for scanning purposes, so he would instead use it for detailed observations of individual objects.
Herschel's first discovery, on the 7th of September 1782, was the Saturn Nebula NGC 7009. By 1785, he had found about 1000 more nebulous objects, another 1000 by 1789, and a final 500 by 1802. Hence, his 20 years of work increased the number of known nebulae by a factor of more than 20 – an immense achievement. William Herschel is probably the most industrious deep-sky observer of all time.

John Herschel (1792–1871)

John diligently continued the work of his father. He shipped the venerable 18-inch telescope to South Africa, where he systematically searched the southern sky for nebulae. In the years 1834 to 1838, he discovered 1689 new objects. In 1864, he finally combined his own and the revised observations of his father into the General Catalogue (GC) of Nebulae and Star Clusters. It became the basis for the famous New General Catalogue (NGC) of 7840 entries. The latter, created by Johann Dreyer in 1888, included all the objects then known and is still in widespread use today.

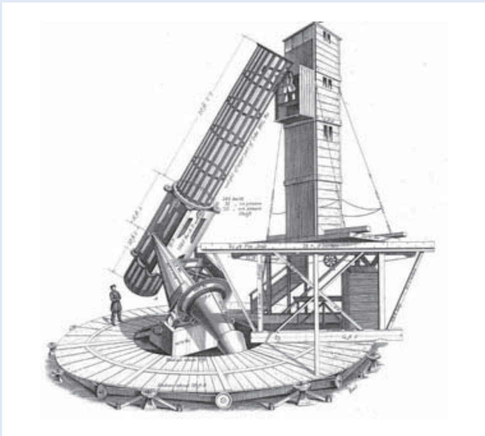


William Smyth (1788–1865)

The retired English admiral discovered astronomy as his hobby and built his own private observatory with a 6-inch refractor. In close contact with John Herschel, he observed numerous deep-sky objects. In 1844, he published the "Bedford Catalogue," the "grandmother" of all deep-sky observing guides, which included descriptions of 98 nebulae and 72 star clusters. His work offers rich insights into the practice of amateur astronomy 160 years ago.

William Lassell (1799–1880)

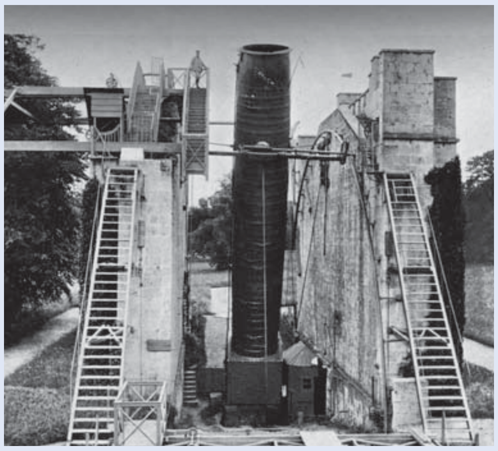
This wealthy brewer and amateur astronomer from Liverpool, England, was able to spend considerably more money for his astronomical desires than his contemporaries. In 1845, he built a 24-inch Newtonian on a fork-mount, which he used to do numerous observations and drawings of nebulae. In 1858 in Liverpool, he had a reflec-



tor with a 48-inch mirror made, one of the largest telescopes of its time. He shipped it to Malta in 1861, to take advantage of the far superior observing conditions there.

William Parsons, Lord Rosse (1800–1867)

The third Earl of Rosse was a rich Irish nobleman who developed an enthusiasm for observing due to his contact with John Herschel. In April 1845, after considerable experimentation with the techniques needed to build very large reflectors, he constructed his huge telescope, "Leviathan," which had a 72-inch (1.8m) mirror. Then the largest telescope in the world, it was set up in the gardens of his Irish estate at Birr castle and was so cumbersome that several people were required to operate it. Nevertheless, the Lord himself and several assistants made a large number of observations and drawings of nebulae in the decades to follow. One of his most important discoveries was the spiral structure of some galaxies. However, this success later tricked him into seeing spiral patterns even in star clusters. The assistants of Lord Rosse were: J. Rambaut (1848), B. Stoney (1850–1852), R. Mitchell (1853–1858), S. Hunter (1860–1864), S. Ball (1866–1867), C.E. Burton (1868–1869), R. Copeland (1871–1874), J. Dreyer (1874–1878).



Heinrich d'Arrest (1822–1875)

D'Arrest, a descendent of Huguenot immigrants to Germany, was director of the Copenhagen Observatory near the Danish capital. His published notes, "Siderosum Nebulorosum," which contain observations of 1942 objects and include 321 discoveries, prove that he was a very diligent observer. For most of his work, he used the 11-inch refractor at the Copenhagen observatory.

Léopold Trouvelot (1827–1895)

This French painter received considerable recognition for his precise drawings of plants and animals. His sketches of the aurora borealis finally caught the attention of Harvard astronomers in Cambridge (USA), who invited him to hone his talents with telescopic observation. In 1875, he was hired by the US Naval Observatory in Washington (DC), where he subsequently produced more than 7000 drawings of astronomical objects – still the finest of their kind. However, after his death, Trouvelot acquired a bad reputation in the USA because he introduced the European gypsy moth, whose caterpillars have caused a lot of damage to US agriculture ever since.

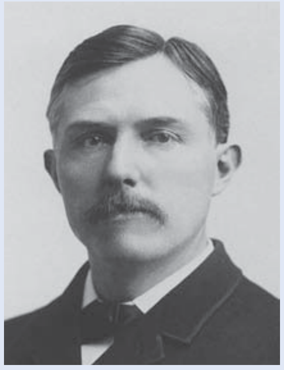
Wilhelm Tempel (1821–1889)

With a very humble, provincial family background in the east of Germany, he received his first recognition from abroad. His breakthrough came in 1859 when he discovered a comet and the nebula in the Pleiades that surrounds Merope – both feats were achieved with his small 4-inch refractor. In 1874, Tempel started work at the Arcetri Observatory near Florence (Italy), where he carried out numerous observations of nebulae and made 146 discoveries of new objects.

Leo Brenner (1855–1936)

Spiridon Gopčević is one of the most debated observers of all time. In 1894, he started to approach the public under his pseudonym Leo Brenner. On the Mediterranean island of Lussin, which then belonged to Austria (today the Croatian island Lošinj), he built a private observatory with a 7-inch refractor and published many incredibly detailed, but often fictitious, reports. In 1909, after he had lost almost all his credibility with professional astronomers, he simply vanished from the astronomical scene. His descriptions are relevant for the German-speaking community, though, because in 1902 he published the first ever observing guide on the deep-sky in the German language.

Edward Emerson Barnard (1857–1923)



This American is regarded as perhaps the best visual observer of all times. He had the combined gift of a keen eye and a well-trained, accurate perception. Coming from a very poor family background, Barnard started his career as a laboratory assistant in a photography shop and observed the night sky as an amateur astronomer. He soon became known as the discoverer of several comets. In 1887, he was hired by the Lick Observatory, where he made some spectacular discoveries with the 36-inch refractor, then the largest refractor in the world. Apart from his skills as a visual observer, he was also a very successful pioneer of deep-sky astrophotography.

Star chart with the observed path of the comet of 1764, according to Messier's positional measurements.

– all other new objects were contributed by Méchain, but verified by Messier through observation and positional measurement.

The last version of the catalog was supposed to have the round number of 100 entries. However, Méchain was discovering new objects in such quick succession, that Messier could not verify them all in time for the submission deadline of the manuscript. Hence, he added M 101, M 102, and M 103 to the finalized list with the remark: "From M. Méchain, have not yet been observed by M. Messier." The objects M 108 and M 109 had been mentioned only in the note on M 97. Apparently, this third version of the catalog was prepared under considerable time pressure. It was printed already in spring 1781, for the 1784 edition of the Connaissance des Temps.

M 104 to M 109: After press

Shortly after he received his personal copy of the third catalog from the printer, Messier made a hand-written note in it about a further discovery of Méchain's from the 11th of May 1781: M 104. Messier also added positions for the now-measured objects M 102 and M 103, as well as for M 108 and M 109 (in the note on M 97). Hence, initially, there was no indication that this would be the last version of Messier's catalog.

Also, Méchain remained active. Not only did he discover his first two bright comets on the 28th of June and the 9th of October of 1781, in July he also discovered the nebula now known as M 106. In addition, a discovery made by Méchain in March that year, M 105, had simply been overlooked in those final hectic days of work on the catalog. The next year (April 1782), M 107 was found by Méchain. Nevertheless, a new, updated version of the Messier catalog would never come. That may well be "blamed" on William Herschel.

De Chéseaux's list of nebulae

Philippe Loys de Chéseaux was a rich, Swiss nobleman living in the countryside near Lausanne, where he had his own observatory. He became known as a result of his independent discovery of comet Klinkenberg (C/1743 X1), on the 13th of December 1743. On the 13th of August 1796, he discovered another comet, C/1746 P1. Using a 2-foot (focal length) Gregorian reflector, he drew up a list of 21 star clusters and nebulae in 1746. For eight of those objects (M 4, M 16, M 17, M 25, M 35, M 71, NGC 6633, and IC 4665), he is the original discoverer.

He sent his list to his grandfather Reaumur, who was a member of the French Academy of Sciences, and who presented the list at an Academy meeting on the 6th of August, 1746. However, no printed publication followed, and de Chéseaux's work was forgotten until its rediscovery in 1884. Messier mentioned the list in the foreword to his first catalog version, but apparently, he had no complete knowledge of it.

Star clusters:

1.	*M 6*	*Between Scorpius, Ophiuchus, and Sagittarius, there is a very beautiful one, of which the principal stars have this year RA 260° 52' 30" and southern declination 32° 1' 30".*
2.	*IC 4665*	*Above the shoulder, beta of Ophiuchus, a cluster of stars of which the two principal stars have this year: RA 264° 46' 50" and southern [should read northern] dec. 6° 50' 20"; RA 264° 31' 55" and southern [should read northern] dec. 7° 00' 10".*
3.	*NGC 6633*	*Near the tail of Serpens in which there is a small cluster of stars, a bit separated from the rest to the west; its RA is at 273° 32' 30" and its southern [should read northern] declination is 6° 19' 20".*
4.	*M 16*	*A cluster of stars between the constellations of Ophiuchus, Sagittarius, and Antinous, of which RA is 271° 3' 10" and southern declination is 13° 47' 20".*
5.	*M 25*	*Another [star cluster] between the bow and the head of Sagittarius, of which RA is about 274° 17' and southern decl. is 19° 11' 30".*
6.	*NGC 869*	
7.	*NGC 884*	*Two clusters of stars in the hilt of Perseus' sword, earlier observed by M. Flamsteed.*
8.	*M 8*	*Another [star cluster] in the bow of Sagittarius, observed by the same.*
9.	*NGC 6231*	
10.	*M 7*	*The last two [objects] of the catalogs of Messieurs Derham and Maupertuis.*
11.	*M 44*	*That in Cancer, ordinarily called Praesepe, the position of which is known.*
12.	*M 35*	
13.	*M 71*	*Two others of which I have not yet determined the positions, one above the northern feet of Gemini, and the other below and very close to Sagitta.*
14.	*M 11*	*Lastly, a prodigious cluster of small stars, near one of the feet of Antinous of which RA is 279° 21' 10" and southern decl. is 6° 32' 20"; it has about 4 1/8' in diameter.*

These 14 nebulae contain among them almost as many stars visible in telescopes of 25 feet as the greater part of the sky contains as visible to the naked eye. Here now are the rightly styled nebulae which, when seen in the largest telescopes, never appear as anything but white clouds:

17.	*M 22*	*A third, discovered by Abraham Ihle, between the head and the bow of Sagittarius, of which I found the RA of 275° 14' 10" and southern dec. 24° 5' 30". It is 5' in diameter, it is round, of a reddish color, whereas the Andromeda Nebula is yellowish and that of Orion, transparent.*
18.	*NGC 5139*	*That in Centaurus, discovered by Mr. Halley; it is invisible in Europe.*
19.	*M 4*	*One which is close to Antares, of which I have found for this year, RA 242° 1' 45" and southern dec. 25° 23' 30". It is white, round and smaller than the preceding ones; I do not think it has been found before.*
20.	*M 17*	*Lastly, one other nebula, which has never been observed. It has a shape quite different from the others: it has the perfect form of a ray, or of the tail of a comet, 7' long and 2' wide; its sides are exactly parallel and quite well terminated, the same for the two ends. The center is whiter than the edges. I found its RA for this year as 271° 32' 35" and its southern declination as 16° 15' 6". It makes an angle of 30° with the meridian.*
21.	*M 13*	*I have not yet found that in Hercules, discovered by M. Halley. I very much hope that the Messieurs astronomers of Paris will be willing to indicate its position for me.*

The catalog of Abbé Lacaille						
No.	**Present designation**	**Con.**	**R.A.**	**Decl.**	**Pos.-error**	**Type**
First section: Nebulae without stars						
Lac I.1	NGC 104	Tuc	$0^h 33.41^{min}$	–72° 4'	41'	GC
Lac I.2	NGC 2070	Dor	$5^h 38.4^{min}$	–69° 10'	5'	GN
Lac I.3	NGC 2477	Pup	$7^h 50.9^{min}$	–38° 37'	15'	OC
Lac I.4	NGC 4833	Mus	$12^h 59.7^{min}$	–70° 49'	4'	GC
Lac I.5	NGC 5139	Cen	$13^h 26.8^{min}$	–47° 29'	0'	GC
Lac I.6	M 83	Hya	$13^h 37.1^{min}$	–29° 52'	2'	Gx
Lac I.7	NGC 5281	Cen	$13^h 46.6^{min}$	–62° 56'	1'	OC
Lac I.8	NGC 6124	Sco	$16^h 25.6^{min}$	–40° 39'	0'	OC
Lac I.9	M 4	Sco	$16^h 23.7^{min}$	–26° 31'	2'	GC
Lac I.10	NGC 6242	Sco	$16^h 55.6^{min}$	–39° 28'	0'	OC
Lac I.11	M 69	Sgr	$18^h 30.0^{min}$	–33° 29'	1,2°	GC
Lac I.12	M 22	Sgr	$18^h 36.4^{min}$	–23° 55'	1'	GC
Lac I.13	(NGC 6777)	Pav	$19^h 26.8^{min}$	–71° 30'	2'	Ast
Lac I.14	M 55	Sgr	$19^h 40.1^{min}$	–30° 57'	2'	GC
Second section: Star clusters						
Lac II.1	–	Hor	$4^h 3.0^{min}$	–44° 28'	0'	Ast
Lac II.2	Collinder 140	CMa	$7^h 26.2^{min}$	–34° 09'	2,1°	OC
Lac II.3	NGC 2516	Car	$7^h 58.9^{min}$	–60° 50'	9'	OC
Lac II.4	NGC 2546	Pup	$8^h 11.2^{min}$	–37° 13'	28'	OC
Lac II.5	IC 2391	Vel	$8^h 38.8^{min}$	–53° 6'	17'	OC
Lac II.6	Collinder 203	Vel	$8^h 46.8^{min}$	–42° 16'	19'	OC
Lac II.7	NGC 3228	Vel	$10^h 21.4^{min}$	–51° 43'	2'	OC
Lac II.8	NGC 3293	Car	$10^h 35.9^{min}$	–58° 13'	2'	OC
Lac II.9	IC 2602	Car	$10^h 43.1^{min}$	–64° 24'	1' (37")	OC
Lac II.10	NGC 3532	Car	$11^h 6.5^{min}$	–58° 40'	10'	OC
Lac II.11	–	Cen	$11^h 22^{min}$	–58° 21'	2'	Ast
Lac II.12	NGC 4755	Cru	$12^h 53.7^{min}$	–60° 22'	1'	OC
Lac II.13	NGC 6231	Sco	$16^h 54.2^{min}$	–41° 50'	1'	OC
Lac II.14	M 7	Sco	$17^h 53.8^{min}$	–34° 45'	3'	OC
Third section: Stars with nebulosity						
Lac III.1	nonexistent	Pic	$5^h 3.4^{min}$	–49° 30'	1' (52")	Single star
Lac III.2	NGC 2547	Vel	$8^h 10.7^{min}$	–49° 15'	7'	OC
Lac III.3	IC 2395	Vel	$8^h 42.4^{min}$	–48° 6'	2'	OC
Lac III.4	IC 2488	Vel	$9^h 27.8^{min}$	–57° 0'	4'	OC
Lac III.5	Collinder 228	Car	$10^h 44.0^{min}$	–60° 7'	3'	OC
Lac III.6	NGC 3372	Car	$10^h 44.3^{min}$	–59° 30'	10'	GN
Lac III.7	NGC 3766	Cen	$11^h 36.2^{min}$	–61° 37'	0'	OC
Lac III.8	NGC 5662	Cen	$14^h 35.3^{min}$	–56° 34'	4'	OC
Lac III.9	–	Cir	$15^h 22.7^{min}$	–59° 10'	2'	Ast
Lac III.10	NGC 6025	TrA	$16^h 3.8^{min}$	–60° 30'	5'	OC
Lac III.11	NGC 6397	Ara	$17^h 40.7^{min}$	–53° 42'	2'	GC
Lac III.12	M 6	Sco	$17^h 40.1^{min}$	–32° 13'	3'	OC
Lac III.13	M 8	Sgr	$18^h 3.9^{min}$	–24° 22'	1'	OC+GN
Lac III.14	–	Ind	$21^h 31.1^{min}$	–56° 53'	1'	Ast

Ast = asterism. The coordinates are the positions given by Lacaille as for equinox 2000.0.

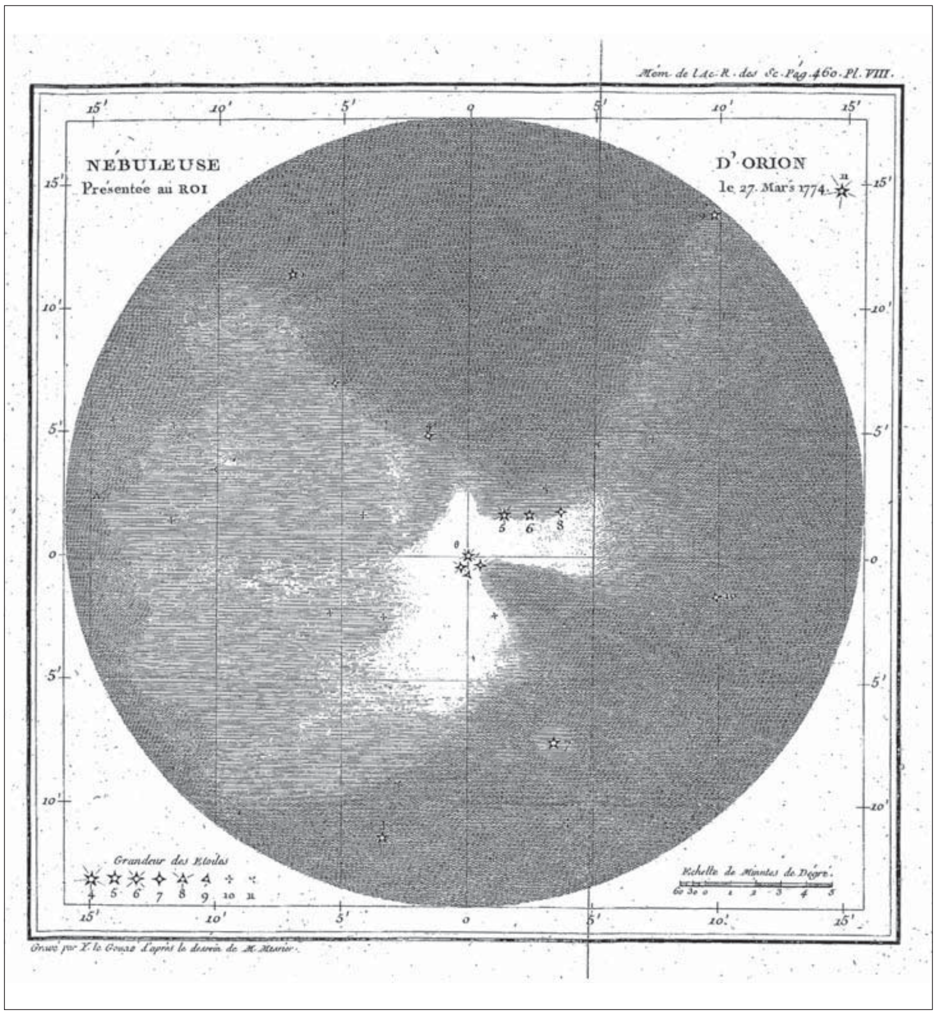
Lacaille's catalog of nebulae

It seems astounding that the very first catalog of deep-sky objects, presented in 1755 by Abbé Nicholas-Louis de Lacaille – 14 years before Messier's first catalog of 45 objects – was actually devoted to the southern sky. In any case, Lacaille's catalog was the first significant work of its kind, which also became widely known and accepted. Earlier object lists either had been very short (like the one by Halley), or had not reached the wider scientific community (like those of Hodierna in 1654, or de Chéseaux in 1746).

Lacaille's catalog of 42 objects was published in 1755 in the Memoirs of the French Academy of Sciences, and again in 1784 as an annex to Messier's work. Lacaille's

The frontispiece of Lacaille's catalog depicts a contemporary view of the Paris Observatory.

list has three sections: "Nebulae without Stars," "Star Clusters," and "Stars with Nebulosity." Incidentally, each of the sections contains exactly 14 objects. This equipartition already puzzled Kenneth Glyn Jones in the 1960s. Perhaps it satisfied a baroque desire for symmetry. Lacaille himself remarked on his list as follows: "I have found a large number of nebulae of these three types in the southern sky, but I would not believe that I have noticed all of them; in particular of the first and third type, because these are visible only after dusk and in the absence of the Moon. Nevertheless, I hope that this list is more or less complete for the most remarkable objects of the three types." For his task, Lacaille had only very humble optical equipment. He wrote: "I have wished dearly to present a more detailed and informative work. But the simple refractors available to me at the Cape of Good Hope, of 15 and 18 inches [focal length], were neither adequate nor sufficient for this kind of observation." Since his telescopes were probably non-achromatic with focal ratios of around f/10, their apertures cannot have exceeded 40mm (1½ inches). The fact that Lacaille could not resolve ω Centauri (NGC 5139) into individual stars, or open clusters like NGC 6124, reveals the poor quality of his instruments.



Messier's drawing of M 42, published in the annex of the first catalog. For this observation, Messier used an achromatic Dollond-refractor with an aperture of 40 lines (90mm), a focal length of 3.5 feet (1.14m), and a magnification of 68×, on the nights of the 25th and 26th of February, and the 19th, 23rd, 25th, and 26th of March 1771. The circular border represents the edge of the actual field of view, about 30'. South is above.

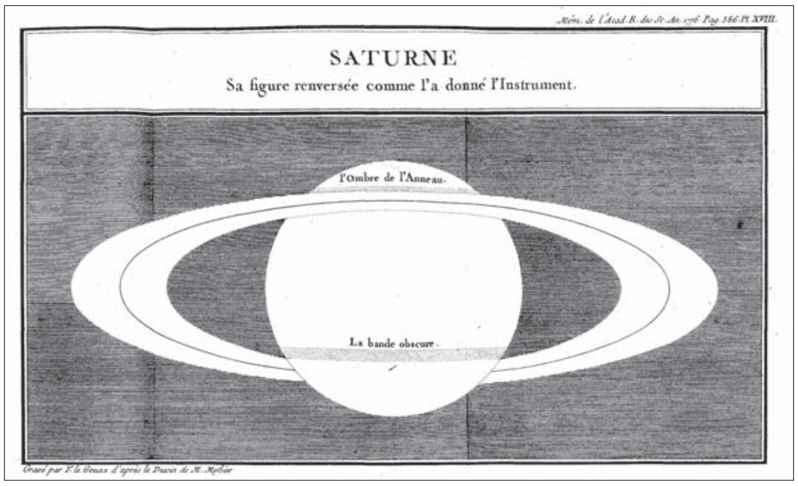
The German-born musician, who had emigrated from Hanover to England, became famous for a discovery he made on the night of the 13th of March 1781 – only four days after the last official entry to Messier's catalog. At first, Herschel took his new object for a comet, and so he asked Messier, the famous expert on comets, for his opinion. Messier observed the new object, measured its position over several nights, and had his friend de Saron calculate the orbit. The result was sensational: Herschel had found a new planet, Uranus.

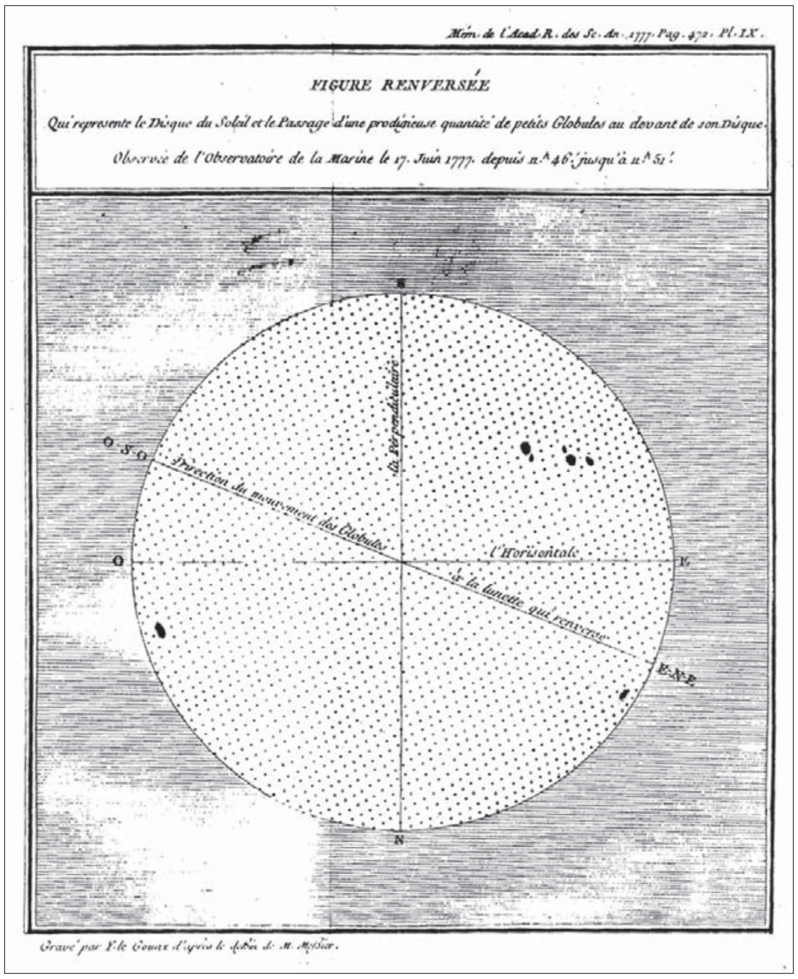
With the fame of this discovery, Herschel received a royal salary, which finally allowed him to concentrate fully on astronomical work. In 1782, he began an extensive search for new nebulous objects and, due to both his superior Newtonian telescopes and his dedication, made about 1000 new discoveries by 1786. By the end of that project in 1802, Herschel had compiled a huge list of about 2500 nebulae. It was the Messier catalog (he received his copy on the 7th of December 1781) that almost certainly gave him the idea.

At the same time, the unlucky Messier had to abandon all his work after his serious accident (6th of November 1781). After a long, painful recovery, he did not resume his search for new nebulae – in 1802 he described why:

> *After me, the famous Herschel published a catalog of 2000 [nebulae] which he had observed. Unveiling the sky in his way, with instruments of large aperture, is not useful for comet seeking. Hence, my objective is different from his: I only need the nebulae that are visible in a telescope of 2 ft [focal length]. I have observed more, meanwhile. I will publish them in the future, organized by right ascension, for the sake of finding them more easily, and so that those who are looking for comets have less uncertainty.*

But such a final publication never came to be.





Examples of Messier's observing results: a drawing of Saturn, the occultation of Saturn by the Moon on the 18th of February 1775, and the sunspots of the 17th of July 1777.

The "missing" Messier objects

Messier's catalog was of high quality and contained relatively few errors. For each object, Messier took the position relative to a bright neighbor star. Furthermore, a large number of objects was observed more than once, especially for the third version of the catalog.

Nevertheless, Messier could not entirely avoid making mistakes. Consequently, there are a few objects for which the identification remained ambiguous and matter of debate. Glyn Jones called these the "missing Messier objects," which has become the adopted choice of words. There is now broad consensus about most identities, except the case of M 102.

M 47

Messier's position lies in a field without any recognizable star clusters. Hence, astronomers after Messier long believed that M 47 did not exist. However, in 1959, T.F. Morris was able to prove an assumption that Oswald Thomas made in 1934: Messier made a sign-related mistake in his calculation of the position. As a curious result, M 47 has two NGC entries: a false one, NGC 2478, in its wrong position, and the true one, NGC 2422, with the correct coordinates from Herschel.

M 48

The same night he recorded M 47, Messier made another simple calculation mistake with M 48, putting it exactly 5° too far south. Again, Oswald Thomas and T.F. Morris found the right identity: NGC 2548 has now been commonly accepted as M 48.

M 91

With this galaxy, a positional error is also the most likely explanation. There is no sufficiently bright galaxy at the position given by Messier, only a lot of faint galaxies of the Virgo Cluster. Owen Gingerich suggested that M 91 may just be an accidentally repeated observation of M 58, a galaxy only 2.7° south of Messier's position. But in 1969, W.C. Williams showed that Messier used a galaxy as his reference point for M 91 (there are hardly any bright stars in this field) and that he sim-

Bode's catalog of nebulae

In 1777, three years after Messier presented his first catalog, the Berlin astronomer Johann Elert Bode undertook the same endeavor. In his publication "On several newly discovered nebulous stars and a complete listing of all known so far" he wrote: "I wanted to search for nebulous stars [objects] with diligence. Since I had the pleasure to discover a number of new ones, which until then, at least, I had not found with any other astronomer, I herewith wish to communicate them." With the use of several different sources, including Messier's first catalog, Bode managed to collect 75 objects north of –35° declination. However, the diverse origin of the data was also the problem with Bode's catalog. We only know with certainty of eleven objects that Bode observed himself. Of these, M 53, M 81, and M 82 were his own discoveries. All of the other objects had been copied from the literature without any verification, as Bode admits: "I have to add that I myself have not yet had the opportunity to observe all of the nebulae discovered by other astronomers." As an example, this explains why M 8 has been listed three times – with different positions.

The problem of non-verified entries was the death-sentence for Bode's list, despite his good reputation as an astronomer. He printed it once again in 1782 in his star atlas "Vorstellung der Gestirne," expanded with some new discoveries (including M 92, IC 4665, and the star pattern near χ Dra known as the "little Cassiopeia"), but the catalog never achieved widespread international use.

The catalog of Johann Elert Bode

Bode's No.	Present designation	Original source	Bode's No.	Present designation	Original source
1	?	own observation	39	M 6	Lacaille
2	M 32	Messier	40	90 Her	Hevelius
3	M 31	Messier	41	M 7	Lacaille
4	Muster 1° W λ Cas	own observation	42	M 23	Messier
5	M 33	Messier	43	4 Sgr	Flamsteed
6	55 And	Flamsteed	44	5 Sgr	Flamsteed
7	M 34	own observation	45	M 8	Le Gentil
8	M 45	–	46	M 69	Lacaille
9	M 38	Messier	47	M 20	Messier
10	M 42	Messier	48	7 Sgr	Flamsteed
11	M 1	Messier	49	M 8	Messier
12	M 36	Messier	50	M 21	Messier
13	M 37	Messier	51	M 24	Messier
14	M 35	Messier	52	M 16	Messier
15	M 41	Messier	53	M 18	Messier
16	M 50	own observation	54	M 17	Messier
17	M 81	own observation	55	γ Sct	Hevelius
18	M 82	own observation	56	M 25	Messier
19	Cr 140	Lacaille	57	M 22	Lacaille
20	M 44	–	58	M 28	Messier
21	NGC 2477	Lacaille	59	M 26	Messier
22	NGC 2546	Lacaille	60	ν^1 Sgr	Flamsteed
23	M 40	Messier	61	ν^2 Sgr	Flamsteed
24	M 40	Hevelius	62	M 11	Messier
25	M 51	own observation	63	M 55	Lacaille
26	M 53	own observation	64	σ Cap	Hevelius
27	M 83	own observation	65	π Cap	Hevelius
28	ξ^1 , ξ^2, 17, 18 Lib	Hevelius	66	o Cap	Hevelius
29	M 5	Messier	67	M 27	Messier
30	M 13	Messier	68	M 30	Messier
31	M 4	Lacaille	69	M 29	Messier
32	M 12	own observation	70	M 2	Messier
33	M 10	own observation	71	M 15	Messier
34	32, 33, 34 Oph	Hevelius	72	ω^{1+2} Cyg	Hevelius
35	M 19	Messier	73	34, 35, 37 Peg	Hevelius
36	M 9	Messier	74	?	Hevelius
37	M 14	Messier	75	M 39	Messier
38	88 Her	Hevelius			



Three people had a significant influence on the extension of the Messier catalog: Camille Flammarion (1842–1925, French writer of popular astronomy), Helen Sawyer Hogg (1905–1993, professional Canadian astronomer), and Oswald Thomas (1882–1963, founder of the planetarium of Vienna).

ply confused M 89 with M 58. This yields the real identity of M 91 as NGC 4548.

M 102

The identity of this object has remained a matter of debate to the present day. Many modern US publications regard this object as "missing," while most European sources identify it with the galaxy NGC 5866.

This discussion has its origin in a letter, which Pierre Méchain wrote two years after the third version of the Messier catalog was completed, on the 6th of March 1783. He sent it to Bernoulli in Berlin, because Messier's list of nebulae was also published in the Berlin Astronomical Almanac. Méchains letter was printed in the 1786 edition of the same almanac. In it, a passage reads:

> *I would only like to add that Nr. 101 & 102 on p. 267 of the Connaissances des Temps for 1784 are nothing else than one and the same nebula, which was taken for two because of an error in the charts.*

In other words, Méchain said that M 102 was his accidentally repeated observation of M 101. Hartmut Frommert, however, came up with some serious doubts. Firstly, the descriptions of M 101 and M 102 given in the catalog differ from each other. And then, like M 103, M 102 had actually been observed and measured by Messier himself, as we know from his handwritten positions in his personal copy of the printed catalog. For M 103, there is an error of 1°, while there is no object near the position he noted for M 102. However, if he had made a simple mistake with the calculation, again by 5° as with M 48, but this time in right ascension, then there would be an object in the right place, which also matches the description of M 102: NGC 5866. Hence, it is quite possible that Méchain accidentally observed M 101 twice, indeed, but that Messier then, while looking for the acclaimed object, found a real nebula – M 102 alias NGC 5866 was probably his last nebula discovery.

The supplementary Messier objects

The original Messier catalog of 1784 contains 103 explicit entries. Nevertheless, today's commonly accepted number of Messier objects is 110. The supplements have been added on in the twentieth century, according to evidence for objects observed by Messier but not (or not explicitly) included in his catalog. An important role is played by the above-mentioned letter of Méchain to Bernoulli, because it contains comments on further observed objects.

The other important source is Messier's personal copy of the catalog, which contains his handwritten notes. In 1924, Camille Flammarion discovered and bought that very copy, and he found Messier's notes in it. One of them is about a further "very faint nebula in Virgo." In his letter, Méchain wrote about this object and three others:

M 104

> *On 11th May 1781, I discovered a nebulous patch above Corvus which did not appear to me to contain single stars. It has a weak light and is difficult to find if the wires of the micrometer are illuminated. I compared it to Spica this day and the following and inferred the right ascension as 187° 9' 42", the southern*