

Mayo Clinic's Moulages and Medical Museum

THE WAXING AND WANING OF A TWENTIETH-CENTURY EDUCATIONAL PARTNERSHIP

Karen Koka

For six decades, from 1924 to 1982, Rochester's Mayo Clinic produced large numbers of medical moulages, lifelike wax models formed from molds to demonstrate pathological changes in the body. The wax models were educational tools used in exhibits at major medical meetings to depict the Mayo Clinic's medical and surgical techniques and to illustrate the signs, symptoms, and treatments of conditions seen at the clinic. Following a successful run at the Century of Progress International Exposition, a world's fair held in Chicago in 1933, the Mayo Clinic began displaying the models in a popular collection at the Mayo Foundation Museum of Hygiene and Medicine in Rochester. The little-known story of this wax model collection exemplifies the innovative spirit of Dr. William J. Mayo, his brother Dr. Charles H. Mayo, and the Mayo Clinic.¹

By the time the two Mayo brothers died within months of each other in 1939, they and the clinic (which had grown from the medical practice begun in 1864 by their father, William

Worrall Mayo) were internationally known. Fondly referred to as Dr. Will and Dr. Charlie, they had excelled at identifying and adopting a variety of methods to share their expertise with other surgeons and practitioners. From the outset, they had welcomed visiting surgeons to view procedures in the operating rooms at Saint Marys Hospital. They also had presented their work at medical association meetings and had published widely on surgical topics. They championed the training of medical specialists and, in association with the University of Minnesota, established a school for postgraduate medical education in 1915.²

Dr. Will and Dr. Charlie expected clinic consulting staff also to participate in medical associations and to publish in the medical literature. To support the doctors' publications, the clinic established an Art Section in 1907, hiring Florence Byrnes to produce original drawings of the

operations, specimens, abnormal conditions, and microscopic structures described in journal articles. The section soon expanded, adding Dorothy Peters in 1909 and Eleanora Fry in 1912 to assist Byrnes.³

Wax in art and the development of anatomical models

In 1924 a new type of visual aid arrived at the clinic—one that moved beyond two-dimensional illustrations to provide more graphical information: wax models. While this technique may have been new to the clinic, it had been developing in Europe for centuries and had evolved over millennia in the ancient world. In antiquity, applications were both religious and commemorative in nature. In the Greco-Roman period, for example, supplicants offered representations of whatever part of the body needed healing.⁴

The first documented use of wax

ABOVE: A model from the exhibit "The Thyroid Gland and Diseases that Affect It," shown at the Century of Progress International Exposition world's fair in Chicago, 1933–34.

in medical education dates to the thirteenth century, but the true era of anatomical wax modeling began in Italy in the late seventeenth century and spread throughout Europe during the eighteenth century. Creating moulages as a teaching aid solved the shortcomings posed by cadavers, the procurement and use of which were limited by religious and legal restrictions. Even when cadavers were available, the lack of “effective preservation techniques . . . made dissection of deteriorating bodies highly unpleasant.” Three-dimensional wax models had the advantage of being lifelike, true to color, and portable. Moulages did have some disadvantages, including fragility, need for storage and display space, and production expense.⁵

European anatomical models were developed at a time when the structures and true functions of the body were being discovered. Painted to look as natural as possible, they depicted healthy body parts or entire figures and were displayed for medical and scientific instruction and sometimes for viewing by the educated public. The moulage evolved as medical research changed from discovering how the body and its systems functioned to demonstrating how specific diseases manifested in defined parts of the body. Dermatology, where the color of the diseased area was important for proper identification of a condition, was a particular medical specialty that contributed to the development of moulage.⁶

By the early twentieth century, when the Mayo moulage story begins, anatomical waxes were a well-established educational tool in the large medical institutions that could afford them in Europe, Japan, and the eastern United States. While three American institutions made their own models—the Armed Forces Medical Museum in Washington, DC, the



Dentists Kenji Hiyama and Boyd Gardner (seated, second and third from left), Mayo Clinic's Section on Dental Surgery, ca. 1926.

Medical School of Fordham University in New York, and the Philadelphia Polyclinic and College for Graduates in Medicine (now part of the University of Pennsylvania Graduate Hospital)—the moulage collections in the United States consisted mostly of purchases made in Europe. Though the Mayo Clinic did not pioneer the use of wax models in North America, once staff physicians discovered how effectively moulages could convey complex medical and surgical information, the clinic fully committed to the support of a growing team of artists dedicated to creating them in-house.⁷

Dentistry resident starts the Mayo moulage collection

The first models used by the Mayo Clinic were created by Dr. Kenji Hiyama, a Japanese dentist and resident in dental surgery at the clinic from 1924 to 1927. Hiyama had received his doctorate in dental surgery (DDS) in 1921 from the Nippon

Dental College in Tokyo, where he had learned the art of medical moulage. The technique had been imported to Japan a few decades earlier by a Japanese dermatologist who had studied the art in Vienna in 1895.⁸

In the United States, Hiyama earned a second DDS degree from Georgetown University in 1922 and came to Rochester in June 1924 at the invitation of Dr. Boyd Gardner, head of the Mayo Section on Dental Surgery. Gardner had met Hiyama in Washington, DC, earlier that year and was impressed by his moulages of “pathologic conditions involving teeth and their adjoining structures.” Gardner’s enthusiasm continued when he saw the depth and color of the models that Hiyama produced for Mayo. Even more exciting to Gardner was the fact that the models could be shown to dentists visiting the clinic, and that he, in his words, “could carry [them] with me whenever I was to appear on a dental program.”⁹

Gardner’s 1925 section report to the Mayo Clinic Board of Governors

noted the models' impact as educational tools at the clinic and at meeting exhibits: "tremendous interest has been shown[,] which has given the clinic publicity, the value of which cannot be overestimated." Hiyama's dental models depicted sequential steps in surgical procedures to make them easy to understand, and this step-by-step demonstration became a hallmark of Mayo Clinic exhibits.¹⁰

The Section on Dental Surgery was not the only area within the Mayo Clinic to recognize the usefulness of wax models. The 1926 annual report of the Section on Dermatology and Syphilology also documents the clinic's commitment to promoting wax as an educational tool: "We will continue to develop the collection of

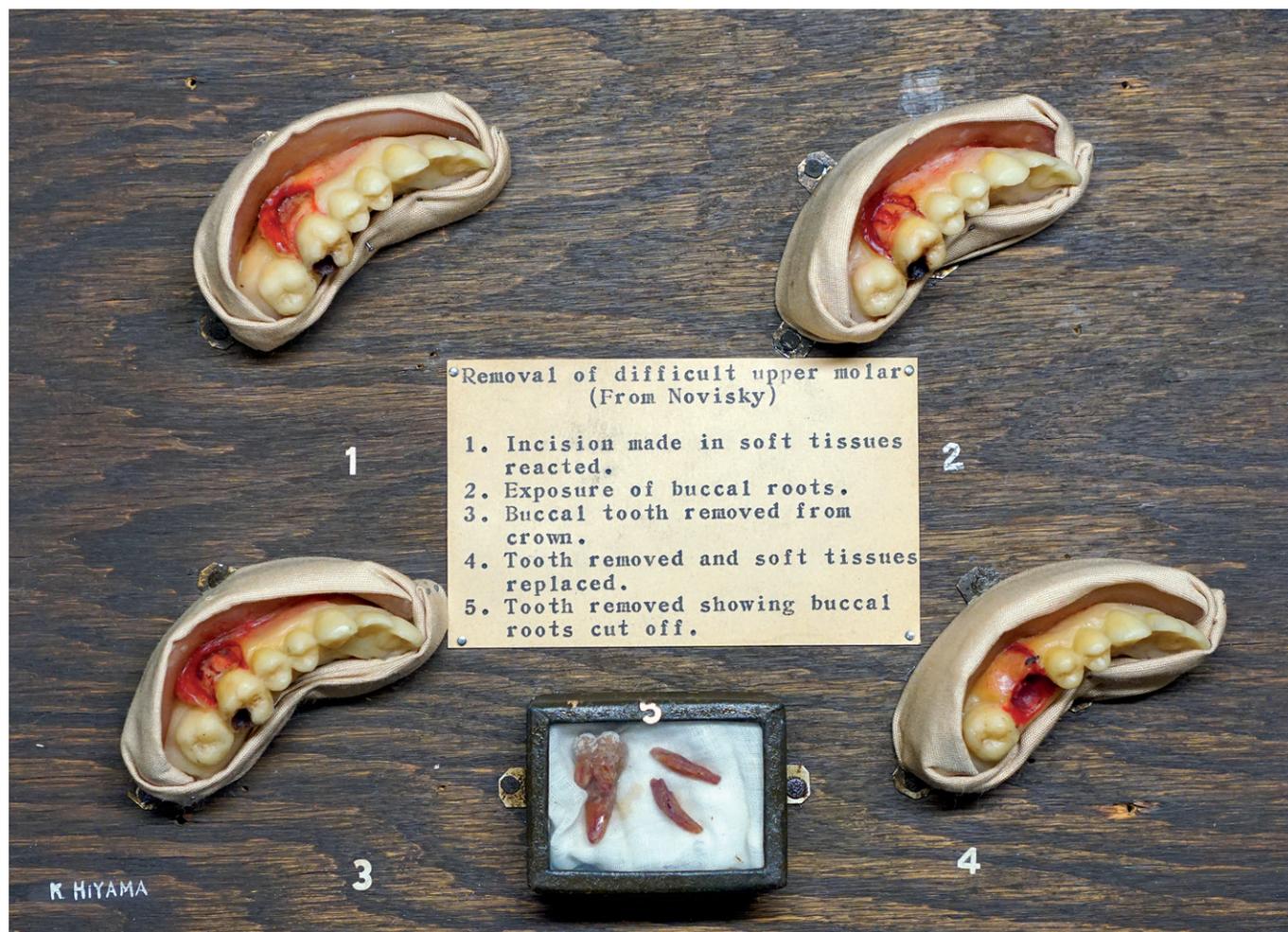
moulages which was started by Dr. Kenji Hiyama." In the same year, the report of the Division of Pathologic Anatomy also reflects his influence: "The need of a capable modeler in wax is demonstrated by the beautiful work of Dr. Hiyama."¹¹

Dr. Will Mayo was noted for taking swift action when the clinic needed new skills to support the work of its busy surgeons and researchers or to enhance patient care. To fill the need for a full-time wax modeler, he chose Nellie Starkson to become an artist in training, most likely in the fall of 1924. In a later interview with Katherine Doyle, a columnist for the *Chicago Daily Times*, Starkson recalled that she had been planning to become an interior decorator, but her career path

changed one summer while the Rochester native was home on vacation from the Minneapolis School of Art (today, the Minneapolis College of Art and Design): "[I] was earning extra money in the Mayo Clinic when Dr. Will Mayo suggested that [I] try making some wax models. 'If you decide to continue,' said Dr. Will, 'I'll see that you study under the best teacher there is.'"¹²

That "best teacher" was Kenji Hiyama, whom Doyle described as "world famous for his wax models of dentures." Starkson joined the clinic's Art Section and trained with Hiyama, creating her first models for a Mayo exhibit at the October 1925 meeting of the American Medical Association held in Charleston, North Carolina.

Models of a tooth extraction in sequence made by Dr. Hiyama, ca. 1925–26.





William J. Mayo, "Dr. Will."



Dr. Walter Alvarez, 1934.



Dr. Thomas Sadler Roberts.

She remained with the Mayo Clinic until 1936, when she joined the staff of the Field Museum in Chicago as an artist-preparator. Hiyama returned to Japan in January 1927.¹³

By 1932 the clinic was producing large numbers of models each year. In the first six years a total of 431 wax models were made, rising from 10 in 1925 to 58 in 1931. Meanwhile, a grand opportunity to display the models to national and international audiences at the upcoming Century of Progress International Exposition world's fair in Chicago was in the planning stages. The fair's theme was technological innovation, designed to give Americans a glimpse of a post-Depression world made better by science and technology.¹⁴

Century of Progress International Exposition, Chicago, 1933-34

The Mayo Clinic's participation in the 1933-34 world's fair in Chicago brought publicity and fame to the wax models. The minutes of the Mayo Clinic Board of Governors meetings provide a great deal of information about how the clinic planned for the Century of Progress International

Exposition. During the meeting of February 25, 1931, staff physician Henry Plummer "called the attention of the Board [to] the fact that there would be a medical exhibit at the World's Fair." By August, the board had decided to accept the invitation to participate in the exposition, "providing it had been approved by the American Medical Association." Further, "It was felt that no expense or effort should be spared to prepare a very representative and unusual exhibit."¹⁵

In December 1931, the board approved an appropriation of up to \$50,000 to cover expenses. Staff physicians George Brown and Walter Alvarez were appointed to gather information about different types of exhibits to begin planning for the display and probably also to find out how much it might cost. In January 1932 the board settled on a \$10,000 appropriation, about \$187,844 today. Though much lower than the initially approved \$50,000 limit, the final appropriation still was notable for the amount of money committed to the project, particularly during the Great Depression.¹⁶

At their December 16, 1931, meet-

ing the board recognized "that it might be necessary to secure a man from the outside to take charge of the preparations." Alvarez was chosen to head the search. In a 1963 letter, Alvarez recalled how he found his man.

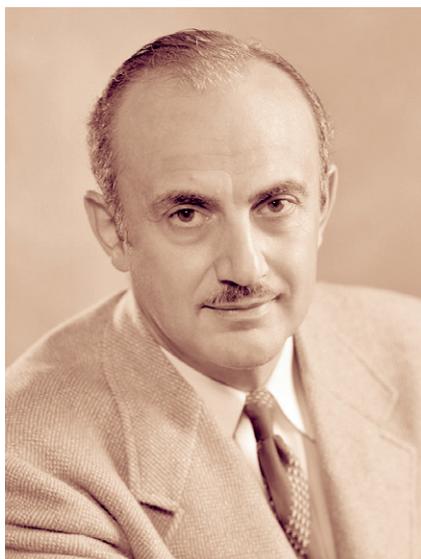
I asked around the place whom I had better see, and Dr. [Harold] Robertson . . . advised me to see sweet old Dr. [Thomas Sadler] Roberts up in Minneapolis. So I drove up there and saw him and told him my problem. He immediately said, "Come, and I'll introduce you to a gifted young Armenian who just graduated here in dentistry, but who does not want to be a dentist. He studied dentistry only because his family doubted if he could make a living as a museum man, and that's what he wants to be."

That young Armenian was Arthur Bulbulian, who would prove to be among the clinic's most remarkable staff recruits. In addition to becoming a talented sculptor, exhibit creator, and acknowledged pioneer in the field of maxillofacial prosthetics, Bulbulian also became the co-inventor,

in 1938, of the first modern American oxygen mask, initially designed for high-altitude flight and subsequently used for medical oxygen delivery.¹⁷

At its February 24, 1932, meeting the Mayo board hired Bulbulian to prepare the clinic's exhibit for the Century of Progress International Exposition. The appointment was for eight months, beginning June 1, 1932, at a salary of \$250 per month (\$4,685 in 2019 dollars), to be paid from the exhibit's appropriation.¹⁸

By March 1933, three months before the exposition was to open, exhibit details were complete. In the display, the Mayo Foundation would tell the story of a century of progress in human knowledge about the functions, diseases, and treatment of the digestive tract, thyroid gland, and sympathetic nervous system. According to the minutes of the board of governors, "The information is presented with the help of transparent photographs, wax models, charts, motion pictures and lantern slides. . . . A series of wax models show the more important steps in the technic of operations on the stomach, colon,



Dr. Arthur H. Bulbulian.

appendix and gall bladder. . . . A large model of the thyroid gland has been made in wax and seven life-like masks show the appearance of patients with different types of goiter and thyroid gland deficiency."¹⁹ (See p. 349.)

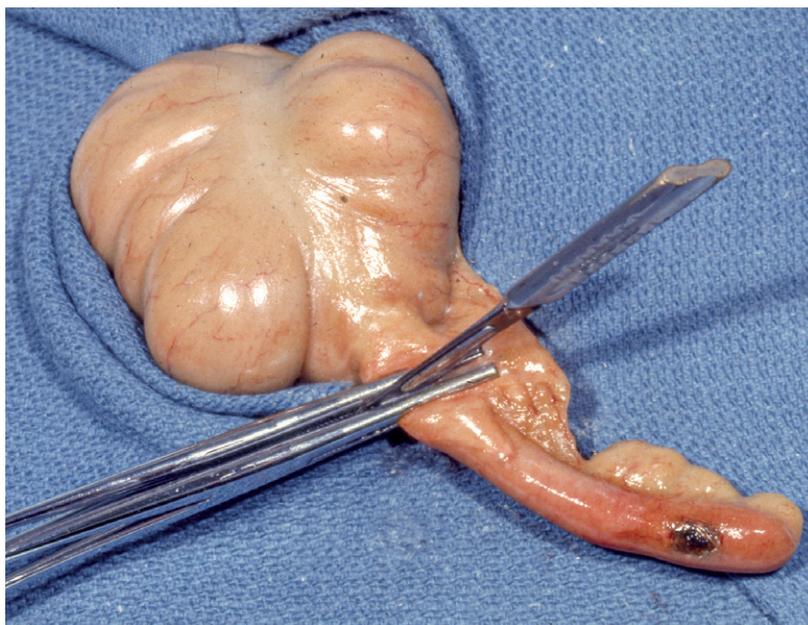
Bulbulian, whose appointment on the project had been extended, stayed in Chicago to oversee the exhibit while the fair was in progress. Mayo fellows, doctors who had been

accepted as trainees in the Mayo Graduate School of Medicine, served as demonstrators in two-week shifts, at a salary of \$2.50 per day (\$49.38 in 2019 dollars), in addition to housing. The daily pay was soon raised to \$3. In August, Alvarez reported, "One of the head guides told me that more people in the Hall of Science asked them about the Mayo Clinic exhibit than about any other."²⁰

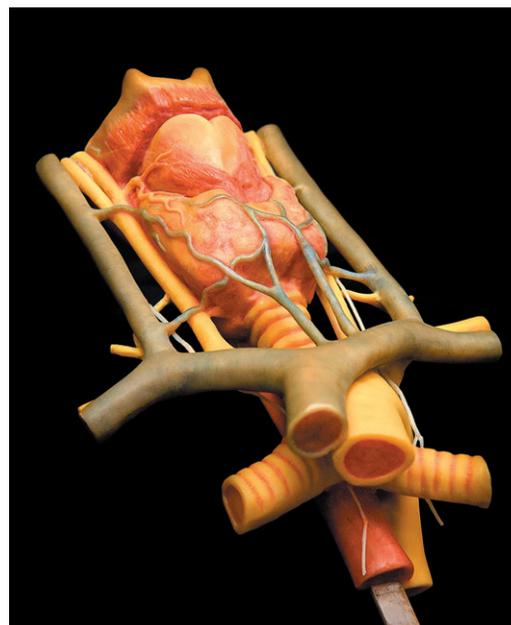
As part of the exhibit, Bulbulian and Nellie Starkson had designed and created a series of life-sized moulages from careful observation of Mayo Clinic surgeons at work. "[The] models were so realistic that some Exposition visitors in Chicago actually fainted," according to a 1994 profile of Bulbulian in *Mayo Magazine*. In fact, "The fainting occurred so often that he needed a supply of smelling salts on hand, which he charged to his expense budget. The business office at the clinic in Rochester protested, until the need for the smelling salts at the exhibit was carefully explained."²¹

Bulbulian's excellent work for the exposition did not go unnoticed.

Detail of a model from the appendectomy series.



Thyroid gland model.



In 1991, he reminisced that when Dr. Will visited the Mayo exhibit in Chicago, he looked specifically for Bulbulian. He recalled Dr. Will saying, “Bulbulian, nice show. . . . You are staying with us, aren’t you?” Though surprised, the young man confirmed that he indeed wanted to “stay on at the Mayo Clinic and do the same type of work that I had been doing.” To which Dr. Will replied, “Of course that can be arranged.” When Bulbulian went to Rochester soon afterward, Harry Harwick, the clinic’s business manager, called him to his office and said, “Art, you are on the staff.”²²

The popularity of the Century of Progress Exposition was so great that organizers extended its run through 1934. Bulbulian remembered that the Mayo exhibits were brought back to Rochester from the Hall of Science and refurbished to prepare them for the additional year, a process he oversaw. He also noted that “at the end of the exposition. . . I had the job of converting these exhibits into a permanent museum.”²³

“Why don’t we make a museum?”

Largely due to the success of the Mayo exhibit at the Century of Progress International Exposition, Dr. Will authorized the creation of a medical museum in Rochester. Alvarez’s recollection of the museum’s founding illustrates Dr. Will’s approach to this educational project:

One day, in 1932 or 1933, I said to Dr. Will, “Why, when we spend thousands of dollars making exhibits for the several big medical societies, do we afterwards throw them into a big room in the back of the power plant and let them go to ruin? Why don’t we make a museum and put those exhibits in it? Then when we get our exhibits back from Chicago

SCULPTING A MOULAGE

The Mayo Clinic Archival Collections retains a copy of the three-page Mayo instructions for making moulages. The wax formula consisted of two parts beeswax to one part each of paraffin, cornstarch, and talc. Once prepared, wax was poured into a negative plaster-of-paris mold and allowed to harden. A mold could be created directly from a patient, from a pathological specimen, or from a clay sculpture. When the mold was removed from the wax, additional surface sculpting smoothed away any seams and added details. The final

step was meticulous painting to create a true-to-life quality for each model. Shortly before his 1965 retirement as Mayo Medical Museum director, Arthur Bulbulian documented the process of creating moulages in an instructional booklet entitled *Planning and Preparing Scientific Exhibits*.¹

Note

1. Untitled typescript [Mayo Clinic instructions for making wax models], n.d., p1–3, MHU-0676: Subject Files, Wax Models, Fye Center for History of Medicine Archives, Mayo Clinic.

The formula is very close, but not identical, to that of the Armed Forces Medical Museum in Washington, DC, where “in 1901 Jay Frank Schamburg and James Frank Wallis were the first ever to publish a description of a wax moulaging procedure” (Schnalke, *Diseases in Wax*, 71, 72). Margaret Phillips, mouleur at Scott & White Memorial Hospital and former Mayo Art Section trainee, used the Armed Forces Medical Museum formula (Margaret W. Phillips, “Moulage Notes,” dated after 1931, 1996.0151.0003, Box 92: Rm. 319, Scott & White Archives, Baylor Scott & White Medical Center—Temple, Temple, TX).



Sculptor Leonard Knudson pours wax for a model of the lower leg, 1966.

in a year or two we will have a permanent place for them.” Dr. Will said, with his immediate decisiveness, “Good idea; take the first floor of the school building across the way, call [architect] Ellerbe’s man this afternoon and go to work tomorrow morning.” This was just before noon.²⁴

By the next morning—and four calls from Dr. Will later—the project was underway, with the assistance of Henry Plummer, the staff physician who had first alerted the board that

the exposition in Chicago would include a medical exhibit. Alvarez reminisced, “When Dr. Will saw the size of the crowds that poured in [after the new museum was opened], he called me and said, ‘I’m moving [Frank Krusen and his Section on Physical Therapy] out of the second floor; so now you can take the whole building.’ And that is what was done.” That building was the Central School Building, now the site of the Mayo Building.²⁵

Bulbulian was installed on April 1, 1935, as the first director of the new



After returning from the Chicago world's fair in 1934, Mayo's moulages found a home as the Mayo Foundation Museum of Hygiene and Medicine, housed in the Central School building (left, today the site of the Mayo Building). There the museum remained until 1950. Mayo's Plummer Building looms over this 1934 scene.

museum, officially named the Mayo Foundation Museum of Hygiene and Medicine, later known as the Mayo Medical Museum. In his first annual report to the board of governors in 1935, Bulbulian's list of the museum's main objectives included "making routine records in the form of wax casts or models of interesting and worthwhile medical, surgical and pathological cases" for future use in exhibits.²⁶

From its opening in 1935, the Mayo Medical Museum and its moulages were a favorite attraction for visitors to Rochester. A reporter from the *Chicago Daily Times* described this fascination in 1937: "The last place in Rochester you would expect to find Mayo patients convalescing from surgery is in the Museum, directly across

from the Clinic. But you find them there, by the dozens, admiring the pathologic specimens, pointing out to shuddering relatives various steps of an appendectomy, reproduced vividly in wax. . . . They tell listeners with pride, "That's what I had."²⁷

The clinic also continued to send the models to large exhibitions and events. Visitor comments could "vary tremendously as people walk by," reported a Mayo hostess at the 1939 Golden Gate International Exposition in San Francisco, ranging from "Simply marvelous" and "I'll let my doctor look at that" to "Ugh, that stuff makes me sick." One of the hostesses' favorites came from "a sweet little old lady [who] was busy with pencil and paper while looking at the Mayo Foundation exhibit. . . . [When she

finished writing] she presented me with the following:

Our innards now are brought to
light—
To me, a most ungodly sight,
And now that I have duly met them
I'll make an effort to forget them.²⁸

Models used beyond the museum

While a large percentage of the model collection was made by the Mayo museum staff specifically for display at medical meetings and then repurposed for use in museum exhibits, they were also used as educational tools outside of the museum. The Mayo team not only created the models, signage, lighting, and cases for the exhibits but also traveled

"I DO NOT KNOW WHAT MAYO WILL FIND WRONG WITH ME, BUT I DO KNOW WHAT'S WRONG WITH YOU."

One visitor to the Mayo medical museum reported a surprising reaction to the thyroid gland exhibit, the same models that had been sent to the Century of Progress Exposition in 1933. In a letter dated March 23, 1977, the visitor told his story.

Dear Sir,

For years I have been telling a story about a true incident involving your Mayo Medical Museum.

I was in the museum only a few minutes when a display of two wax images caught my attention. I remember this so well that even today I believe that on entering it was the first display in the second aisle on the right. This particular display was of a woman's face with myxedema before and after treatment.

[My wife] was transforming from an outgoing . . . to a lethargic person, lacking in vitality, gaining weight without eating and becoming very emotional. Her face was also taking on some of the characteristics of the wax images.

On seeing this display and reading the symptoms, I said to myself, "That's Patricia." I immediately walked across the street

to the clinic and to the first pay phone I could find. I called . . . and told her, "I do not know what Mayo will find wrong with me, but I do know what's wrong with you." I asked her to join me in Rochester as quickly as possible and she arrived the next day by plane.

[Three weeks after testing] the head of the thyroid department confirmed my diagnosis of myxedema from the museum display and commented that he had never seen anyone look as well as she did, but who was as sick as she was.

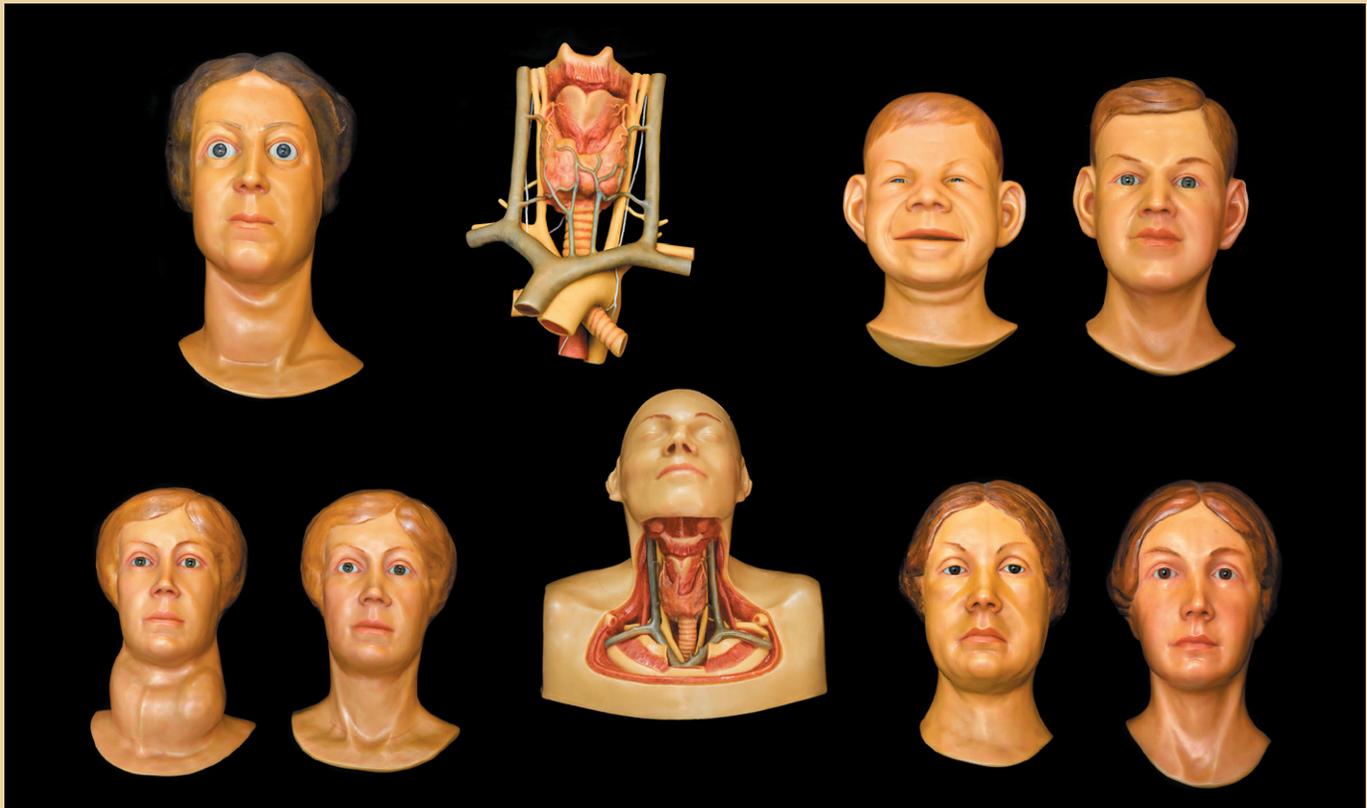
I realize this is a lengthy story, but I did not feel that a short note would fully convey how one display in your museum changed, and perhaps saved, the life of a fine person and helped her two daughters develop normally.

As myxedema is a rare but life-threatening complication of a long-term underactive thyroid gland condition, it was fortunate that the woman had been diagnosed. Both girls also tested positive for the disease following their mother's diagnosis, and all three were able to receive treatment.¹

Note

1. Letter, [typescript, photocopy], March 23, 1977, MHU-0676: Subject Files, Wax Models, Fye CHOM Archives.

"The Thyroid Gland and Diseases that Affect It," models in exhibit configuration.





Building an exhibit case in the Mayo museum workshop.



Preparing an exhibit for railroad shipment to the 1950 American Medical Association meeting.

to the meetings to assemble them. These exhibits frequently received awards for their excellence.

The Mayo Anatomy Laboratory supplied Bulbulian “with anatomical material which he dissects in preparation for the annual AMA [American Medical Association] exhibit,” noted a 1935 report. “This provides him with a proper anatomical review so that he can bring out in his exhibit the things which he should stress.” This comment reflects the centuries-old connection between art and anatomy, and the importance of dissection to the *mouleur* [wax model artist] in thoroughly understanding the parts of the body to be modeled.²⁹

In 1939 Dr. John S. Lundy, founder and chairman of the Mayo Section on Anesthesia, made plans for a sufficient number of models demonstrating different methods of anesthesia to be made “so that not only our own fellows in anesthesia but the visiting anesthetists will be able to observe our methods and learn them quickly and accurately.” The plan, which included additional

display space outside the operating room amphitheater in Saint Marys Hospital, came to fruition in 1942: “As a further effort to use visual methods we have arranged with Doctor Bulbulian for the installation of exhibits on the sixth floor of Saint Mary’s [sic] Hospital. The visiting physicians [sic] attention is called to the methods of anesthesia utilized here and they are able to get a good deal of information from the exhibits whereas they used to ask a great many questions. The officers in training here also make use of these exhibits.”³⁰

The “officers in training” were part of a program Lundy had started in 1938 when he “invited the Surgeons General of the Army, the Navy and the U.S. Public Health Service to send a medical officer to spend at least six months on our Section.” Lundy saw that America would become involved in what became World War II and felt that “the methods of anesthesia in use [at Mayo] are applicable to the large Government hospitals.” Two other exhibits showing the clinic’s techniques for intratracheal anesthe-

sia (AMA exhibit, St. Louis, 1938) and venipuncture (AMA exhibit, Chicago, 1944) were added to the sixth-floor display area at Saint Marys Hospital.³¹

ONE OF THE most interesting aspects of the Mayo moulage collection from a research perspective is that most of the models were made from real cases, though not all have an identifying patient number. For those with numbers, a corresponding patient file containing medical records for the case may be requested for study, with permission granted by the Mayo Clinic Institutional Review Board. Models in older European collections were generally not identified in this way, but some are now being matched to descriptions in case reports in the medical literature.³²

Farm accidents are another unique topic area in the Mayo moulage collection. Because of Rochester’s rural, agricultural location these types of accidents were commonly seen by clinic surgeons. Three sets of models show traumatic injuries—hands and fingers caught

Regional and Local Methods of Anesthesia

1 and 2
Block for Craniotomy

1. Hat band block of scalp and skull. Solution injected in three layers: intradermally, subcutaneously and along the periosteum.
2. Solution injected deeply into the temporal fossa with level of needle kept against the skull.

5 and 6
For Operation
On the Septum and Turbinates

5. Sphenopalatine block. The applicator carrying epinephrine and cocaine crystals is inserted through the nostril at an angle of approximately 45 degrees to the floor of the nose and is advanced to bisect the middle and posterior thirds of the middle turbinate. It passes between the middle turbinate and the septum until it reaches the anterior border of the sphenoidal protuberance.
6. Maxillary block. The probe carrying epinephrine and cocaine crystals is advanced into the anterior part of the nasal chamber until it rests in the fossa just below the nasofrontal duct.

3
Median Orbital Block for Operation on the Ethmoid Sinuses

A wheel is raised 1 cm. above the inner canthus of the eye. The needle is directed posteriorly and inferiorly until the tip of the needle is felt to drop into the anterior ethmoid foramen. The level of the needle must be kept against the periosteum.

4
Maxillary Nerve Block for Operation on the Antrum or for Extraction of the Upper Teeth

A wheel is raised 0.5 cm. below the zygoma just anterior to the coronoid process of the mandible. The needle is usually directed at an angle of 25 degrees superiorly and a 10 degree angle posteriorly and is advanced until its tip encounters the lateral pterygoid plate. The tip of the needle then is withdrawn slightly and directed anteriorly until it leaves the anterior border of the lateral pterygoid plate and is advanced 0.5 cm. The solution is deposited directly anterior to the foramen rotundum.

7 and 7₁
Block for Operation on the Thyroid Gland

Superficial cervical block. The solution is deposited on the superficial surface of the sternocleidomastoid muscle and beneath the overlying skin. The line of incision is infiltrated intradermally and subcutaneously. This also may be used for operations on the phrenic nerve.

8 and 9
Block for Operations on the Breast

8. Intradermal and subcutaneous injections are made around the breast in a diamond shaped outline.
9. Solution is injected between breast and pectoral major muscle.

10 and 11
Block for Excision of Superficial Tumor

An intradermal wheel is raised 2 cm. from the border of tumor. Intradermal and subcutaneous injection is carried in a diamond shaped pattern surrounding the tumor at a distance of 2 cm. from the border. The point of the needle is 1 cm. under the tumor and at 5 c.c. of the solution is injected at this point in one plane the tumor.

12 and 13
Intercostal Nerve Block

12. Position of point of needle in relation to 6th thoracic nerve.
13. Position of point of needle in relation to 7th thoracic nerve.

14
Infiltration of the line of fracture of the rib or the associated laminae.

15, 16, 17 and 18
Block of Abdominal Wall for Colotomy

- 15, 16 and 17. The three positions of the needle used in infiltrating the abdominal wall.
15. Intradermal injection.
16. Subcutaneous injection.
17. Injection through superficial sheath of rectus abdominis muscle.
18. Continuation of block below, by 15, 16 or along the lateral border of the rectus abdominis muscle.

19, 20 and 21
Block for Operation on Inguinal Hernia

An intradermal wheel is made 4 cm. medial to anterior superior iliac spine. The needle is passed toward the medial border of the spine until it lies just above the fascia of the transverse abdominal muscle. 5 c.c. of 1 per cent solution is injected at this point.

20. The infiltration is being carried out intradermally, subcutaneously and just above the fascia of the transverse abdominal muscle from the wheel illustrated in 19 to the umbilicus.
21. The infiltration is being carried out along the line of the spine. May be used to supplement blocks 19, 20.

22
Infiltration for Operation on Inguinal Hernia

Infiltration is being carried out along the line of the spine. May be used to supplement blocks 19, 20.

23
Injection into Spermatic Cord

Injection into spermatic cord is usually done if it has been exposed in the course of operation.

In regional methods of anesthesia concentrations of the local anesthetic (procaine or its equivalent) in solution vary directly as the thickness of the nerve trunks to be blocked. A vasoconstrictor (epinephrine) is added to the solution of the local anesthetic in low concentration. Usually 1 gm. of procaine is well tolerated by an average adult.

Examples	Procaine	Epinephrine
Infiltration of skin	0.5% (1 gm. in 200 c.c.)	+ 1:500,000 (1 c.c. of 1:2500)
Superficial cervical block	1.0% (1 gm. in 100 c.c.)	+ 1:200,000 (1 c.c. of 1:2500)
Brachial plexus block	2.0% (1 gm. in 50 c.c.)	+ 1:150,000 (1 c.c. of 1:2500)

*Saline or water

Anesthesia display on the sixth-floor surgical pavilion of Saint Marys Hospital.

a horrible death when the handle of a pitchfork penetrated his abdomen a distance of fourteen inches." The date of this accident, however, predates the year 1924, in which the first clinic wax model was made. It is possible that a moulage was created from earlier photographs of the victim, or perhaps another accident of the same nature occurred at a later time when clinic wax artists were available to document it in wax.³³

The museum moves

In August 1950 the clinic demolished the Central School Building, which housed the museum, to make way for the new Mayo Building, which was being planned as a diagnostic center to provide much-needed space for the continually growing clinic. Two Quonset buildings were erected to temporarily house the museum, Bulbulian's prosthetic laboratory, and the brace, belt and shoe shops. The move, named Operations Quonset, started on July 29 and required three days, four trucks, 28 trips, 35 clinic employees, and an unspecified number of movers and other support workers to complete the task. The team transferred the museum exhibit cases—uncrated—to one of the Quonsets, a space of 40 by 120 feet, "under tense and hawk-eyed supervision. . . . There were no casualties."³⁴

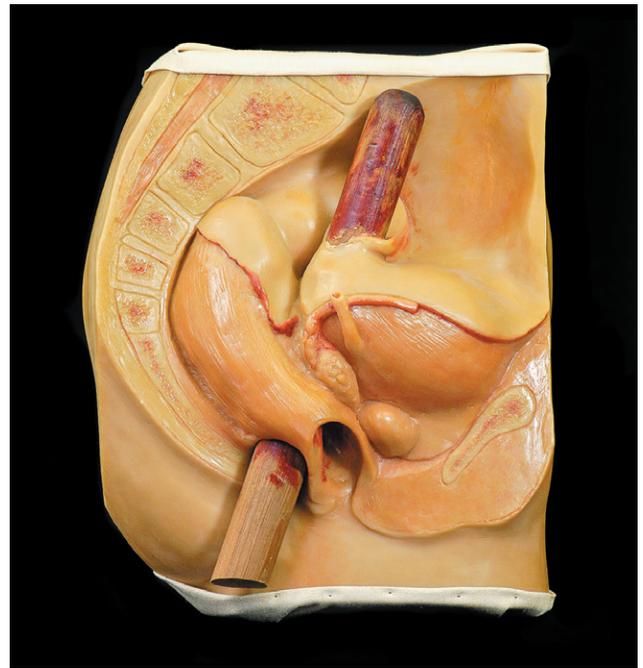
Though intended to be a temporary situation, the museum occupied the Quonset space for the next 13 years, until April 1963. It then moved to the main floor of the newly finished Damon Parkade Building. The new location offered about six times the exhibit space of the Quonset building and twice that of the original home in the Central School Building. Not surprisingly, visitation improved with more visible and easily accessed space. The *Rochester Post-Bulletin* reported in January 1966, "Mayo

in farm machinery—before and after surgery, while one depicts an injured foot before surgery. Another model involving an accident with a pitchfork provides the most graphic evidence of the dangers to be found in farming. Though the model does

not bear a patient number, the Mayo historical staff initially thought it had been identified in an August 1910 article that appeared in several Minnesota newspapers: "Jumping from the top of a stack of grain in the harvest field . . . , R. C. Davidson met



Mayo's location in a rural area meant clinic surgeons treated many farm accidents. Left, a model of a hand caught in machinery with damage to the fourth finger. Right, an accident with a pitchfork.



Medical Museum in Damon Parkade Building is the largest-single drawing attraction for Mayo Clinic visitors. Some 117,028 persons toured the museum last year bringing the total to more than [3],000,000 visitors since it opened in [1935]."³⁵

End of an era

The July 1974 issue of *Mayovox*, the clinic's employee newspaper, reported that in April and May visitors to the Mayo Medical Museum included 5,935 young people, many of whom came on end-of-the-school-year field trips each spring. Visitation statistics averaged 100,000 per year. By the 1980s, however, the number of visitors began to show a downward trend. Furthermore, the clinic was turning to a less graphic approach to patient education and, since the 1950s, custom-made medical moulage as a teaching tool and visual aid was being replaced by color photography, new audiovisual tools, and mass-produced models using materials that were less

expensive than wax. The last Mayo moulage exhibit was made in 1983.³⁶

When the clinic announced the pending demolition of the Damon Parkade Building in October 1988, the Mayo Medical Museum was closed for good—just three years after celebrating its golden anniversary. Proposals for creating a new museum

in the Siebens Building, then under construction, were considered but never implemented. Some of the historical artifacts and major exhibits found homes in other areas of the Mayo campus. Many others, however, including most of the medical moulages, went into storage. Plans to use them "for educational purposes and

The Quonset home of the Mayo Foundation Museum of Hygiene and Medicine, 1954. The "temporary" location lasted 13 years.



in various staff and patient areas” faded away. As of 2019, 31 years after the museum closed, almost all of an estimated 1,500–1,800 extant wax models remain in storage. Only seven are now exhibited in the Mayo Clinic’s patient education library in the Siebens Building, and a few others are on display in departmental areas.³⁷

Though not widely on display, the models are not forgotten. The Mayo historical staff is often asked about them by patients who remember childhood field trips to the Mayo Museum and recall the fascination inspired by their lifelike features. The models have also been well-received in temporary exhibits at recent clinic events and during the Mayo sesquicentennial in 2014. They continue to resonate with viewers as both teaching tools and fine art. Perhaps one day they will again find an exhibit home to celebrate these qualities. □

Notes

The author wishes to thank Dr. Vanda A. Lennon, a staff physician and professor of neuroimmunology at the Mayo Clinic, and *Minnesota History* editors for reviewing the manuscript and suggesting improvements.

1. Thomas Schnalke, *Diseases in Wax: The History of the Medical Moulage*, trans. Kathy Spatschek (Chicago: Quintessence Publishing Co., 1995), 9–10.

The exact number of models made is unknown; the old drawers in which they are stored make a count impossible without a great deal of handling. The Mayo staff at the W. Bruce Fye Center for the History of Medicine is inventorying the models as they are cleaned and rehoused. Not all have survived storage. A tentative estimate is approximately 1,500–1,800 models.

2. See David Blistein and Ken Burns, *Mayo Clinic: Faith, Hope, Science* (New York: Rosetta Books, 2018), and Helen Clapesattle, *The Doctors Mayo* (Minneapolis: University of Minnesota Press, 1941) *passim*, especially Ch. 24, “My Brother and I.”

The Mayo Clinic is consistently named one of the top hospitals in the United States by *U.S. News and World Report*; for the past three years it was ranked No. 1 on the Best Hospitals Honor Roll: (“2019–20 Best Hospitals Honor Roll and Medical Specialties Rankings,” *U.S. News & World*

Report, July 29, 2019). Saint Marys Hospital, which was at that time owned and operated by the Sisters of St. Francis, maintained a close affiliation with Mayo Clinic, beginning in 1883. The clinic and Saint Marys Hospital merged in 1986.

3. “History and Timelines” [internal document, photocopy], 1995, MHU-0676: Subject Files, Medical Graphics/Illustrations, Mayo Foundation for Medical Education and Research, W. Bruce Fye Center for the History of Medicine, Mayo Clinic, Rochester, MN (hereinafter cited as Fye CHOM Archives).

4. Moulagen: Geschichte, Technik, Lehre und weiterführende Informationen. Portal für Moulagen und medizinische Wachsmodele. <https://www.moulagen.de/moulagen/>.

5. R. A. Cooke, “A Moulage Museum Is Not Just a Museum: Wax Models As Teaching Instruments,” *Virchows Archiv* 457 (2010): 513; R. Ballastriero, “Anatomical Models and Wax Venuses: Art Masterpieces or Scientific Craft Works?” *Journal of Anatomy* 216 (2010): 223–24; D. Mendis and H. Ellis, “Joseph Towne (1806–1879), Master Modeler of Wax,” *Journal of Medical Biography* 11 (2003): 212; A. Riva, G. Conti, P. Solinas, F. Loy, “The Evolution of Anatomical Illustration and Wax Modelling in Italy from the 16th to Early 19th Centuries,” *Journal of Anatomy* 216 (2010): 220.

6. Schnalke, *Diseases in Wax*, 47; “Moulagen: Geschichte, Technik, Lehre und weiterführende Informationen,” Portal für Moulagen und medizinische Wachsmodele, <https://www.moulagen.de/moulagen/>.

7. Schnalke, *Diseases in Wax*, 71, 72.

8. Kenji Hiyama, MHU-0510: Residents Files, Mayo School of Graduate Medical Education, B012.SG01.F1220, Fye CHOM Archives; T. Imai-zumi, Y. Nagatoya, “Dermatologic Moulage in Japan,” *International Journal of Dermatology* 34 (1995): 817.

Wax modeling techniques had originally been brought to Japan by Keizo Dohi after 1895 when he studied with Dr. Carl Henning in Vienna. On his return to Japan, Dohi, a professor of dermatology at the University of Tokyo, taught many Japanese moulage artists, or *mouleurs*. Hiyama may have learned from either Dohi or one of his protégés.

9. Kenji Hiyama, Fye CHOM Archives; Boyd Gardner, notebook, transcripts of dental history recordings in Mayo Clinic Archives, p11, MHU-0713: Joseph A. Gibilisco Papers, B001, Fye CHOM Archives.

Gardner established the Mayo Section on Dental Surgery in 1918. An accomplished teacher and speaker, he became prominent in both national and international dental research and professional organizations. His work with dental pain relief and anesthesia produced with nitrous oxide and oxygen were of particular note in the field.

10. Section on Dental Surgery, 1925, p2, MHU-0002: Board of Governors Records, Annual Reports (hereinafter, BOG Annual Reports), B059.SG02.S03.SS02.F002, Fye CHOM Archives.

11. Section on Dermatology and Syphilology, 1926, p8, B033.SG02.S02.SS01.F003, and Division of Pathologic Anatomy, 1926, p2, B096.SG02.S04.SS08.SSS01.F003—both BOG Annual Reports.

12. Katherine Doyle, “Rochester Native Is Only Woman Anatomical Sculptor in America,” *Rochester Post-Bulletin*, Jan. 9, 1943, 2.

13. Doyle, “Rochester Native.”

Hiyama may also have worked with or influenced Margaret Whiting Phillips, a young woman doing postgraduate studies with Eleanor Fry in 1924. Their time at Mayo overlapped for a little over six months, June 1924 to early 1925, when Phillips left to work as a medical illustrator at the Scott and White Memorial Hospital in Temple, Texas. She created medical moulages there until her retirement in 1955 (M. Mears, V. Feaster, “The Wax Moulage Collection at Scott and White Memorial Hospital,” *International Journal of Dermatology* 33 [1994]: 446). On his return to Japan from the United States, Hiyama became a professor at the Tokyo Medical and Dental University. He retired from the university in 1960, though he continued to serve as dentist to the Hirohito Family (Japan’s imperial family) until 1969 (Kiyoshi Koyano, Section of Implant and Rehabilitative Dentistry, Kyushu University, Fukuoka, Japan, email to author, Mar. 18, 2018).

14. Table, “Models Produced Each Year”, 1925–1933, [photocopy, compiled “from the Annual Reports of the Art Section”], MHU-0676: Subject Files, Wax Models, Fye CHOM Archives. Models counted for the years 1925 and 1926 would likely have included those made by both Kenji Hiyama and Nellie Starkson.

15. Minutes of the Board of Governors Meetings (hereinafter, BOG Minutes), Mayo Clinic, unpublished, Feb. 25, 1931, p9, Aug. 19, p27, reviewed by permission, Mayo Clinic Administration.

Born in 1874, Henry Stanley Plummer became known as the Mayo Clinic’s “diversified genius.” He made significant contributions to the field of endocrinology and was also an authority on conditions of the lungs and airways, trachea, and esophagus. He devised the clinic’s communication system and a new medical record system that assigned a unique number to each patient. He collaborated with architect Thomas Ellerbe to produce the first two Mayo Clinic buildings, specifically designed to facilitate the activities of an integrated group practice. Dr. Will said “the best day’s work” he ever did for the clinic was when he hired Plummer (Emeritus Staff and Cataloging Biographies, MHU-0571: Mayo Historical Unit, SG06, and Henry Stanley Plummer, MHU-0675: People Files—both Fye CHOM Archives).

16. BOG Minutes, Dec. 16, 1931, p57–58, and Jan. 20, 1932, p3–4; US Inflation Calculator, <https://www.usinflationcalculator.com/>.

George Brown joined the clinic in 1921 and became head of the Section on General Diagnosis. An authority on vascular diseases, high blood pressure, and disturbances of the sympathetic

nervous system, he died at 50 of pneumonia ("Dr. G. E. Brown, 50, Dies of Pneumonia," *Rochester Bulletin*, Nov. 29, 1935).

Walter Alvarez joined the clinic in 1926 from private practice in California. An expert in diseases of the digestive system, he was elected president of the American Gastroenterological Association in 1928 and was the first editor of its journal. After his 1950 retirement from Mayo, he served as the editor of the journals *Modern Medicine* and *Geriatrics*. He wrote several books and a syndicated column published in almost 100 newspapers on health topics for the general public. In 1959 the New York City Chapter of the American Medical Writers' Association awarded him for "distinguished service in the improvement of medical education." His son, Luis Alvarez, was awarded the Nobel Prize in Physics in 1968 (Walter Clement Alvarez, MHU-0675: People File, Fye CHOM Archives).

17. BOG Minutes, Dec. 16, 1931, p57-58; Walter C. Alvarez, "Medical Museum," letter, 1963, MHU-0670: Memoirs and Department Histories Collection, B001.F003, Fye CHOM Archives; Arthur H. Bulbulian, MHU-0675: People Files, Fye CHOM Archives.

Thomas Sadler Roberts was a retired physician who had taken an unpaid post as associate curator of the state's Museum of Natural History at the University of Minnesota. "The Museum is referred to in the University President's reports as the Zoological Museum of the Zoological Survey until 1928 when the name was changed to Museum of Natural History. In 1967 it was renamed the James Ford Bell Museum of Natural History to honor James Ford Bell who was one of the Museum's greatest benefactors" (Collection Overview: Historical Note, Bell Museum of Natural History records, University Archives, University of Minnesota, Twin Cities).

The co-inventors of the oxygen mask were W. Randolph Lovelace and Walter M. Boothby.

18. BOG Minutes, Feb. 24, 1932, p13.

19. BOG Minutes, Mar. 22, 1933, 33-34.

20. BOG Minutes, May 10, 1933, p60-61, and Aug. 9, 1933, p96.

The clinic used the term *fellow* because Dr. Will was dissatisfied with *resident* and *intern*. Louis Wilson, MD, director of the Mayo Graduate School of Medicine (1915-37), recalled, "The Fellows were never interns here; they were associates. The whole idea was that they should hold a fellowship, not subserviency" (Helen Clapesattle interview with Wilson, Jan. 25, 1940, MHU-0602: Helen Clapesattle Papers, B001, Fye CHOM Archives).

21. G. A. Swanson, "Pathfinders: Arthur H. Bulbulian, D.D.S.," *Mayo Magazine* 8 (Winter 1994): 21; Doyle, "Rochester Native."

22. Letter, June 12, 1991, MHU-0657: Bulbulian papers, B006.SG05.S01.F002, Fye CHOM Archives.

Born in 1887, Harry Harwick helped the Mayo Clinic develop from its group practice beginnings to the charitable and educational organization it is today. Dr. Will hired Harwick

as a bookkeeper in 1908, and by 1918 he was the clinic's business manager. He helped the Mayo Foundation achieve incorporation in 1919 and was elected its chairman in 1939. He served as the executive officer of the Mayo Clinic Board of Governors from 1933 to his retirement in 1952 (Harry J. Harwick, MHU-0675: People Files, Fye CHOM Archives). When he died in 1978, a colleague noted, "What the Mayo Brothers . . . brought to the institution in the way of medical acumen and talent, Harry Harwick brought in financial and management expertise" (K. McCracken, "Harwick Lauded as Architect of Clinic Financial Structure," *Rochester Post-Bulletin*, Feb. 13, 1978, 23).

23. Letter, June 12, 1991.

24. Alvarez, "Medical Museum."

25. Alvarez, "Medical Museum."

Often referred to as the father of physical medicine, Frank H. Krusen established the nation's first department of physical medicine in 1928 at Temple University Hospital (Program, Convocation and Dedication of the Frank H. Krusen Center, Temple University Health Sciences Center, Philadelphia, PA, 1966). In 1935 Mayo hired him to create a similar section in Rochester with facilities for patient care, research, and training for students. He was a founder of the American Board of Physical Medicine and Rehabilitation (1947) and the International Federation of Physical Medicine (1950) (Frank Hammond Krusen, MHU-0675: People Files, Fye CHOM Archives).

26. Museum of Hygiene and Medicine, 1935, p8, BOG Annual Reports, B118.SG02.S06.SS01.SSS03.F001.

27. F. Smith, "Morbid Thrills in Mayo Museum," *Chicago Daily Times*, July 27, 1937, 12.

28. "On Being a Hostess at a Scientific Exhibit at a World's Fair!" typescript, 1939, p1-2, MHU-0657: Arthur H. Bulbulian Papers, B004.SG02.S04.F009.

29. Section on Anesthesia, 1935, p35, BOG Annual Reports, B055.SG02.S03.SS01.SSS01.F010.

Leonardo da Vinci is probably the most famous artist known to have performed dissection in order to "explore the structures of the human form and the movement of the human body" (Schnalke, *Diseases in Wax*, 23).

30. Section on Anesthesia, 1939, p14, BOG Annual Reports, B055.SG02.S03.SS01.SSS01.F014.

John Lundy came to the clinic on April 1, 1924, at the invitation of Dr. Will and retired on October 1, 1959. An internationally known anesthesiologist, Lundy was recognized for testing and refining the use of intravenous Sodium Pentothal (1934), for opening the first postoperative recovery room in the world at Saint Marys Hospital (1942), and for helping found the American Board of Anesthesiology (1938) (J. Myers, "John Silas Lundy, M.D.," *The Journal-Lancet* 77 [1957]: 478-79. Section on Anesthesia, 1942, p46, BOG Annual Reports, B055.SG02.S03.SS01.SSS01.F017).

31. Section on Anesthesia, 1938, p9, BOG Annual Reports, B055.SG02.S03.SS01.SSS01.F013.

32. M. Geiges, "Traces of Marion B. Sulzberger in the Museum of Wax Moulages in Zurich and Their Importance for the History of Dermatology," *Journal of the American Academy of Dermatology* 60 (2009): 982.

33. "Minnesota Briefs," *Duluth Herald*, Aug. 9, 1910, 10.

34. *Mayovox* 1, no. 15 (1950): 1; *Mayovox* 1, no. 20 (1950): 4.

Since 1911 Mayo Clinic has worked with Ellerbe and Company and its descendant companies to create most of its buildings. The partnership began when Henry Plummer and Thomas Ellerbe designed the Clinic Building completed in 1914, followed in 1928 by what is now called the Plummer Building, and continued with the new diagnostic center in 1950. "Dr. Plummer . . . had an architectural sophistication far in advance of his time" ("Mayo Clinic Offices: A New High in Efficient Handling of People and Papers," *Architectural Forum* 100 [1954]: 136, 138).

Bulbulian made noses, ears, and other facial prostheses for patients with severe deformities or losses. In a process similar to making a moulage, he used molds and different combinations of synthetic materials instead of wax to create the prosthetics. He published two textbooks on this topic, *Facial Prosthesis* (1945) and *Facial Prosthetics* (1973), which became standard references for many years (Swanson, "Pathfinders," 22-23).

35. *Mayovox* 14, no. 14 (1963): 1-2; "Museum is Top 'Draw'," *Rochester Post-Bulletin*, Jan. 15, 1966. This article incorrectly cites 1962 as the year in which the visitor counts were started. The 2,000,000 number is based on an average visitation of 100,000 people per year from the opening of the museum in 1935. K. McCracken, "Medical Museum Celebrates 50th Year," *Rochester Post-Bulletin*, Apr. 1, 1985, 3.

36. *Mayovox* 25, no. 7 (1974): 4; McCracken, "Medical Museum Celebrates 50th Year." The exhibit, "Near-total Laryngectomy" was created for the October 1982 annual meeting of the American Academy of Otolaryngology—Head and Neck Surgery. Memo, November 30, 1982, MHU-0921: Peter M. McConahey Papers, B001.SG02.S01.F003. McConahey, who created the models, still works as a designer in Mayo's Brand Strategy and Creative Studio.

37. "Medical Museum Closing Marks End of an Era," *Rochester Post-Bulletin*, Oct. 26, 1988, B7; *Mayovox* 39, no. 11 (1988): 2.

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