

#### THE CITY OF SAN DIEGO

## Report to the Historical Resources Board

| DATE ISSUED: | August 18, 2016  | REPORT NO. HRB-16-048       |
|--------------|--|-----------------------------|
| ATTENTION:   | Historical Resources Board<br>Agenda of August 25, 2016            |                             |
| SUBJECT:     | ITEM #6 – 2345 Via Siena   |                             |
| APPLICANT:   | Sonoca Corp represented by Scott A. Moomjia                        | an                          |
| LOCATION:    | 2345 Via Siena, La Jolla Community, Council District 1             |                             |
| DESCRIPTION: | Consider the designation of the property loca historical resource. | ated at 2345 Via Siena as a |

#### STAFF RECOMMENDATION

Do not designate the property located at 2345 Via Siena under any adopted HRB Criteria.

#### BACKGROUND

This item is being brought before the Historical Resources Board in conjunction with a proposed building modification or demolition of a structure of 45 years or more, consistent with San Diego Municipal Code Section 143.0212. The building is a one story single family home located on APN 352-165-03-00, in the residential subdivision of Hidden Valley Hills Unit No 1. The property was located within the boundary of the 2004 Draft La Jolla Survey, but was not identified in the survey because the survey did not include post-1960s buildings.

On February 29, 2016, a permit application was submitted to the City of San Diego for a remodel. Historical Resources staff reviewed the submittal, which included a photo survey of the property (Attachment 1), along with input received by members of the public and required a historic report to evaluate the property under all HRB Criteria. (Subsequent communication from the La Jolla Historical Society and SOHO is included in Attachments 2 and 3.) On March 16, 2016 a Neighborhood Code Compliance case was opened on the subject property in response to work that occurred without a permit. The unpermitted work has resulted in loss of all interior finishes, as well as some exterior cladding and roofing.

The City Attorney's Office issued a Memorandum of Law (MoL) dated April 18, 2007 which speaks to when the physical condition of a nominated historical resource must be evaluated by the Historical Resources Board for the purposes of designation (Attachment 4). This memo was issued in response

to a similar situation where work began before a permit was obtained. The memo concludes that the Board must consider the building's condition at the time a building permit was applied for or should have been applied for. Therefore, the Board can and must evaluate the building prior to the unpermitted modifications.

#### <u>ANALYSIS</u>

A Historical Resource Research Report was prepared by Scott A. Moomjian, which concludes that the resource is not significant under any HRB Criteria, and staff concurs. This determination is consistent with the *Guidelines for the Application of Historical Resources Board Designation Criteria*, as follows.

CRITERION A - Exemplifies or reflects special elements of the City's, a community's or a neighborhood's historical, archaeological, cultural, social, economic, political, aesthetic, engineering, landscaping or architectural development.

Research into the history of the property at 2345 Via Siena did not reveal any information to indicate that the property exemplifies or reflects special elements of the City's or La Jolla's historical, archaeological, cultural, social, economic, political, aesthetic, engineering, landscaping or architectural development. Therefore, staff does not recommend designation under HRB Criterion A.

#### CRITERION B - Is identified with persons or events significant in local, state or national history.

The subject property at 2345 Via Siena was constructed in 1960 for the original owners and residents, Dr. Joseph Mayer and Dr. Maria Goeppert Mayer. Research indicates that they resided in the home beginning in at least 1963 through her death in 1972 and his death in 1983. Joseph Mayer earned his PhD in chemistry from the University of California at Berkley in 1927. German-born Maria Goeppert earned her PhD in physics from the University of Gottingen in 1930 and married Mayer that same year before relocating to the United States when Joseph accepted a faculty position at Johns Hopkins University. Maria worked as an unpaid assistant and lecturer at Johns Hopkins, producing ten papers and a textbook in her nine years there.

In 1939, Joseph and Maria moved to Columbia University. Denied a faculty position, Maria worked again as an unpaid lecturer. She obtained her first paid teaching job from Sarah Lawrence College in 1942, while still working at Columbia. Columbia managed the Substitute Alloy Materials project, nicknamed SAM, for the federal government, and the government paid Maria. Mayer spent a month in Los Alamos working on Teller's hydrogen bomb, but her work did not contribute to the development of the bomb – a fact she was grateful for. After the war, Joseph and Maria moved again to work at the University of Chicago. Maria would also work as a senior physicist at the nearby Argonne National Laboratory. It was here that Maria would undertake her most significant work.

Maria Goeppert-Mayer developed a mathematical model for the structure of nuclear shells, which she published in 1950. Her model explained why certain numbers of nucleons in an atomic nucleus result in particularly stable configurations. These numbers are what Professor Eugene Wigner called "magic numbers" (2, 8, 20, 28, 50, 82, and 126). Enrico Fermi provided critical insight by inquiring of "spin orbit coupling," leading to a theory that the nucleus is a series of closed shells and pairs of neutrons and protons tend to couple together. At the time, three German scientists-Otto Haxel, J. Hans D. Jensen, and Hans Suess, were also working on solving the same problem, and arrived at the same conclusion independently. Their results were announced before Maria's announcement in June 1949. Afterwards, she collaborated with them, and co-authored a book with Hans Jensen entitled Elementary Theory of Nuclear Shell Structure (1950). She also published a number of articles during the 1950s, including The Structure of the Nucleus (March 1951); Classification of Beta Transitions (1955); and Statistical Theory of Asymmetric Fission (1958).

In 1960, Joseph and Maria moved to La Jolla to accept faculty positions at the newly formed University of California, San Diego (UCSD). This time, Maria was offered a full professorship, with pay. Shortly after moving to California, while unpacking her books, Mayer suffered a devastating stroke. In 1963, while living at the subject property, Maria was awarded the Nobel Prize in physics for her work on nuclear shell theory completed during her time in Chicago. She was only the second woman in history to be awarded the Nobel Prize in the field of physics. The prize was divided, with on half awarded to Professor Eugene Wigner of Princeton University, and the remaining one-half awarded to Professor Maria Goeppert Mayer and Professor J. Hans D. Jensen.

There is conflicting documentation about the impact of Maria's stroke on her career and her work. In her book *Nobel Prize Women in Science: Their Lives, Struggles and Momentous Discoveries*, author Sharon Bertsch McGrayne states, "It paralyzed her left arm and blurred her speech. Although she tried to continue working, her health was never good again." (Attachment 5) In Robert Sachs biographical memoir of Maria Goeppert Mayer published by the National Academy of Sciences, he states, "...shortly after arriving in San Diego, she had a stroke, and her years there were marked by continuing problems with her health. Nevertheless, she continued to teach and to participate actively in the development and exposition of the shell model. Her last publication, a review of the shell model written in collaboration with Jensen, appeared in 1966; and she continued to give as much attention to physics as she could until her death in early 1972." (Attachment 6) While the extent to which she was able to continue her work is questionable, it is clear that her most significant work was not done while working at UCSD and living in San Diego.

The HRRR identifies the properties Maria Goeppert Mayer was associated with during her illustrious and distinguished career. While in Baltimore, Maria and Joseph are known to have resided at 2901 Cresmont Avenue (extant)During her time in Chicago she resided at an apartment located at 5454 South Shore Drive (extant) from approximately 1950-1951, and a house located at 4923 South Greenwood Avenue (extant) from 1951-1960. The subject property at 2345 Via Siena is their only known address in San Diego.

In regard to establishing significance under HRB Criterion B, the Board's adopted *Guidelines for the Application of Historical Resources Board Designation Criteria* states, "Eligibility under Criterion B for significant person(s) involves first determining the importance of the individual, second ascertaining the length and nature of the individual's association with the resource under study and in comparison to other resources associated with the individual, and third determining if the resource is significant under HRB Criterion B as a resource that is best identified with a person(s) significant in local, state, or national history... Criterion B is generally restricted to those properties that are associated with a person's important achievements, rather than those that are associated with their birth or retirement, or that are commemorative in nature... The person must have made demonstrable achievements and contributions to the history of San Diego, the state, or the nation. In addition, the resource must be associated with the person during the period that the person's significant achievements and contributions occurred. If the resource is not associated with the historical person during the person's significant period, research other resources associated with the person in order to identify those that best represent the person's historic contributions. Determine the status of the associative properties as demolished, extant, or out of the locality and length of time associated with the person. The best representatives are properties associated with the person's productive life. Properties associated with the person's formative or later years may also qualify if it can be demonstrated that the person's activities during this period were historically significant or if no properties from the person's productive years survive elsewhere."

The HRRR concludes and staff concurs, that while all available documentation suggests that Dr. Maria Goeppert Mayer should be considered a historically significant individual, other properties exist which better represent her important accomplishments and historical significance. Specifically, the property located at 4923 South Greenwood Avenue in Chicago, which remains extant, served as Mayer's home from 1951-1960 - during which time she completed her Nobel Prize-winning research on nuclear shell theory and published her findings – and would be the most appropriate property to designate for an association with Goeppert Mayer as a historically significant individual. While she did receive the Nobel Prize while owning and residing at the subject property, the work which earned her that prize had been completed years before while residing at another property. Therefore, staff recommends against designation of the subject property under HRB Criterion B.

# CRITERION C - *Embodies distinctive characteristics of a style, type, period or method of construction or is a valuable example of the use of natural materials or craftsmanship.*

The subject property is one story single family home constructed in 1960 in the Custom Ranch style, and features a compact, generally "L" shaped floorplan; low-to-moderately pitched cross gable and hipped roofs with wood shingles; overhanging eaves with exposed rafter tails; and a combination of wood lap, board and batten, stucco and brick veneer siding over wood frame construction. The building is set up from the street, with on-grade stairs providing access to a slightly recessed entry porch with brick veneer dominated by a large tri-partite metal frame window featuring a fixed center pane flanked by casements. To the right of the entry porch, attached to the house is a two-car garage clad in board and batten and accessed by a wide concrete driveway. To the left of the entry porch is a bay, also clad in board and batten, which prominently features a large tri-partite metal frame window with a fixed center pane flanked by single lite casements with a fixed single lite upper. The west side of the house exhibits wide wood lap siding in the gable end with a combination of board and batten siding and stucco below. The east side also exhibits board and batten siding and stucco, as well as an exposed brick chimney. The rear of the home is stucco and includes a recessed covered patio. Overall, fenestration is simple and consists of primarily metal frame fixed and casement windows.

Prior to the recent unpermitted work which is not considered in the evaluation of integrity, modifications were generally limited to the addition of a stucco chimney at the rear, restuccoing of the stuccoed portions with a more contemporary finish, and the addition of two metal sliding windows along the southeast and southwest elevations.

The Custom Ranch style of architecture was popular between 1950 and 1975 and is differentiated from Tract Ranch homes because they were typically custom-designed with a specific client in mind. The Ranch style became the era's most prevalent type of residential construction in San Diego. Custom Ranch Homes are generally more lavish than their tract counterparts, but like Tract Ranch

housing, materials and detailing are generally traditional. Primary character defining features include horizontal massing, wide to the street; usually single-story; custom details such as wood shutters, large wood windows, or large prominent brick or stone chimneys; and prominent low-sloped gabled or hipped roofs with deep overhangs. Secondary character defining features include a sprawling floor plan frequently "L" or "U" shaped around a central courtyard; large attached carports or garages; and expensive building materials such as wood shingle roofing, wood siding, brick, stone, and adobe which are usually much more generous in materials and craftsmanship than tract homes.

The subject property does exhibit elements of Custom Ranch architecture, including low-sloped hipped and gable roofs, overhanging eaves, large windows, attached garages, and building materials that include wood siding and brick. However, the overall design is not well executed as a Custom Ranch home. The floorplan is generally compact and not particularly sprawling, with the "L" shaped plan minimally expressed. Large windows are limited to the front façade, with smaller windows used at the sides and rear. While the materials do include brick and wood siding, the wood siding stops a little less than halfway down the side façade. While it is not uncommon to see less expensive materials used on rear facades, the use of stucco on just over half of the side facades is not very indicative of the "generous" use of expensive building materials. Overall, the home exhibits very basic characteristics of Custom Ranch architecture, but fails to exhibit an overall quality of design one would expect from custom designed architecture. Therefore, staff does not recommend designation under HRB Criterion C.

CRITERION D - Is representative of a notable work of a master builder, designer, architect, engineer, landscape architect, interior designer, artist or craftsman.

The subject property at 2345 Via Siena was built and possibly designed by Charles E. Chandler. Chandler has not been established by the Historical Resources Board as a Master Architect, Designer or Builder, and there is insufficient information to designate him as such at this time. Therefore, staff does not recommend designation under HRB Criterion D.

CRITERION E - Is listed or has been determined eligible by the National Park Service for listing on the National Register of Historic Places or is listed or has been determined eligible by the State Historical Preservation Office for listing on the State Register of Historical Resources.

The property at 2345 Via Siena has not been listed on or determined eligible for listing on the State or National Registers. Therefore, the property is not eligible for designation under HRB Criterion E.

CRITERION F - Is a finite group of resources related to one another in a clearly distinguishable way or is a geographically definable area or neighborhood containing improvements which have a special character, historical interest or aesthetic value or which represent one or more architectural periods or styles in the history and development of the City.

The property at 2345 Via Siena is not located within a designated historic district. Therefore, the property is not eligible for designation under HRB Criterion F.

#### **OTHER CONSIDERATIONS**

If the property is designated by the HRB, conditions related to restoration or rehabilitation of the resource may be identified by staff during the Mills Act application process, and included in any future Mills Act contract.

#### CONCLUSION

Based on the information submitted and staff's field check, it is recommended that the property located at 2345 Via Siena not be designated under any HRB Criteria. Designation brings with it the responsibility of maintaining the building in accordance with the Secretary of the Interior's Standards. The benefits of designation include the availability of the Mills Act Program for reduced property tax; the use of the more flexible Historical Building Code; flexibility in the application of other regulatory requirements; the use of the Historical Conditional Use Permit which allows flexibility of use; and other programs which vary depending on the specific site conditions and owner objectives.

Keller Stanco Senior Planner/HRB Liaison

KS

Attachments:

- 1. Photos of 2345 Via Siena taken 12/18/2015 and submitted 2/29/2016
- 2. Letter from Save Our Heritage Organisation (SOHO) under separate cover
- 3. Letter from La Jolla Historical Society (LJHS) under separate cover
- 4. City Attorney Memorandum of Law dated April 18, 2007
- 5. Excerpt from *Nobel Prize Women in Science: Their Lives, Struggles, and Momentous Discoveries* by Sharon Bertsch McGrayne
- 6. *Maria Goeppert Mayer 1906—1972* A Biographical Memoir by Robert G. Sachs
- 7. Applicant's Historical Report under separate cover

# Photographic Survey

2345 Via Siena La Jolla, CA 92037

Year Built: 1961 APN#: 352-165-03-00

Legal Description: Lot: 22 Map Ref: 003921 Abbreviated Description: LOT: 22 CITY: SAN DIEGO SUBD: HIDDEN VALLEY HILLS UNIT #1 0003921 LOT 22\* City/Muni/Twp: SAN DIEGO

Date: December 21, 2015



7724 Girard Avenue, Second floor La Jolla, CA 92037 PH: 858.459.3769 FAX: 858.459.3768 EMAIL: camarengo@marengomortonarchitects.com



A: Front Elevation (North)



| Marengo Morton Architects, Inc.   | Project: 2345 Via Siena | Project #: 2015-61 |
|---|-------------------------|--------------------|
| 7724 Girard Avenue, Second Floor-<br>La Jolla, California 92037<br>Tel 858-459-3769 • Fax 858-459-3768<br>Cmarengo@san.rr.com | Address: 2345 Via Siena | Date: 12-18-2015   |



B: Side Elevation (East)



KEY MAP



Marengo Morton Architects, Inc. 7724 Girard Avenue, Second Floor La Jolla, California 92037 Tel 858-459-3769 • Fax 858-459-3768

Cmarengo@san

| nitects, Inc.   | Project: 2345 Via Siena                       | Project #: 2015-61 |
|---|---|--------------------|
| cond Floor<br>ia 92037<br>858-459–3768<br>. r r . com | Address: 2345 Via Siena<br>La Jolla, CA 92037 | Date: 12-18-2015   |



#### C. Side Elevation (West)



KEY MAP N.I.S.





Marengo Morton Architects, Inc. 7724 Girard Avenue, Second Floor La Jolla, California 92037 Tel 858-459-3769 • Fax 858-459-3768

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| ts, Inc.                  | Project: 2345 Via Siena                       | Project #: 2015-61 |
|---------------------------|---|--------------------|
| Floor<br>92037<br>59–3768 | Address: 2345 Via Siena<br>La Jolla, CA 92037 | Date: 12-18-2015   |
| . com                     |   |                    |



D. Side Elevation (West)



KEY MAP N.I.S.



Marengo Morton Architects, Inc. 7724 Girard Avenue, Second Floor La Jolla, California 92037 Tel 858-459-3769 • Fax 858-459-3768

Cmarengo@san.

| itects, Inc.           | Project: 2345 Via Siena | Project #: 2015-61 |
|------------------------|-------------------------|--------------------|
| cond Floor<br>ia 92037 | Address: 2345 Via Siena | Date: 12-18-2015   |
| 5 8-4 5 9–3 7 6 8      | La Jolla, CA 92037      |                    |
| rr.com                 |                         |                    |



#### E. Rear Elevation (South)



KEY MAP



Marengo Morton Architects, Inc. 7724 Girard Avenue, Second Floor La Jolla, California 92037 Tel 858-459-3769 • Fax 858-459-3768 Cmarengo@san.rr.com

| tects, Inc.                                   | Project: 2345 Via Siena                       | Project #: 2015-61 |
|---|---|--------------------|
| ond Floor<br>a 92037<br>58-459–3768<br>rr.com | Address: 2345 Via Siena<br>La Jolla, CA 92037 | Date: 12-18-2015   |



F. Rear Elevation (South)



KEY MAP



Marengo Morton Architects, Inc. 7724 Girard Avenue, Second Floor La Jolla, California 92037 Tel 858-459-3769 • Fax 858-459-3768

Cmarengo@san

| nitects, Inc.                          | Project: 2345 Via Siena                       | Project #: 2015-61 |
|--|---|--------------------|
| cond Floor<br>ia 92037<br>858-459–3768 | Address: 2345 Via Siena<br>La Jolla, CA 92037 | Date: 12-18-2015   |
| .rr.com                                |   |                    |

OFFICE OF

# THE CITY ATTORNEY

#### CITY OF SAN DIEGO

1200 THIRD AVENUE, SUITE 1100 SAN DIEGO, CALIFORNIA 92101-4178 TELEPHONE (619) 533-5800 FAX (619) 533-5856

Michael J. Aguirre

#### MEMORANDUM OF LAW

| DATE: | April 18, 2007 |
|-------|----------------|
|       |                |

- TO: Historical Resources Board
- **FROM:** City Attorney
- **SUBJECT:** When the Physical Condition of a Nominated Historical Resource Must Be Evaluated by the Historical Resources Board for Purposes of Designation.

#### **INTRODUCTION**

This memorandum arose following the unauthorized, partial demolition of a private property, *after* a construction permit had been applied for, *after* the applicant was told by the City that the property may be historically significant, *but before* the City or the Historical Resources Board had had an opportunity to review the property, as required, in conjunction with the permit review process prescribed by the local Land Development Code. This matter caused the Historical Resources Board to question when a potential historical resource, in terms of its physical condition, must be evaluated for purposes of designation. The memorandum resolves this issue for historical resources whether nominated by the Historical Resources Board, the City Manager or, the City Council, or any member of the public.

#### **QUESTION PRESENTED**

What is meant by "current condition" for purposes of the Historical Resources Board designating an historic resource pursuant to its duties under the San Diego Municipal Code [SDMC] section 111.0206(d)?

#### SHORT ANSWER

When the Historical Resources Board evaluates a historical resource, where the nomination arises from SDMC section 143.0212, the "current condition" of the resource refers to when a project application is submitted to the City. The Board evaluates and designates historic properties, as part of the land development review process, in reliance on the information provided to the City at the time of project submittal. Where nominations arise outside SDMC

section 143.0212, the "current condition" of the resource refers to when a research report or similar documentation, prepared pursuant to the Historical Resources Guidelines, is submitted to the Board, as such submission, like a project application submitted to the City for a permit, triggers review for designation.

#### BACKGROUND

On September 5, 2006, the owner of a single-family home located at 4004 Lark Street applied for a construction permit with the City. On October 5, 2006, pursuant to SDMC section 143.0212, because the project application indicated the home was over 45 years old, the City required a site-specific historic research report to assess the historical significance of the property. On November 15, 2006, neighbors notified the Historical Resources Board staff and Neighborhood Code Compliance that partial demolition had begun on the property. On or about November 22, 2006, the City issued the owner a Notice of Violation, for failure to obtain a permit before starting work. The non-permitted work included removal of two windows, part of the roof, a brick chimney, the entry door, concrete stairs, and original clapboard siding. These modifications are considered an "adverse impact to an historical resource,"<sup>1</sup> according to a January 11, 2007 staff report, recommending designation of the subject property. January 11, 2007 Historical Resources Board Staff Report No. HRB-07-004, Item #9 - August and Mabel Blaisdell Spec House #1, p. 3. On November 28, 2006, the owner submitted a sitespecific historical research report which concluded the property is not significant based on its demolished condition. At the January 25, 2007 meeting of the Historical Resources Board, a motion was made to designate the property as an historical resource, as a good example of a Craftsman bungalow structure, pursuant to the local designation criterion C in the Draft Guidelines for the Application of Historical Resources Board Designation Criteria," November 2006, p. 11-13. The property owner countered that the property could not be designated because the property no longer possessed sufficient integrity in its current condition meaning at the time of the vote. Board members then questioned whether the property should be evaluated based on its condition at the time of the hearing or at the time the project was submitted for permit review. Pursuant to SDMC section 123.0202 (d) the item was continued at the request of the property owner.

<sup>&</sup>lt;sup>1</sup> A substantial adverse change to an historical resource under the California Environmental Quality Act (Pub. Res. Code § 21000 et. seq.) ". . . includes demolition, destruction, relocation or alteration such that the significant of an historical resource would be impaired Pub. Res. Code § 5020.1(q). While demolition and destruction are fairly obvious significant impacts, it is more difficult to assess when change, alteration, or relocation crosses the threshold of substantial adverse change. The CEQA Guidelines provide that a project that demolishes or alters those physical characteristics of an historical resource that convey its historical significance (i.e., its character-defining features) can be considered to materially impair the resource's significance." *See* "California Environmental Quality Act (CEQA) and Historical Resources," California Office of Historic Preservation, Technical Assistance Series # 1, at p. 9.

#### ANALYSIS

#### I. Fair and Effective Decision Making Can Only be Facilitated by Using a Consistent Point of Review for Designation Depending on the Origination of the Designation.

An essential ingredient of the Land Development Code is to "facilitate fair and effective decision making" by establishing uniform procedures to apply land use regulations. SDMC § 111.0102 The Historical Resources Board operates under the Land Development Code. In exercising its duties pursuant to SDMC section 111.0206 (d), the Board plays an integral role in resource protection. For example, upon nomination by City staff during the permit review process, the Board advises the City as to whether such projects will potentially impact significant historic resources. Nominations may also originate from other sources as enumerated in SDMC section 123.0202 as follows:

Nominations of a historical resource to become a designated historical resource may originate from the Historical Resources Board, the City Manager, the City Council, or any member of the public including the property owner by submitting a research report or similar documentation, as identified in the Historical Resources Guidelines of the Land Development Manual, to the Board's administrative staff for consideration by the Board. Nominations from the City Manager may originate as a result of a site-specific survey required for the purpose of obtaining a construction or development permit consistent with Section 143.0212.

In the instant matter, 4004 Lark Street was nominated by the staff as a result of a site-specific survey pursuant to SDMC section 143.0212, which states (emphasis added):

The City Manager shall determine the need for a <u>site-specific</u> <u>survey</u> for the purposes of obtaining a <u>construction permit</u> or development permit for development proposed for any parcel containing <u>a structure that is 45 or more years old</u> and not located within any area identified as exempt in the Historical Resources Guidelines of the Land Development Manual or for any parcel identified as sensitive on the Historical Resource Sensitivity Maps.

It would promote unfair decisions and eviscerate a core function of the Board if a permit applicant could avoid historic designation by altering or demolishing evidence supporting designation before the Board has had an opportunity to evaluate the property. To promote decisions that do not give unfair advantage to some applicants (and not to others) the Historical Resources Board must evaluate potential designations in a consistent manner. As the Land Development Manual, Historical Resources Guidelines, p. 1) (emphasis applied) states: The intent of the guidelines is to ensure consistency in the management of the City's historical resources, including identification, <u>evaluation</u>, preservation/mitigation and development.

Accomplishing consistent evaluation of nominations will depend on the origin of the designation since not all designations originate with the City staff upon submission of an application for a permit under the Land Development Code (SDMC Chapters 11-14).

#### II. When a Historical Designation Originates Under SDMC section 143.0212, Then "Current Condition" Means When an Application is Submitted Because That is When the Historical Designation Review Process Begins.

When the Historical Resource Board evaluates a potential historic resource based on its "current condition," when that evaluation originates from the specific-survey requirement under SDMC section 143.0212, it refers to when a project application is submitted to the City. The Board evaluates and designates historic properties, as part of the land development review process, in reliance on the information provided to the City at the time of project submittal. The permit application process is built on the condition of potentially significant resources at the time an application is submitted. To wit, the Land Development Code at SDMC section 143.0211 requires an applicant, as a prerequisite, to submit certain documentation to obtain a project permit. The Land Development Manual, which spells out the "submittal requirements, review procedures, standards and guidelines" (SDMC section 111.0106 (a)) that implement the Land Development Code, explains to permit applicants, at Volume 1, Chapter 1, at page 3 (emphasis added):

City staff must determine if your proposed site contains one or more elements of a historical resource and then further, if a <u>site-</u> <u>specific survey</u> is required to properly evaluate the resource . . . If your project site . . . proposes demolition or external alteration of <u>a</u> <u>structure that is 45 or more years old</u>, then your project is subject to this review and additional submittal information will be requested . . . Determination of the need for a site-specific survey is made by staff based upon the Parcel Information Checklist submitted as part of the General Application Package.

At Volume 1, Chapter 1, at page 4, the Manual adds:

If potential historic resources are identified, then the proposed project is referred to the Historical Resources Board for possible designation.

The Historical Resources Board functions as an extension of the permit review process. So when evaluating a property undergoing City regulatory assessment, the Board must make the date of its examination congruent with the same date the City starts its review, which is the day an application is submitted. On September 5, 2006, the owner of 4004 Lark Street submitted an application to the City for a construction permit. On October 5, 2006, City staff required a site-specific historic research report. This was because the application showed the property was over 45 years old. On November 28, 2006, the owner submitted such report. It concluded the property was not significant. This was based on the condition of the property after the non-permitted demolition work started but before the Historical Resources Board was able to review the property. On January 25, 2007, City staff recommended to the Board the property be designated consistent with the local Draft Guidelines for the Application of Historical Resources Board Designation Criteria," November 2006, p.11-13, under Criterion C, as a good example of Craftsman bungalow.<sup>2</sup> Staff properly made its determination based on the condition of the property at the time the project permit application was submitted.<sup>3</sup>

The San Diego Municipal Code does not define the term "current condition." Yet the property owner relies on a January 11, 2006, Historical Resources Board staff report, prepared for an entirely different property, to assert that this term refers to the condition of the property the day of the Board vote. In a power point presentation the owner cites the staff report:

The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and...C. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction ... "

and, on state criteria at Title 14 CCR 4852 (b)(3):

An historical resource must be significant at the local, state, or national level under one or more of the following four criterion  $\dots$  (3) It embodies the distinctive characteristics of a type, period, region, or method of construction, or represents the work of a master or possesses high artistic values  $\dots$ 

<sup>3</sup> As stated earlier, under SDMC section 123.0202, nominations may also originate, not from a permit application under the Land Development Code SDMC Chapters 11-14 but from City Council, a member of the public, or the Board itself. Such nomination is, as the ordinance states, triggered by, "... submitting a research report or similar documentation, as identified in the Historical Resources Guidelines of the Land Development Manual, to the Board's administrative staff for consideration by the Board ..." (SDMC section 123.0202(a)). When such research report is submitted to the Board, just like a project application submitted to the City for a construction or other type of permit, it is the submission of the report that triggers review by Board staff, for designation. Thus "current condition" refers to the date the research report is submitted to the Board.

<sup>&</sup>lt;sup>2</sup> Criterion C of the local draft guidelines is analogous to and modeled on both federal Criteria C for design/construction, as set forth in, "How to Apply the National Register Criteria for Evaluation," U.S. Department of Interior, National Register Bulletin #15, at pp. 2, 17-20, as follows:

The Board, as it is aware, may not condition designations to require restorations or modifications. <u>All properties considered for</u> <u>designation must meet the criteria and be eligible for designation in</u> <u>their current condition</u>." (Slide 12, January 25, 2007, power point presentation by Scott Moomjian, entitled "4004 Lark Street," citing to an October 12, 2006 Historical Resources Board Staff Report No. 06-046, Item # 7- 4374 Cleveland Avenue, p. 3) (emphasis applied by Moomjian not in original)

The property owner takes the meaning of the term "current condition" out of context. The October 12, 2006 staff report was to remind the Historical Resources Board that it may not designate a resource based on the potential or future promises to restore a property to the level of integrity required for designation. The property at 4374 Cleveland Avenue, at the time the project was submitted to the City for a project permit, had already been so modified it had lost its historical integrity. Pers. Comm., April 3, 2007, Kelly Saunders, Senior Planner, City of San Diego, Planning Department, Historical Resources Board.

... [T]he cumulative effects of multiple modifications to the house has substantially and adversely impacted the historical integrity of the property. . . Furthermore, despite the [historical survey] report's contention that the modifications are 'minimal alterations, which 'can easily be changed to restore the home to its original appearance, the Board as it is aware, may not condition designations to require restorations or modifications. All properties must be considered in their current condition." (October 12, 2006 Historical Resources Board Staff Report No. 06-046, Item # 7- 4374 Cleveland Avenue, p. 3) (emphasis applied)

By contrast, the property owner of 4004 Lark Street caused a substantial adverse change to the property *after* the project application was submitted and, significantly, *after* being notified by City staff that the house would be evaluated for historical significance. The San Diego Municipal Code nowhere specifies that the concept of integrity is restricted to the physical condition of a resource when the Historical Resources Board votes on a proposed designation. Thus the property owner's reliance on the October 12, 2006, Historical Resources Board Staff Report No. 06-046, Item # 7- 4374 Cleveland Avenue is misplaced.

Indeed, the property owner not only misplaces reliance on a staff report irrelevant to 4004 Lark Street but also incorrectly equates "current condition" with the concept of "integrity" as it is applied under state law to the designation of historical resources:

Integrity is the authenticity of an historical resource's physical identity evidenced by the survival of characteristics that existed during the resource's period of significance. Historical resources eligible for listing in the California Register must meet one of the criteria of significance... and retain enough of their historic character or appearance to be recognizable as historical resources

and to convey the reasons for their significance. Historical resources that have been rehabilitated or restored may be evaluated for listing. Integrity is evaluated with regard to the retention of location, design, setting, materials, workmanship, feeling, and association. It must also be judged with reference to the particular criteria under which a resource is proposed for eligibility. Alterations over time to a resource or historic changes in its use may themselves have historical, cultural, or architectural significance. It is possible that historical resources may not retain sufficient integrity to meet the criteria for listing in the National Register, but they may still be eligible for listing in the California Register. A resource that has lost its historic character or appearance may still have sufficient integrity for the California Register if it maintains the potential to yield significant scientific or historical information or specific data." See "California Environmental Quality Act (CEQA) and Historical Resources," California Office of Historic Preservation, Technical Assistance Series # 1, Appendix C, at p. 31. See also Title 14 CCR 4852 (c). (emphasis added)

#### CONCLUSION

The "current condition" of a potential historic resource, where its nomination arises from SDMC section 143.0212, refers to the date a project application is submitted to the City. The local permit review process is predicated on the information provided by an applicant when it submits a project to the City. The application submittal date, in essence, tolls and locks the condition of a property, for purposes of fair and equitable review, thus avoiding the situation, as in the instant case of 4004 Lark Street, whereby an applicant could avoid designation by demolishing a resource before it can be evaluated by the Historical Resources Board pursuant to SDMC section 111.0206 (d).

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By

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MG:ca ML-2007-7

cc: Betsy McCullough, Deputy Director, Planning Department Cathy Winterrowd, Senior Planner, Planning Department Robert A. Vacchi, Chair, Historical Resources Board

### **Nobel Prize Women in Science Their Lives, Struggles, and Momentous Discoveries** SECOND EDITION

Sharon Bertsch McGrayne

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Maria Goeppert Mayer June 28, 1906–February 20, 1972 MATHEMATICAL PHYSICIST Nobel Prize in Physics 1963

"NEVER BECOME just a woman," her father insisted.

Maria understood instantly. Someone who was "just a woman" was a housewife interested only in her children. "This he didn't like," she explained late in life. "My father always said I should have been a boy."

To follow in her father's footsteps, she vowed to become a scientist and the seventh-generation university professor in the Goeppert family. To that end, Maria Goeppert Mayer patched together a career of volunteer work unique in the annals of the Nobel Prize. In all, she worked for thirty years in three different fields for three American universities—as an unpaid volunteer. She taught, supervised graduate students, served on university committees, and published articles—but she did not receive a university salary until ten years after her Nobel Prize–winning work.

Maria Gertrud Käte Goeppert was the only child of Friedrich and Maria Wolff Goeppert. She was born on June 28, 1906, in Upper Silesia, which was then a part of Germany but is now in Poland. When she was four years old, her family moved to the small university town of Göttingen in central Germany. Göttingen treated Maria like a little princess, and both the town and its university profoundly influenced her life.

Friedrich Goeppert was the professor of pediatrics at the university. He also directed a children's hospital and founded a day-care center for the children of working mothers. As a German university professor, he occupied a position of great prestige. German professors were on a par financially with successful American doctors, lawyers, and businessmen. Socially, they were the equals of high government officials. When Frau Professor Goeppert shopped, she was served first—unless another "Frau Professor" who outranked her in some subtle way was also present. Göttingen's social life revolved around the parties hosted by professors' wives, and their children were Göttingen's socialites.

Competition to be Göttingen's leading hostess was fierce, but Frau Goeppert's parties set the standard for hospitality. When she entertained, she opened every room of the house to guests. If the dance band quit at midnight, she played the piano for singing until four A.M. When she bought a Christmas tree and discovered a taller one elsewhere, she returned the inferior tree for the better one.

Although Frau Goeppert set her daughter's entertaining and mothering standards, Maria's father was her favorite parent. "He was, after all, a scientist," she explained. She called him a gentle bear of a man, because he doted on children and they followed him Pied Piper-like through the streets. He took his daughter on science walks, hunting for quarry fossils and studying forest plants. When she was three and a half years old, she asked for—and he gave— an accurate description of a half-moon; when she was seven, he made her dark lenses for watching a solar eclipse.

As a pediatrician, Professor Goeppert liked children to feel brave and self-confident. He was famous for rousing his little surgical patients from bed the day after their operations; at the time, other doctors insisted on weeks or months of bed rest. He thought that mothers were the natural enemies of their children: women stifled inquisitiveness and daring. When Maria climbed a tree, her father led Frau Goeppert away, lest she inhibit her daughter's spirit.

An only child, Maria was thin and pale, with almost translucent skin—definitely not an "outdoor" girl. She suffered from frequent and throbbing headaches all her life, but her father told her, "We 've done all we can for them. You can either be an invalid, or you can ignore them and go on as best you can." She decided to ignore them.

On Maria's eighth birthday in 1914, Archduke Ferdinand of Austria was assassinated. World War I soon followed. Toward the end of the war and during the runaway inflation that followed, the Goepperts dined on turnip soup and pigs' ears to save food for the children in Dr. Goeppert's clinic. A Quaker organization fed Maria hot lunches at school, and when a New York Times reporter wrote that "the professor who is feeding the children is suffering from malnutrition himself," food packages poured in from the United States. By the time Maria was in her late teens, however, conditions had returned to normal and Mrs. Goeppert had resumed her fabulous entertaining schedule. Maria frequently voiced her bitterness, however, about the postwar transfer of Upper Silesia, the region where she was born, to Poland.

"When I grew older," she explained later in life, "there was never any doubt in the minds of my parents or myself that I would study at the university.... Ever since I was a very small child, I knew that when I grew up I was expected to acquire some training or education which would enable me to earn a living so that I was not dependent on marriage." Getting enough education to pass a university's rigorous entrance examination seemed impossible, though.

Even as late as 1924, Göttingen had two large schools that prepared hundreds of boys for the university every year while the city had nothing comparable for girls. For several years, Mayer attended a small, private school endowed by suffragettes. When it collapsed during the post–World War I inflation, she decided to take the university examination a year early. Her former teachers were horrified.

"You won't be able to do it," they scolded her.

"I will," she replied resolutely.

"You won't be able to do it, and you're too young. You won't be admitted," they warned.

"All right, I'll take my chance on that too," she announced firmly. And then she pulled strings until she was admitted to the examination.

She and four other girls from the suffragettes' school took and passed the exam. "Imagine," Mayer said indignantly years later, "Five girls compared to hundreds of men!" When Mayer entered the university at Göttingen in 1924 to study mathematics, fewer than one in ten German university students was a woman. In the United States, women accounted for roughly one out of three students.

Mayer attended Göttingen at the peak of its prestige in mathematics and physics, and she became the personal friend of many of its leading stars. Professor David Hilbert, Emmy Noether's mentor, was regarded as the greatest mathematician since Karl Friedrich Gauss and the greatest geometrician since Euclid. Hilbert's famous garden, with its long sheltered blackboard for outdoor seminars, bordered the Goepperts' yard. Hilbert always invited his latest ladyfriend to attend the public lectures he gave each Saturday morning.

One Saturday when he was fresh out of ladies, he invited Maria to substitute.

"Won't you come?" Hilbert asked her. Arranging an excuse from school, she got her first glimpse of atomic physics. Later, when Hilbert was dying of pernicious anemia, Maria waited anxiously for the first liver extract to arrive in Germany. Daily doses of the vitamin B12 extract kept Hilbert alive for years.

Two of Göttingen's leading physicists, Max Born and James Franck, became Maria's lifelong admirers as well. Born regarded her as his daughter and Franck considered her "at least a niece." Thanks to them, most of the physicists who developed quantum mechanics during the mid-1920s and early 1930s visited Göttingen. She was friendly with many of them and, as a result, was among the first practitioners of the new physics.

Quantum mechanics—perhaps the greatest intellectual achievement of the twentieth century—describes the behavior of atoms, nuclei, and their components. The key to understanding all matter, quantum mechanics united physics, chemistry, astronomy, and much of biology. It was developed under the loose leadership of Niels Bohr in Copenhagen by a small group of Europeans, particularly Maria's teacher Max Born and Werner Heisenberg in Göttingen, Erwin Schroedinger and Wolfgang Pauli in Austria, and Paul Dirac in England.

"Maria was a lovely and lively young girl and, when she appeared in my class, I was rather astonished," Max Born wrote. "She went through all my courses with great industry and conscientiousness, yet remained at the same time a gay and witty member of 'Göttingen society,' fond of parties, of laughing, dancing, joking. We became great friends." Even before Maria joined his seminar, Born asked her to join him and his students in walks through the hills surrounding Göttingen to nearby village inns for supper. Eventually, it became obvious that she was Born's favorite student, and Göttingen's small-town rumor mill, still unaccustomed to women students, concluded that there was more than physics between Maria and her married professor.

Maria Goeppert entered the university expecting to study mathematics, but her first taste of quantum mechanics turned her into a physicist. "This was wonderful. I liked the mathematics in it....Mathematics began to seem too much like puzzle-solving.... Physics is puzzle-solving, too, but of puzzles created by nature, not by the mind of man.... Physics was the challenge." Furthermore, she observed, "quantum mechanics was young and exciting."

"The spirit in Göttingen was so different at that time than anywhere else," Maria thought. Born and Franck ran a joint seminar in which participants were required to interrupt the speaker and criticize ruthlessly. Born and Heisenberg were developing quantum mechanics, and a friend in Heisenberg's class reported to Maria, "It's very exciting. Heisenberg tells us what he thought about last night."

Born's quantum mechanics students sometimes overwhelmed him, but they did not scare Maria Goeppert. Born believed that his advanced theory seminar attracted "the most brilliant gathering of young talent then to be found anywhere." Among its stars were Paul Dirac, Robert Oppenheimer from the United States, Enrico Fermi from Italy, and Eugene Wigner and John von Neumann from Hungary. Oppenheimer, the Harvard wunderkind, interrupted Born so often that Maria Goeppert finally organized a student petition demanding that he keep quiet. Born casually left the petition where Oppenheimer would read it and was relieved when the interruptions ceased. "But I am afraid he was deadly offended," Born reported.

Maria Goeppert's closest friends were fellow students Victor Weisskopf and Max Delbrück, who became Lise Meitner's assistant in Berlin and Barbara McClintock's colleague at Cold Spring Harbor. Maria often ate two dinners a day— one with her mother at home and one with her friends in town—so she could talk quantum mechanics with them. As Weisskopf, one of the great men of modern physics, explained, "We both were students of Max Born. We actually worked on rather similar problems and worked together and, if I may be a little personal, I fell in love with her." Delbrück, on the other hand, flunked his final examination the first time around, switched fields and eventually became a leading molecular biologist. Other friends who became science luminaries were Linus Pauling, Leo Szilard, and Arthur Holly Compton. As Maria Goeppert herself remarked, "I have to confess, I never much associated with the women. I always was with the boys…and that was enjoyable, you see."

When Professor Goeppert died in 1927, his wife followed Göttingen's time-honored custom and took in student boarders. The university did not provide student housing. Joseph Mayer, a good-looking Californian who had come to Göttingen to study quantum mechanics with Franck, knocked on Frau Goeppert's door and asked for a room. "To my enquiry, the maid brought a pretty little blond girl who, in spite of her obvious attractiveness, annoyed me by ignoring my painfully halting German and talking with me in faultless Cambridge English," Joe said. "I soon found that Maria, in addition to her pulchritude and linguistic accomplishment, was a student of Max Born's."

Joe was smitten. She was "a terrible flirt— but lovely, and brighter than any girl I had ever met." In fact, a chemist who knew them both concluded that she was brighter than Joe— and that he knew it. She liked to ski, swim, and play tennis, and wanted to go dancing almost every night. According to Joe, "She didn't do any of those things well, but she was a joy to be with."

Small and slim with blond hair and blue eyes, Maria Goeppert was called "The Beauty of Göttingen." Male scientists found her a delightful blend of intelligence and femininity. "She was nothing else if not feminine," her daughter Marianne Wentzel mused later. "For most of those scientists, they'd never met a woman who was as intelligent as they were, and then to have a woman who was very definitely a woman—it was an unbeatable combination."

"I wasn't beautiful at all," Maria Goeppert protested. "Göttingen was the classic European university town in which professors' daughters were tops in society and were terribly spoiled and popular."

Weisskopf and Joe Mayer, however, were not the only young men infatuated with her. "Everybody who boarded in that house apparently was taken with her, and half those guys proposed to her," according to Robert G. Sachs, who became her student in the United States. Years later, the American Nobel Prize–winner Robert S. Mulliken, who had boarded with the Goepperts, wondered, "What if I had married Maria Goeppert?" And another American student confessed, "We were all in love with her—not that I ever said a word to her. I didn't even know she spoke beautiful English." As Maria's daughter explained, "Men fell in love with her all the time. It wasn't important to her. It always seemed to me so amazing that she could just bend men around her finger." The skill proved useful in the years ahead.

Joe Mayer was a tanned, jazz-age Californian who had graduated from the California Institute of Technology and earned his Ph.D. at the University of California at Berkeley. He had pizzazz and could argue with verve and style about almost anything. A child of the Roaring Twenties and Prohibition, he laid in a supply of whisky and gin as soon as he arrived in Göttingen. In a town where Fermi felt like a millionaire because he owned a bike, Joe bought a convertible for cash. Gossip had it that Maria chose Joe from all her suitors because he had a car. Joe had another advantage, though. Like her father, he wanted Maria to become a professor. When Maria and Joe became engaged, she thought about quitting physics, but Joe convinced her to continue. He was the feminist of the two. As a chemistry professor, he would have several women students; she never had any. By far the more famous of the two for most of their marriage, Joe pushed, prodded, cajoled, and supported Maria into doing physics all her life.

That fall, while she was still procrastinating with her thesis, he drove her to the Netherlands to visit one of Albert Einstein's closest friends, Paul Ehrenfest, a physicist. Ehrenfest and his wealthy Russian wife had built a beautiful house just before the Bolshevik Revolution intervened and left them with no money for decorating the walls. So Ehrenfest simply hung up his pocket watch and asked visitors to sign the guest room wall.

During their visit, Maria Mayer chatted happily about her thesis until suddenly Ehrenfest interrupted, "You've talked enough: now write." Locking her into the guest room, he told her not to emerge without an outline.

"It was a marvelous room, with one wall covered by the largest collection of detective novels I have ever seen and the other walls covered by autographs of famous scientists," Maria Mayer recalled.

"Einstein's autograph was over my bed. I solved my problem within an hour, and it was the basis for my doctor's thesis." Then she signed the wall and departed.

Joe insisted that Maria finish her thesis. The day after Christmas was the maid's day off, and Maria decided to cook an elaborate dinner of deer loin and trimmings. Joe, who knew how to cook, soon realized that Maria did not. Waiting until she became thoroughly distraught, Joe struck a deal: "If you go on in science, I will always keep a maid for you. If you stop, you'll have to learn to do your own cooking. I won't be able to afford a maid."

Maria and Joe were married on January 18, 1930, and by March she had finished her thesis and passed her final examination. Three Nobel Prize winners sat on her examining committee. She had calculated the probability that an electron orbiting an atom's nucleus would emit not one, but two, photons or quantum units of light as it jumps to an orbit closer to the nucleus. Eugene P. Wigner, who later shared the Nobel Prize with Maria, called her thesis "a masterpiece of clarity and concreteness." Her solution was confirmed by lasers in the 1960s and is still quoted in papers on optics, atomic physics, and molecular physics. She also contributed an eight-page section to a quantum mechanics book that Born wrote with Pascual Jordan.

When Joe and Maria left Göttingen, she had "more first-class mentors than anyone I ever knew in the world," Bob Sachs said. "She had everybody—David Hilbert, James Franck, Max Born, Karl Herzfeld—just everybody was enthusiastic about her. She had a tremendous support structure. Everybody was helping her." She would need them all. She arrived in the United States on April Fool's Day, 1930.

The Mayers went straight to Baltimore, Maryland, where Joe had an assistant professorship at Johns Hopkins University. Maria loved Baltimore all her life and often said that her ten years there were her happiest. The bitterness came only at the end of their stay. Initially, however, she was homesick. America seemed wild and woolly. When she ordered wine in a Prohibition-era restaurant, it came disguised in a coffeepot. When a large wooden box from a German arms manufacturer arrived for Joe, she thought the worst: "My God, is he buying weapons? Is he a gangster?" But his response was reassuring: "Oh good, my razor blades have arrived."

She eased into American life by writing and cabling her mother frequently and by spending her first four summers of married life among Europeans. The University of Michigan held a summer school in Ann Arbor during the early 1930s to teach European quantum mechanics to American physicists. Her old friends Fermi and Ehrenfest sat in the front row at each other's lectures, gleefully correcting one another's fractured English. So many of the visitors spoke German that Maria felt sorry for the Americans. The next three summers, she returned to Göttingen to work with Max Born.

Maria's golden youth in Göttingen had convinced her that she could have it all: children, an elaborate social life like her mother's, and a career like her father's. Joe agreed; he calculated that a working mother with hired help could handle the household chores easily in two hours a day. The social part of the equation was fun in Baltimore. The Mayers sailed Chesapeake Bay, hiked Maryland's hills, and crushed enough grapes in an old washing machine to make 100-liter batches of wine. A faculty wife observed a trifle sourly, "Whenever there's a party, the men seem to collect around Maria." And when an innocent young scientist asked how to emulate her gracious lifestyle on an academic salary, Maria advised him simply, "Live beyond your means!"

When her daughter Marianne was born in 1933 and her son Peter in 1938, her life became complicated. Raised an only child by a full-time housewife, Maria Mayer confessed, "I never stopped feeling guilty, thinking that I should have been home more. Marianne and Peter are wonderful, but I will feel forever that they have missed something.... The combination of children and professional work is not quite easy.... There is an emotional strain due to the conflicting allegiances, that to science and that to the children who, after all, need a mother. I have had this experience in full measure." Joe still wanted her to continue in science, though, and she knew she would be miserable if she gave it up. She hated staying home, even when the children were sick.

The biggest complication of all was professional. Mayer wanted to be one of the world's best physicists, not just one of the best women physicists. Göttingen had proved she could hold her own at the top. But for her, being a top scientist "did not mean doing science at home," her friend and collaborator Jacob Bigeleisen noted.

"Going to the office and doing science was important because the office was an indication of her status as a professor."

Maria Mayer realized that she could never have a university career in Germany. Emmy Noether, Lise Meitner, and her friend Hertha Sponer—none of them ever became a regular professor in Germany. But she had thought America might be different. During the 1920s, women earned 15 percent of all American Ph.D.'s. Johns Hopkins itself had a famous coeducational medical school, though the university proper was adamantly opposed to admitting womenas regular undergraduates. Johns Hopkins had even appointed two women as professors of psychology and education, fields that were popular among women; one of them was a department chair.

The Mayers had not counted on the Depression. "Nobody, especially no university, would give a paid position to the wife of a professor," Mayer soon learned. Hopkins, like most U.S. colleges and universities, had strict antinepotism rules prohibiting the employment of relatives (generally wives) of university employees. The rules are often described as an outgrowth of the Depression, when the public opposed two-paycheck families. But the practice began in the 1920s before the Depression and continued long after, into the 1970s. Nepotism rules trapped Maria Mayer for decades.

Johns Hopkins adorned her with a potpourri of titles like "fellow by courtesy," "voluntary assistant," "associate," and "research associate." The university did not even consider Mayer a regular "research associate"; she was never listed with the twenty or thirty male research associates in its catalog. When Mayer asked if she could use an empty office on the main floor, she was sent to the attic.

"So I worked for a number of years without pay, just for the fun of doing physics," Maria Mayer explained. To keep her skills up-to-date in case she ever had to earn her own living, "we considered the added expenses of part-time household help as insurance—insurance for me in case of my husband's death.... I sensed the resentment very early, so I simply learned to be inconspicuous. I never asked for anything, and I never complained."

She would not let Joe complain, either. She knew she was good, but she did not like to be angry. She was having fun doing physics, and she had a nice husband and two babies, a lovely home, and friends. "I would have fought if I had had to, but I only wanted to learn, to teach, and to work.... I just didn't feel put upon in the least."

Curiously, Hopkins did not seem to want a quantum mechanics expert anymore than it wanted a woman physicist. American theoretical physics lagged far behind Europe in 1930. Its physicists were oriented toward engineering and nineteen-century classical mechanics; they were uninterested in theory, especially the new quantum theory of atomic particles and waves.

Luckily, Hopkins was like Göttingen in one vital respect. The collaboration between chemists, physicists, and mathematicians was unusually close, and Maria could piece together a research program by linking the different disciplines. She produced ten papers and a textbook in nine years at Hopkins—what Joe proudly called "quite a bit of scientific work."

She collaborated with Joe and a kindly Austrian, Karl Herzfeld, a devout Catholic whose parents had converted from Judaism. Although physics at Hopkins was almost exclusively experimental, Herzfeld was an outstanding theorist. Max Born asked him to look out for Maria, and he did. Since Herzfeld was interested in chemical physics and Joe was a chemist, Maria began applying quantum mechanics to chemical problems, such as the structure of organic compounds.

Quantum mechanics was just beginning to have a profound effect on chemistry, and the range of available problems was broad, deep, and seemingly boundless. One of her papers, written with graduate student Alfred Sklar, was a milestone in quantum chemistry. Herzfeld paid her two hundred dollars a year for help with his German correspondence, and Maria and Joe wrote Statistical Mechanics, such a popular chemistry textbook about molecular systems that its various editions sold for forty-four years.

When Adolf Hitler came to power in Germany, Mayer's old friend James Franck fled to Hopkins and she found him a house in the well-to-do neighborhood of Roland Park. Franck's presence made Baltimore feel like Göttingen, and he turned Hopkins into a world center for atomic physics. Maryland was extremely anti-Semitic at the time, however. Beach billboards screamed "Gentiles Only" in huge letters, and Roland Park enforced strict real estate covenants against selling houses to Jews. Relishing the prospect of playing a joke on Baltimore's snobs, Maria Mayer signed Franck's real estate contract as his proxy even though it included a clause against selling to Jews.

By then Hopkins was treating Maria Mayer quite graciously. She had a pleasant office in the physics department and was teaching and supervising her student Bob Sachs's Ph.D. thesis. But she still had neither job nor salary. Herzfeld asked the dean at least to put Maria Mayer's name on the department's stationery. The dean became so angry that he dropped every name but his own from the letterhead, Maria recalled.

Outraged, Herzfeld wrote to Hopkins' president: "Dr. Goeppert-Mayer does at least one-third of the work of a full-time associate, both as a teacher and in research.... As so often happens in women, she does not often originate a paper, but she is always instrumental in reaching the result. It has often happened that I could not proceed and she saw the way out. Her mind is really brilliant and penetrating, although perhaps not very original.... The adequate amount of remuneration would be \$1,000." Nothing happened.

While many students took a romantic view of "Joe and Maria," most were overwhelmed by her extremely technical and highly condensed lecturing style and by her mathematical virtuosity. Before strangers, the self-confident flirt from Göttingen was "very shy. She was at her best when she was with people she knew well," Sachs said. Uncomfortable lecturing, she spoke fast and almost inaudibly in abrupt, clipped sentences. To calm her nerves, she puffed one cigarette after another.

Top students like John Wheeler and Sachs were inspired, though. In fact, she was one of Wheeler's favorite professors at Hopkins. Wheeler, who became an eminent professor in Princeton, New Jersey, and Texas, liked "her quiet firmness, the rising emphasis at the end of her last sentence, and her inability to leave a problem until it was clarified."

Sachs recalled that when he asked her for a thesis topic, she declared firmly, "Any young man— (and she said 'man')—starting out in theoretical physics at this time must work in nuclear physics where all the exciting new things are happening." In a remarkable series of events during the early 1930s, neutrons, positrons, deuterium, and artificial radioactivity were discovered and particle accelerators invented. Wheeler knew a man who had "traveled to the Arctic. He'd gone on mountain-climbing expeditions. He had carried a caravan across the Sahara. But now he had gone into physics because that's where the excitement lay."

Mayer was still unfamiliar with nuclear physics, she told Sachs. "Therefore, we'll go over to Washington to see Edward Teller. He'll tell us what you should do." Mayer loved to talk physics with her Göttingen friend Teller. He, in turn, wrote her scores of letters over the years, mixing personal confidences and physics. Teller, who had emigrated to George Washington University, became the controversial father of the hydrogen bomb and of Star Wars. Together, Mayer and Sachs published a nuclear physics article that was her first and only foray into the field until shortly before her discovery of the shell model almost fifteen years later.

In the course of working with Mayer, Sachs discovered that "in a quiet way she was a driven person. She was very shy. Sometimes she would whisper very fast with great intensity. It was clear that she really wanted to get the solution to that problem.... Maria was very unassuming in demeanor but she was very competitive."

Sachs noticed something else about his adviser. "She wasn't very sensitive in the early stages to the implications of what was going on in Germany.... Before Born left Germany, she wanted me to go work with him in Göttingen." Sachs is Jewish and, "Well, I wasn't thinking very much of going to Germany in those days."

The prewar years were difficult for Maria and for many German-Americans proud of their homeland's culture. Mayer's attitudes, like theirs, changed slowly and not necessarily steadily. "She was very strongly oriented toward the Prussians," Sachs noted. "She was proud of that heritage, politically. She and Joe had a strong faith in the German way of doing things. In the early days of the Nazi regime, she was a strong believer that [then Reichstag President Hermann] Goering would be the savior, that he was biding his time, letting Hitler clean up 'the mess.' She was typical of many upper-class Germans who felt they could trust Goering. I heard her say it. I had a much different point of view." As it turned out, Sachs was right. Goering was one of Hitler's most loyal supporters and a prime architect of the Nazi police state and its military.

As time passed, Mayer became increasingly depressed about the Nazi takeover in Germany. As a student, Weisskopf had heard her denounce Nazi influence in student organizations. During her summer visits to Göttingen in the early 1930s, she was dismayed at the decay of its intellectual life. When government guards gave her a "Heil Hitler" greeting, she responded with a simple "Good morning."

In 1933, she became a U.S. citizen and with Herzfeld was temporary treasurer of a fund established by German professors in the United States who pledged a portion of their salaries to help German refugees. She opened her home to several exiles and signed affidavits of support for would-be immigrants. Nevertheless, the old feelings died hard, and in 1940, when Sachs saw her after the fall of Paris, she was torn between pride at Germany's quick victory and dismay at its aggression.

In 1938, when Maria was pregnant with Peter, Hopkins fired Joe. As Maria told the story, Hopkins president Isaiah Bowman decided that he could solve the university's financial plight by getting rid of the best—and hence most expensive—faculty members and by replacing them with junior faculty at a third the price. At the time, many universities, including Hopkins, did not give senior faculty members tenure after seven years of employment. Although Joe was by no means senior, he was thrown out during the housecleaning; even the Baltimore Sunpapers lamented the fact that young people like Joe were being let go. "My understanding is that the administration was prejudiced against Communists, against Jews, against Catholics, against women, and against foreigners," Sachs recalled. In the process of "cleansing" the atmosphere and balancing the budget, Hopkins lost almost a dozen of the world's leading scholars, and Joe and Maria Mayer.

According to the Mayers, Donald Andrews, who chaired the chemistry department, was jealous of Joe's spectacularly successful theory of condensation. In a terse fifteen-minute interview, Andrews told Joe that his contract would not be renewed because he had not attracted enough graduate students. Maria Mayer detested Andrews and the Hopkins administration ever after. "I am sure that Joe was fired from the Johns Hopkins faculty in 1939 partly because I was around and was some trouble," she declared. "I was very careful after that."

"To use her expression, she felt she had to be a 'lady," explained Mayer's daughter Marianne. "She had to be absolutely fair, and if someone else did some work, she always let them publish it first and then she published her additions afterwards. She was always very conscious that she had to behave properly if she was not to be accused of being a conniving, abrasive woman."

On the other hand, "she never felt discriminated against particularly," reported her daughter. And, in some sense, Maria Mayer was right. The small and rarefied circle of top scientists—the only people she cared about— admired her; it was primarily outsiders like Andrews who did not.

Ironically, Joe's experience at Hopkins hurt Maria more than it did Joe. Joe wound up at Columbia University at twice his Hopkins salary. Harold Urey, who had won the Nobel Prize in chemistry in 1934 for discovering the deuteron and heavy water, chaired the chemistry department there and became Joe's mentor. From then on, wherever Urey went, the Mayers were sure to go. On the other hand, Maria Mayer's years at Columbia were among the most difficult of her life, even though they transformed her in the eyes of her colleagues into a full-fledged, professional physicist.

"She was shy, but she was absolutely driven. She was very competitive. She wanted to make her name on her own and to compete with the top people in theoretical physics in the world, no question about that," recalled Bigeleisen, who collaborated with her at Columbia. "Maria wanted to be recognized as one of the world's top scientists." So she applied for a job in Columbia's physics department.

Its chairperson, George B. Pegram, turned her down cold. He assigned her an office but made it clear she was unwelcome. From then on, Maria Mayer loathed Pegram. After the war, she even refused to publish her wartime research at Columbia if it meant getting clearance from him. "Over my dead body," she exploded. "This paper can rot in hell before I will ask Dean Pegram for anything."

Eventually, she published it with no mention of Columbia. Years later, when she was ill, her biographer Joan Dash concluded that Maria Mayer had acquired such self-control that she never became angry. But Marianne said her mother had given that impression because she had felt "very uncomfortable" being interviewed. Among friends, Maria Mayer could erupt like the proverbial volcano.

Columbia's chemistry faculty refused to give her even an honorary job title to put on the title page of Statistical Mechanics. According to the scientific community, Maria had been Joe's editorial assistant, not his coauthor. However, Urey, the chemistry department chair, greatly admired Maria's abilities and gave her a minor teaching job. Thanks to him, she got an office in the chemistry building and the all-important job title. Resentments lingered, though.

Someone in the department later told Maria and another scientist's wife, the only two women who attended the department's weekly seminars, to attend the lectures but not the dinners afterward.

"Naturally, I went to no more seminars and I made Joe promise not to complain," Maria said. "Later, they had a woman speaker and invited me, but I went to the opera with Edward Teller instead."

Soon after the invasion of Poland in the winter of 1939–1940, the Mayers moved to a modest clapboard house in Leonia, New Jersey, twenty minutes from Columbia. There they formed a little colony of past and future Nobel Prize winners, including the Fermis, the Ureys and a few years later the Willard Libbys. The Mayers' fierce bridge-playing, fervent partying, and heavy smoking were considered wildly dashing and sophisticated.

The Mayer children remember the Leonia years warmly. In the evenings, their mother read them German editions of French stories and of Kipling's Jungle Book, translating as she went. She sang so often that Peter thought, "She must know every song Schubert ever wrote." Joe, who was more talkative than Maria, generally

answered the children's science questions and took them on beach walks and camping expeditions. Maria ran the house with lists and elaborate filing systems for everything from science to personal correspondence. Books were alphabetized by authors' names. "It makes life simpler if you know what you're doing," she explained.

Although she formed several lifelong friendships there with women "as close to my heart as my own family," she never warmed to Leonia. "I am more accustomed to the company of men because of my work, and I've never had time for science, my family and kaffeklatsches. Frankly, I think large groups of women tend to get shrill."

When the Mayers left Leonia, a woman complained to the local paper that Maria had not done enough volunteer work—as if her physics had not been volunteer work enough.

By early 1940, the Fermis and Mayers were afraid that American Fascists might take control of the United States. The pro-Nazi German-American Bund was active in New Jersey, and Maria and Joe resigned from a German-American social club near Leonia because its members were pro-Nazi. Despite her admiration for Prussian ways, "my mother was about as anti-Nazi as possible," Marianne recalled.

In many respects, World War II was a physicists' war. Physicists developed both the radar that protected Britain from German air attacks and the atomic bomb that ended the war. Physicists were in such short supply that even Maria Mayer got a paying job.

Her first break occurred that fall when the American Physical Society wrote her a letter addressed "Dear Sir" and named her a "Fellow." Then the day after Pearl Harbor, she received her first job offer, from Sarah Lawrence College, which she described as "a rather swell, but definitely not scientifically inclined, girls' school." When a Sarah Lawrence interviewer asked her if an interdisciplinary science course could be as important to women as learning how to regulate a furnace flue, Mayer was stunned. "I asked if the only reason students learned English was to read a cookbook," she remarked. "It was the right thing to say. Sarah Lawrence was trying to find out if I would be traditional and dull." She took the job, telling Sarah Lawrence, "You really ought to have a man to do this."

The college paid Mayer her first-ever salary—\$2,800 a year part-time after twelve years in the profession. Mayer enjoyed teaching, although balancing two jobs and a family was sometimes hectic.

She once dropped Joe off at the Leonia train station for his commute to Columbia and then forgot to drive home to get dressed herself. She drove the twenty miles to Sarah Lawrence in her bathrobe. At Columbia after Pearl Harbor, Mayer took over Fermi's courses on twenty-four hours' notice and Urey assigned her top-secret atomic bomb research problems even before she got security clearance. She was learning a new field, atomic physics. By then, "Maria was absolutely frightened the Germans would get the bomb first," recalled Bigeleisen. "She had to do everything possible to see that the United States produced the bomb first."

Urey and Columbia were in charge of developing a supersecret method to enrich uranium for an atomic bomb. They needed to separate uranium U-235, which is easily fissionable, from the more common, natural uranium U-238, which is not. Columbia managed the Substitute Alloy Materials project, nicknamed SAM, for the federal government, and the government paid Maria Mayer. When she told Urey that she would not work Saturdays or when her children were sick, he assigned her to "side issues," like investigating the possibility of separating isotopes by photochemical reactions. "This was nice, clean physics although it did not help in the separation of isotopes," Maria Mayer said. Eventually she became the unofficial scientific leader of about fifteen people, mostly chemists.

During the war, she felt guilty— not about the bomb, but about leaving the children. Joe was away six days a week doing weapons research, a German maid proved to be physically abusive, and an expensive English nanny

became psychologically abusive. Marianne decided that when she grew up she would stay home with her children.

SAM was good for Mayer's professional development, however. "Suddenly I was taken seriously, considered a good scientist.... It was the beginning of myself standing on my own two feet as a scientist, not leaning on Joe." She developed a reputation as an expert problem-solver. "Take her a problem and— zingo," marveled Bigeleisen. The day she returned to work from a gallbladder operation, she asked Bigeleisen what he was working on. He told her; she said it sounded interesting and asked if she could help. Her third sentence completed the problem's solution and revolutionized isotopic chemistry.

The war years were hard on Mayer's health. She had pneumonia and surgery for gallbladder and goiter problems. Yet nothing stopped her chain-smoking or heavy social drinking. She smoked constantly, often three or four cigarettes at once. She and Joe, who was also a chainsmoker, sat through seminars in a cloud of smoke.

She favored vile-smelling, denicotinized Carl Henry cigarettes and nudged Joe for another before she finished the first. When Bigeleisen smuggled a bottle of rationed Ballantine scotch into her hospital room under his coat, she called him "a savior." During a tough, war-time session on the spectrum of uranium-235, Bigeleisen provided Urey, Teller, and Mayer with a midmorning cocktail break that proved extremely popular. Marianne said her parents realized that smoking was bad for their health and tried to quit, although her mother never reached the same conclusion about alcohol. In the 1940s and 1950s, macho men and sophisticated women smoked and drank, and the drunker the party the more fun it was, Marianne observed.

When Joe went to the South Pacific to observe the Okinawa invasion, Mayer spent a month in Los Alamos working on Teller's hydrogen bomb. She analyzed the behavior of uranium compounds at the very high temperatures and pressures expected in a thermonuclear explosion. At her security clearance interview, an officer lectured her sternly, "There is one thing you must always keep in mind. Do not mention to anybody that there is a connection between the work going on at Los Alamos and at Chicago, Columbia, Hanford, Oak Ridge, etc., because that is Top Secret information." That was the first that Mayer had heard about any relationship between the installations. She was particularly irritated by his bungling because she had been forbidden to talk about her atomic bomb work with Joe. "Some friends say I am too dependent on Joe, but I've always told him everything," Maria said later. "Keeping from him that awful secret of the atom bomb research I did during World War II for four years was harder on me than all the prejudice of the years."

After the war, Mayer said she was glad that her particular project at Columbia had not contributed to the bomb. "We failed. We found nothing, and we were lucky, because we didn't contribute to the development of the bomb, and so we escaped the searing guilt felt to this day by those responsible for the bomb." Working on the bomb did not bother her at the time, though. And from private conversations with Urey as well as from her knowledge of physics and of Fermi's and Urey's research, she knew she was working on a fission bomb and what that meant, Bigeleisen emphasized.

When Japan surrendered, the Leonia crowd moved en masse to Chicago, the center of postwar scientific excitement. Her old Göttingen and Baltimore friend, James Franck, was already there.

And when the University of Chicago formed an interdisciplinary institute to explore the nucleus, Fermi, Urey, Teller, Libby, and the Mayers joined the fun. Brilliant graduate students like future Nobel Prize winners T. D. Lee and C. N. Yang (chapter 11) flocked to the Windy City to study with Fermi.

In a new variation of the old volunteer theme, Maria became a "voluntary associate professor"—still unpaid. Later, she was promoted to "voluntary professor"— also unpaid. The Depression was over, but nepotism rules lived on. This time, Mayer did not care. Chicago was "the place to be," and Mayer was a major player in the "in" crowd. Chicago was the first place where she was not considered a nuisance, but was greeted with open arms, she said. Chicago was Göttingen revived.

Joe chaired Chicago's famous weekly meeting at the Institute for Nuclear Studies (now the Fermi Institute). Although he was a chemist, physicists respected him so much that they later elected him president of the American Physical Society. His only seminar rule was "Don't interrupt while someone else is interrupting." Attending the meetings was "like sitting in on a conversation of the angels," according to a participant.

Maria ran a physics-theory seminar as freewheeling as Joe's physics-chemistry session. She served on committees, helped hire faculty, advised graduate students, and helped set the tone for Chicago's notoriously difficult graduate examinations in physics.

"We are interested only in the future Heisenbergs!" she announced loftily. The first year, four future Nobel Prize winners and thirteen future members of the National Academy of Sciences took the exam.

#### One flunked.

"One of my favorite teachers at Chicago was Maria Mayer," reported Sam Treiman, a future Princeton University physics professor. "Professor Mayer taught solid, no-nonsense courses. She would have disdained even the hint of show biz. It happens, however, that she was a dedicated cigarette smoker, and in those days, it was quite acceptable for the professor to smoke in class. She often did. She would light up and lecture with a cigarette in one hand, a piece of chalk in the other. She puffed on the one and wrote on the black-board with the other. They interchanged places in her hands frequently and in a seemingly random manner. Often, in the excitement of some physics development about to reach a watershed, she would come very, very close to writing with the cigarette or puffing on the chalk."

One morning Urey asked her for a calculation. It was based on a theory that she and Bigeleisen had developed. Urey wanted the answer in time for a four P.M. speech. "I suspected that he presented this as a challenge to Maria Mayer and me to see whether our method was as powerful as we claimed it to be," Bigeleisen recalled.

Dividing up the work, they gave Urey his figures at two o'clock. By four P.M., the absent-minded Urey had already forgotten who had prepared the calculation; in his talk, he recommended attending Joe Mayer's class to get more information. Maria was so irritated that she called in a loud stage whisper from the back of the room, "What's wrong with my course?" She was competing even with Joe.

In the meantime, Bob Sachs, her former Hopkins student, had become head of the theory division of the new Argonne National Laboratory outside Chicago. He later became director of the entire laboratory. Sachs asked Maria, "Wouldn't you like to earn some money?"

"That would be nice," she admitted.

"Why don't we arrange a half-time appointment for you at Argonne as a senior physicist?" Sachs suggested.

"But I don't know anything about nuclear physics [the major project at Argonne at the time]."

"You'll learn," promised Sachs.

So the student became the boss, Mayer entered a third field, and the federal government supported her financially while she worked on her Nobel-winning project. This time, though, it was her choice.

She could have worked full time at Argonne, but she did not want to miss the excitement at Chicago.

She did not complain. "I had everything else I wanted—the biggest office, faculty status, and the Argonne National Laboratory paid me a nice consulting salary," Mayer said. "Most of our faculty friends were fighting for me." Her cardinal rule was, "You don't rush your friends." Like a politician, she realized she could not move too far ahead of public opinion.

Mayer liked Chicago life outside the university too. She and Joe bought an old three-story brick mansion in Kenwood, on the South Side of Chicago, at 4923 Greenwood Avenue. After Chicago's rich abandoned the area, faculty families had moved in. The house had high ceilings, six fireplaces, and space for big vegetable and flower gardens. In a third-floor glass porch, Maria raised cymbidium orchids, and when Marianne was married, Maria coaxed them into bloom all at once: twenty plants with two thousand flowers.

With James Franck living nearby, Chicago's social life felt like old times in Göttingen. The Mayers' annual New Year's Eve party for a hundred or more senior scientists featured a twelve-foot-tall Christmas tree decorated Göttingen-style with tinsel and real candles. With orchids in every room and liquor flowing, there was a buffet supper downstairs, singing in the second-floor library, and dancing in the third-floor billiard room. The climax of the Mayers' social extravaganzas was an international conference held at the University of Chicago in 1951; Maria gave cocktail parties on four successive nights with laboratory beakers for glasses. At the parties, Maria was animated and happy, the center of a crowd of scientists.

For a short time after the war, she was active in national politics, too. She, Urey, and Joe ardently supported the development of Teller's H-bomb in the early 1950s. In a postwar speech, she said that, without international control of nuclear energy, the United States should reduce its vulnerability to Soviet nuclear attack by building cities in long strips. On the other hand, she supported civilian control of nuclear energy and joined other scientists who lobbied in Washington against Pentagon control. Later, she and Urey changed their minds about the hydrogen bomb. During the 1960s, she opposed the Vietnam War and mediated painful arguments between Joe, who was a hawk, and her son, Peter, who was a dove.

Chicago was the scene of Maria Mayer's greatest scientific triumph, too. Wartime research had produced a wealth of data about isotopes, atoms of the same element that have differing numbers of neutrons. Why some isotopes are more abundant than others became a lively issue among scientists. Unstable nuclei tend to decay radioactively into other more stable elements; they change gradually from one element to another until they reach a stable form. Once they are stable, they do not change any more, so their numbers accumulate. Thus, the more stable the isotope, the more abundant it is in the universe. But why? Teller suggested that they find the answer.

Teller soon lost interest, but Maria Mayer was fascinated by a series of odd clues.

• Why, for example, does an isotope with 126 neutrons hold onto its neutrons more strongly than an isotope with 127 or 128 neutrons?

• A few elements are much more abundant than contemporary theories could explain. All have nuclei with either 50 or 82 neutrons. Maria Mayer thought that "the excess stability must have played a part in the process of the creation of elements." But how?

And so it went, puzzle after puzzle, until she had uncovered a series of what she called "magic numbers" —2, 8, 20, 28, 50, 82, and 126. Nuclei with these numbers of protons or these numbers of neutrons are unusually stable. But why?

She began collecting data to support a nuclear shell theory. Such a theory had been considered during the 1930s and then set aside during the 1940s as Niels Bohr's liquid drop model of the atom solved one problem after
another. As an outsider to the postwar nuclear physics scene, however, Maria Mayer was not wedded to Bohr's model and was looking at the problem afresh.

Particles inside the nucleus orbit in shells, she suggested, "like the delicate shells of an onion with nothing in the center." After that comment, her old friend Wolfgang Pauli called her "The Madonna of the Onion." She looked at esoteric figures for energy levels, spins, angular momentum, potential wells, binding energies, radioactive-decay energies, isotopic abundances, and the like. If a vital fact was missing, she asked Argonne experimentalists to develop the information. No mere problem-solver, she dug deeply into the fundamental processes of nature. "How the protons themselves are held together, how they interact with one another and with the uncharged neutrons also present in the nucleus—these are the great mysteries of nuclear physics," she realized.

She marshaled her evidence—without any theoretical explanation of its meaning—in a 1948 paper. She had "much better statistics of nuclei than were done ever before," according to Hans Bethe, dean of nuclear physicists. "The shells were established beyond doubt, but there was no theory."

One day she and Fermi were chewing over the problem in her office, where they met because Fermi did not like smokers in his room. As Fermi left to take a long-distance telephone call, he flung back a question, "Incidentally, is there any evidence of spin-orbit coupling?"

"When he said it," Maria recalled, "it all fell into place. In ten minutes, I knew." She experienced an almost physical reaction, an awesome process, as pieces fell together for her. She had the entire problem with its thousands of details worked out by the time he returned.

She floated home, excited, high, exalted. "I finished my computations that night. Fermi taught it to his class the next week."

"It was kind of a jigsaw puzzle," Maria Mayer said later, recreating the moment. "One had many of the pieces (not only the magic numbers), so that one saw a picture emerging. One felt that if one had only just one more piece, everything would fit. The piece was found, and everything cleared up.... Only if one had lived with the data as long as I, could one immediately answer: 'Yes, of course, and that will explain everything.'... In ten minutes, the magic numbers were explained." Winning the Nobel Prize would not be nearly as exhilarating as doing the work.

Her solution was totally unexpected. Spin-orbit coupling had never seemed important before. It has practically no effect on the atom's electrons, for example. Yet Maria Mayer had discovered that, inside the nucleus, it has a crucial effect.

To explain the theory to Marianne, she pictured a roomful of couples waltzing in circles, each circle enclosed inside another like the shells inside the nucleus. As the couples orbit the room, they also spin like tops, some clockwise and some counterclockwise. And as Maria pointed out triumphantly, anyone who has danced a fast waltz knows that it is easier to spin in one direction than in the other direction. Thus, the couples spinning in the easier direction will need slightly less energy than the couples spinning in the more difficult direction. And that tiny energy difference was enough to explain the magic numbers.

Maria procrastinated about writing an article, just as she had her thesis. Two other physicists had produced a theory, and she decided to wait until their work was published. Joe was exasperated with her and told her she was carrying good sportsmanship too far.

She finally submitted her paper in December 1949. By that time three Germans—Hans Jensen, Hans E. Suess, and Otto Haxel—had submitted their own paper outlining the same theory. Cut off from mainstream physics

during World War II, they had not spent years working with Bohr's liquid drop model either. It was clear that they had conceived the same idea at the same time as Maria Mayer.

When she read their paper, she was "at first dismayed...for about five minutes." Then she realized that their work actually confirmed her theory. Together, they could convince more people faster.

As Weisskopf said, "You know, now I believe it, now that Jensen has done it, too." And Jensen wrote her, "You have convinced Fermi, and I have convinced Heisenberg. What more do we want?"

For a theory that ran counter to decades of nuclear physics, the nuclear shell model was adopted remarkably quickly. The model has been so successful that physicists today find it difficult to imagine studying nuclear behavior without it. "The nuclear shell model is the central idea of nuclear structure.... The shell model lurks somewhere in every paper on nuclear structure," noted the nuclear theorist Elizabeth Urey Baranger of the University of Pittsburgh.

Instead of competing with Jensen for priority over the theory, Mayer captivated him. He became the last in a long string of men charmed by Maria Goeppert Mayer. He called the shell model "your model," and she called it "your model." She said Jensen was "a dear, gentle man; we look at things in the same way, even our eyeglass prescriptions are identical." Jensen thought her "unbelievably modest."

They wrote a book together about the shell model. Actually, Mayer wrote most of it. In a letter, Jensen confessed to her that she had written 80 percent of the book—more than 95 percent of the important parts— and that he should not be listed as her coauthor.

He complained that "I'm deeply ashamed that you've written so many chapters." He said he felt like "a parasite." Although Mayer did not drop his name from the book, she did list her name first.

The book established both their reputations as the primary originators of the shell model theory, overshadowing Jensen's original collaborators, Haxel and Suess.

During the book-writing period, Jensen's letters mixed physics with affectionate remarks like "Precious Maria," "Always your little Hans," "Yours constantly," "Yours sincerely, The Scamp, the Spoiled Boy...". He confided, "This isn't much of a love letter—but physics is so very much less complicated." And when the book was finally finished, he was happy at being able to write "only love letters."

Once the book was complete, however, his infatuation cooled. Months went by between letters; he planned trips to the United States without knowing that Maria would be in Europe at the same time, and he started letters and finished them months later. He still depended on her for writing, however. Years later, when Jensen learned that Maria Mayer had had a stroke, he wrote to wish her a speedy recovery and to ask if she would write an article for a German journal: "maximum two typed pages, but the longer the better."

He agreed to contribute a chapter to an anthology and then asked her to write it with him.

Maria Mayer was elected to the National Academy of Sciences in 1956, the same year that she suddenly lost the hearing in her left ear. By then, Fermi had died of cancer, the top graduate students had stopped coming to Chicago to work with him, and Teller and Libby had left. Urey moved soon after to a new University of California branch at La Jolla and, as always, invited the Mayers.

California offered Maria a full professorship—with pay. Overnight, Chicago's administrators discovered that they, too, could offer her a real professorship. She was mildly amused by Chicago's offer and delighted with California's. The Mayers moved in 1960. At age fifty-three, ten years after her revolutionary discovery, she finally had a regular, full-time, paid university job. She had fulfilled her father's dream: she was the seventh generation of professors in her family, and her son would be the eighth. It was too late.

Shortly after moving to California, while unpacking her books, Mayer suffered a devastating stroke. It paralyzed her left arm and blurred her speech. Although she tried to continue working, her health was never good again. Joe told her and all their friends that she suffered from a rare virus disease affecting her nerve endings; grave illnesses were less readily publicized then than today. Maria guessed she had had "a small stroke." She continued to smoke, though, and Marianne and her brother thought she drank more to numb the pain. Certainly, Marianne said, her health problems made her drinking more evident.

At four A.M. the morning of November 5, 1963, a Swedish newsman telephoned their home. Joe answered, handed her the phone, and then raced to ice some champagne. Mayer and Jensen had won half the Nobel Prize, and Eugene Wigner, an old Göttingen friend who had moved to Princeton University, had won the other half. The local paper headlined the news, "La Jolla Mother Wins Nobel Prize." The Mayers celebrated at dawn with bacon, eggs, and champagne.

Once in Stockholm, Mayer relaxed and scrutinized the Swedish palace like a professional hostess. She gave it high marks: "So warm and alive, with roaring fires in every hearth, great Oriental rugs, and white lilacs in all the vases." She was the only living woman in the world with a Nobel Prize in science, and she and Marie Curie were the only women to have won a Nobel in physics. Sitting on a flower-banked dais before the king, she thought of all the people who had stood there before her, names she had heard as a child and friends from the past. Catching her eye, Joe realized that he had burst into tears that were streaming down his cheeks. Without Joe, she said, she would never have gotten to Stockholm.

In photographs, she looks small and frail, stepping gingerly down to King Gustav VI Adolf. Her arms are too weak to hold the gold medal or the heavily bound diploma, so a Swedish aide hovers nearby to carry them for her. After the ceremony, the king gave Mayer his arm and, as they swept through the reception room on their way to dinner, onlookers sank to their knees. "It was a fairy tale," she said.

Maria Mayer's last years were limited by her health. She had fulfilled her father's dream, and the Nobel Prize had made her a symbol of Superwoman: the brilliant professional with a happy marriage and successful children. She tried to continue working. As she said, "If you love science, all you really want is to keep on working. The Nobel Prize thrills you, but it changes nothing." As her health deteriorated, she acquired a pacemaker and published less. She died of a pulmonary embolism on February 20, 1972.

Joe gave her papers to the University of California at San Diego. They include personal letters and scientific notes; her daughter's report card from nursery school and travel plans to conferences; hand-copied notebooks of German poems and party menus—all mixed together in one woman's life.

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# NATIONAL ACADEMY OF SCIENCES

# MARIA GOEPPERT MAYER

# 1906—1972

A Biographical Memoir by ROBERT G. SACHS

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Biographical Memoir

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Man Goupper Mayer

# MARIA GOEPPERT MAYER

June 28, 1906–February 20, 1972

# BY ROBERT G. SACHS

W HEN IN 1963 she received the Nobel Prize in Physics, Maria Goeppert Mayer was the second woman in history to win that prize—the first being Marie Curie, who had received it sixty years earlier—and she was the third woman in history to receive the Nobel Prize in a science category. This accomplishment had its beginnings in her early exposure to an intense atmosphere of science, both at home and in the surrounding university community, a community providing her with the opportunity to follow her inclinations and to develop her remarkable talents under the guidance of the great teachers and scholars of mathematics and physics. Throughout her full and gracious life, her science continued to be the theme about which her activities were centered, and it culminated in her major contribution to the understanding of the structure of the atomic nucleus, the spin-orbit coupling shell model of nuclei.

Maria Goeppert was born on June 28, 1906, in Kattowiz, Upper Silesia (then in Germany), the only child of Friedrich Goeppert and his wife, Maria née Wolff. In 1910 the family moved to Göttingen, where Friedrich Goeppert became Professor of Pediatrics. Maria spent most of her life there until marriage.

On January 19, 1930, she married Joseph E. Mayer, a chemist (elected to the National Academy of Sciences in 1946),

and they had two children: Maria Ann, now Maria Mayer Wentzel, and Peter Conrad. Maria Goeppert Mayer became a citizen of the United States in 1933. She died on February 20, 1972.

Both her father's academic status and his location (Göttingen) had a profound influence on her life and career. She was especially proud of being the seventh straight generation of university professors on her father's side. Her father's personal influence on her was great. She is quoted as having said that her father was more interesting than her mother, "He was after all a scientist." \* She was said to have been told by her father that she should not grow up to be a woman, meaning a housewife, and therefore decided, "I wasn't going to be *just* a woman." †

The move to Göttingen came to dominate the whole structure of her education, as might be expected. Georgia Augusta University, better known simply as "Göttingen," was at the height of its prestige, especially in the fields of mathematics and physics during the period when she was growing up. She was surrounded by the great names of mathematics and physics. David Hilbert was an immediate neighbor and friend of the family. Max Born came to Göttingen in 1921 and James Franck followed soon after; both were close friends of the Goeppert family. Richard Courant, Hermann Weyl, Gustav Herglotz, and Edmund Landau were professors of mathematics.

The presence of these giants of mathematics and physics naturally attracted the most promising young scholars to the institution. Through the years, Maria Goeppert came to meet and know Arthur Holly Compton, Max Delbrueck, Paul A. M. Dirac, Enrico Fermi, Werner Heisenberg, John von Neumann, J. Robert Oppenheimer, Wolfgang Pauli, Linus Pauling, Leo Szilard, Edward Teller, and Victor Weisskopf. It was the oppor-

<sup>\*</sup> Joan Dash, A Life of One's Own (New York: Harper and Row, 1973), p. 231. † Ibid.

tunity to work with James Franck that led to Joseph Mayer's coming to Göttingen and gave him the chance to meet and marry her.

Maria Goeppert was attracted to mathematics very early and planned to prepare for the University, but there was no public institution in Göttingen serving to prepare girls for this purpose. Therefore, in 1921 she left the public elementary school to enter the Frauenstudium, a small private school run by sufragettes to prepare those few girls who wanted to seek admission to the University for the required examination. The school closed its doors before the full three-year program was completed, but she decided to take the University entrance examination promptly in spite of her truncated formal preparation. She passed the examination and was admitted to the University in the spring of 1924 as a student of mathematics. Except for one term spent at Cambridge University, England, her entire career as a university student was completed at Göttingen.

In 1924 she was invited by Max Born to join his physics seminar, with the result that her interests started to shift from mathematics to physics. It was just at this time that the great developments in quantum mechanics were taking place, with Göttingen as one of the principal centers; in fact, Göttingen might have been described as a "cauldron of quantum mechanics" at that time; and in that environment Maria Goeppert was molded as a physicist.

As a student of Max Born, a theoretical physicist with a strong foundation in mathematics, she was well trained in the mathematical concepts required to understand quantum mechanics. This and her mathematics education gave her early style of research a strong mathematical flavor. Yet the influence of James Franck's nonmathematical approach to physics certainly became apparent later. In fact, a reading of her thesis reveals that Franck already had an influence at that stage of her work.

She completed her thesis and received her doctorate in 1930.

#### **BIOGRAPHICAL MEMOIRS**

The thesis was devoted to the theoretical treatment of double photon processes. It was described many years later by Eugene Wigner as a "masterpiece of clarity and concreteness." Although at the time it was written the possibility of comparing its theoretical results with those of an experiment seemed remote, if not impossible, double photon phenomena became a matter of considerable experimental interest many years later, both in nuclear physics and in astrophysics. Now, as the result of the development of lasers and nonlinear optics, these phenomena are of even greater experimental interest.

After receiving her degree, she married and moved to Baltimore, Maryland, where her husband, Joseph Mayer, took up an appointment in the Chemistry Department of Johns Hopkins University. Opportunities for her to obtain a normal professional appointment at that time, which was at the height of the Depression, were extremely limited. Nepotism rules were particularly stringent then and prevented her from being considered for a regular appointment at Hopkins; nevertheless, members of the Physics Department were able to arrange for a very modest assistantship, which gave her access to the University facilities, provided her with a place to work in the Physics Building, and encouraged her to participate in the scientific activities of the University. In the later years of this appointment, she also had the opportunity to present some lecture courses for graduate students.

At the time, the attitude in the Physics Department toward theoretical physics gave it little weight as compared to experimental research; however, the department included one outstanding theorist, Karl Herzfeld, who carried the burden of teaching all of the theoretical graduate courses. Herzfeld was an expert in classical theory, especially kinetic theory and thermodynamics, and he had a particular interest in what has come to be known as chemical physics. This was also Joseph Mayer's primary field of interest, and under his and Herzfeld's guidance and influence Maria Mayer became actively involved in this field, thereby deepening and broadening her knowledge of physics.

However, she did not limit herself to this one field but took advantage of the various talents existing in the Johns Hopkins department, even going so far as to spend a brief period working with R. W. Wood, the dean of the Johns Hopkins experimentalists. Another member of the department with whom she had a substantial common interest was Gerhard Dieke. The Mathematics Department, which was quite active at that time, included Francis Murnaghan and Aurel Wintner, with whom she developed particularly close connections. However, the two members of the Johns Hopkins faculty who had the greatest influence were her husband and Herzfeld. Not only did she write a number of papers with Herzfeld in her early years there, but also they became close, lifelong friends.

The rapid development of quantum mechanics was having a profound effect in the field of chemical physics in which she had become involved, and the resulting richness and breadth of theoretical chemical physics was so great as to appear to have no bounds. She was in a particularly good position to take advantage of this situation, since no one at Johns Hopkins had a background in quantum mechanics comparable to hers. In particular, she became involved in pioneering work on the structure of organic compounds with a student of Herzfeld's, Alfred Sklar; and in that work she applied her special mathematical background, using the methods of group theory and matrix mechanics.

During the early years in Baltimore, she spent the summers of 1931, 1932, and 1933 back in Göttingen, where she worked with her former teacher, Max Born. In the first of those summers she completed with him their article in the *Handbuch der Physik*, "Dynamische Gittertheorie der Kristalle." In 1935 she published her important paper on double beta-decay, representing a direct application of techniques she had used for her thesis, but in an entirely different context. Later, James Franck joined the faculty at Johns Hopkins and renewed his close personal relationship with the Mayers. Also in that later period, Edward Teller became a member of the faculty of George Washington University, in nearby Washington, D.C., and she looked to him for guidance in the developing frontiers of theoretical physics. At about the same time, she became deeply involved in a collaboration with Joseph Mayer in writing the book *Statistical Mechanics*, published in 1940.

When as her first bona fide student I turned to her for guidance in choosing a research problem, nuclear physics was on the rise; and she told me that that was the only field worth consideration by a beginning theorist. She took me to Teller to ask his advice about possible research problems. Our resulting joint work was her first publication in the field of nuclear physics. My thesis problem on nuclear magnetic moments was also selected with Teller's help, and she gave her guidance throughout that work, suggesting application to this problem in nuclear physics of techniques of quantum mechanics in which she was so proficient. These two forays into the field were her only activities in the physics of nuclear structure until after World War II.

Her approach to quantum mechanics, having been so greatly influenced by Born, gave preference to matrix mechanics over Schroedinger wave mechanics. She was very quick with matrix manipulations and the use of symmetry arguments to obtain answers to a specific problem, and this ability stood her in good stead in her later work on nuclear shell structure, which led to her Nobel Prize. She appeared to think of physical theories, in general, and quantum mechanics, in particular, as tools for solving physics problems and was not much concerned with the philosophical aspects or the structure of the theory.

When she had the opportunity to teach graduate courses, her lectures were well organized, very technical, and highly con-

densed. She spent little time on background matters or physical interpretation. Her facility with the methods of theoretical physics was overwhelming to most of the graduate students, in whom she inspired a considerable amount of awe. At the same time, the students took a rather romantic view of this young scientific couple, known as "Joe and Maria," and felt that it was a great loss when they left Johns Hopkins to go to Columbia University in 1939.

At Columbia University, where Joseph Mayer had been appointed to an associate professorship in chemistry, Maria Mayer's position at first was even more tenuous than at Johns Hopkins. The chairman of the Physics Department, George Pegram, arranged for an office for her, but she had no appointment.

This was the beginning of a close relationship between the Mayers and the Harold Ureys, a relationship which was to continue throughout her life, as they always seemed to turn up in the same places in later years. Willard Libby became a good friend, and it was at Columbia that she first began to come under the influence of Enrico Fermi, although she had already met him in her first summer in the United States (1930) at the University of Michigan Special Summer Session in Physics. The Mayers also saw much of I. I. Rabi and Jerrold Zacharias during their years at Columbia.

She quickly put to work her talent for problem solving when Fermi suggested that she attempt to predict the valence-shell structure of the yet-to-be-discovered transuranium elements. By making use of the very simple Fermi-Thomas model of the electronic structure of the atom, she came to the conclusion that these elements would form a new chemical rare-earth series. In spite of the oversimplifications of the particular model, this subsequently turned out to be a remarkably accurate prediction of their qualitative chemical behavior.

In December 1941, she was offered her first real position: a

half-time job teaching science at Sarah Lawrence College, and she organized and presented a unified science course, which was developed as she went along during that first presentation. She continued, on an occasional basis, to teach part time at Sarah Lawrence throughout the war.

She was offered a second job opportunity in the spring of 1942 by Harold Urey, who was building up a research group devoted to separating U 235 from natural uranium as part of the work toward the atomic bomb. This ultimately became known as Columbia University's Substitute Alloy Materials (SAM) Project. She accepted this second half-time job, which gave her an opportunity to use her knowledge of chemical physics. Her work included research on the thermodynamic properties of uranium hexafluoride and on the theory of separating isotopes by photochemical reactions, a process that, however, did not develop into a practical possibility at that time. (The much later invention of the laser has reopened that possibility.)

Edward Teller arranged for her to participate in a program at Columbia referred to as the Opacity Project, which concerned the properties of matter and radiation at extremely high temperatures and had a bearing on the development of the thermonuclear weapon. Later, in the spring of 1945, she was invited to spend some months at Los Alamos, where she had the opportunity to work closely with Teller, whom she considered to be one of the world's most stimulating collaborators.

In February of 1946, the Mayers moved to Chicago where Joe had been appointed Professor in both the Chemistry Department and the newly formed Institute for Nuclear Studies of The University of Chicago. At the time, the University's nepotism rules did not permit the hiring of both husband and wife in faculty positions, but Maria became a voluntary Associate Professor of Physics in the Institute, a position which gave her the opportunity to participate fully in activities at the University.

Teller had also accepted an appointment at The University of Chicago, and he moved the Opacity Project there, giving Maria Mayer the opportunity to continue with this work. It was accommodated in the postwar residuum of the Metallurgical Laboratory of the University where, in its heyday during the war, the initial work on the nuclear chain reaction had been carried out. She was hired as a consultant to the Metallurgical Laboratory so that she could continue her participation in this project, and several students from Columbia who had become graduate students at Chicago worked under her guidance.

The Metallurgical Laboratory went out of existence to make way for establishing Argonne National Laboratory on July 1, 1946, under the aegis of the newly formed Atomic Energy Commission. She was offered and was pleased to accept a regular appointment as Senior Physicist (half time) in the Theoretical Physics Division of the newly formed laboratory. The main interest at Argonne was nuclear physics, a field in which she had had little experience, and so she gladly accepted the opportunity to learn what she could about the subject. She continued to hold this part-time appointment throughout her years in Chicago, while maintaining her voluntary appointment at the University. The Argonne appointment was the source of financial support for her work during this very productive period of her life, a period in which she made her major contribution to the field of nuclear physics, the nuclear shell model, which earned her the Nobel Prize.

Since the mission of Argonne National Laboratory at the time was, in addition to research in basic science, the development of peaceful uses of nuclear power, she also became involved in applied work there. She was the first person to undertake the solution by electronic computer of the criticality problem for a liquid metal breeder reactor. She programmed this calculation (using the Monte Carlo method) for ENIAC, the first electronic computer, which was located at the Ballistic Research Laboratory, Aberdeen Proving Ground. A summary of this work was published in 1951 (U.S. Department of Commerce, Applied Mathematics, Series 12:19–20).

While carrying on her work at Argonne, she continued her voluntary role at The University of Chicago by lecturing to classes, serving on committees, directing thesis students, and participating in the activities at the Institute for Nuclear Studies (now known as the Enrico Fermi Institute). The University had pulled together in this Institute a stellar assembly of physicists and chemists, including Fermi, Urey, and Libby, as well as Teller and the Mayers. Gregor Wentzel joined the faculties of the Physics Department and Institute later, and the families quickly became very close, one outcome being the joining of the families by marriage of Maria Ann to the Wentzels' son.

Subrahmanyan Chandrasekhar, who had been on the faculty of the Astronomy Department for many years, also joined the Institute. A stream of young and very bright physical scientists poured into the Institute, and the atmosphere was stimulating to the extreme. To add to this exciting atmosphere, which in some ways must have been reminiscent of Göttingen in the early days, her former teacher and friend, James Franck, was already a member of the University's Chemistry Department.

The activities in the Institute reflected the interests of the leading lights, interests that were very broad indeed, ranging from nuclear physics and chemistry to astrophysics and from cosmology to geophysics. The interdisciplinary character of the Institute was well suited to the breadth of her own activities over the past, so that her Chicago years were the culmination of her variety of scientific experience. In keeping with this, she turned her attention at first to completing and publishing some earlier work in chemical physics, including work with Jacob

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Bigeleisen on isotopic exchange reactions. Bigeleisen had collaborated with her in other work at Columbia University and at this time was a fellow of the Institute. At the same time, she began to give attention to nuclear physics.

Among the many subjects being discussed at the Institute was the question of the origin of the chemical elements. Teller was particularly interested in this subject and induced Maria Mayer to work with him on a cosmological model of the origin of the elements. In pursuit of data required to test any such model, she became involved in analyzing the abundance of the elements and noticed that there were certain regularities associating the highly abundant elements with specific numbers of neutrons or protons in their nuclei. She soon learned that Walter M. Elsasser had made similar observations in 1933, but she had much more information available to her and found not only that the evidence was stronger but also that there were additional examples of the effect. These specific numbers ultimately came to be referred to as "magic numbers," a term apparently invented by Eugene Wigner.

When she looked into information other than the abundance of the elements, such as their binding energies, spins, and magnetic moments, she found more and more evidence that these magic numbers were in some way very special and came to the conclusion that they were of great significance for the understanding of nuclear structure. They suggested the notion of stable "shells" in nuclei similar to the stable electron shells associated with atomic structure, but the prevailing wisdom of the time was that a shell structure in nuclei was most unlikely because of the short range of nuclear forces as compared to the long-range coulomb forces holding electrons in atoms. There was the further difficulty that the magic numbers did not fit simple-minded ideas associated with the quantum mechanics of shell structure.

Maria Mayer persisted in checking further evidence for shell

structure, such as nuclear beta-decay properties and quadrupole moments, and in trying to find an explanation in terms of the quantum mechanics of the nuclear particles. In this she was greatly encouraged by Fermi and had many discussions with him. She was also strongly supported by her husband, who acted as a continual sounding board for her thoughts on the subject and provided the kind of guidance that could be expected from a chemist who, in many ways, was better equipped to deal with phenomena of this kind than a physicist. The systematics of regularities in behavior with which she was faced had great similarity to the systematics in chemical behavior that had led to the classical development of valence theory in chemistry, and whose fundamental explanation had been found in the Pauli Exclusion Principle.

It was Fermi who asked her the key question, "Is there any indication of spin-orbit coupling?" whereupon she immediately realized that that was the answer she was looking for, and thus was born the spin-orbit coupling shell model of nuclei.

Her ability to immediately recognize spin-orbit coupling as the source of the correct numerology was a direct consequence of her mathematical understanding of quantum mechanics and especially of her great facility with the numerics of the representations of the rotation group. This ability to instantly identify the key numerical relationships was most impressive, and even Fermi was surprised at how quickly she realized that his question was the key to the problem.\*

While she was preparing the spin-orbit coupling model for

<sup>\*</sup> Joseph Mayer gives the following description of this episode: "Fermi and Maria were talking in her office when Enrico was called out of the office to answer the telephone on a long distance call. At the door he turned and asked his question about spin-orbit coupling. He returned less than ten minutes later and Maria started to 'snow' him with the detailed explanation. You may remember that Maria, when excited, had a rapid fire oral delivery, whereas Enrico always wanted a slow detailed and methodical explanation. Enrico smiled and left: 'Tomorrow, when you are less excited, you can explain it to me.'"

publication she learned of a paper by other physicists presenting a different attempt at an explanation and, as a courtesy, she asked the Editor of the *Physical Review* to hold her brief Letter to the Editor in order that it appear in the same issue as that paper. As a result of this delay, her work appeared one issue following publication of an almost identical interpretation of the magic numbers by Otto Haxel, J. Hans D. Jensen, and Hans E. Suess. Jensen, working completely independently in Heidelberg, had almost simultaneously realized the importance of spin-orbit coupling for explaining the shell structure, and the result had been this joint paper.

Maria Mayer and Jensen were not acquainted with one another at the time, and they did not meet until her visit to Germany in 1950. In 1951 on a second visit, she and Jensen had the opportunity to start a collaboration on further interpretation of the spin-orbit coupling shell model, and this was the beginning of a close friendship as well as a very productive scientific effort. It culminated in the publication of their book, *Elementary Theory of Nuclear Shell Structure* (1955). They shared the Nobel Prize in 1963 for their contributions to this subject.

After Fermi's death in 1954, other members of the Institute for Nuclear Studies who had provided so much stimulation for her left Chicago. Teller had gone earlier in 1952, Libby left in 1954, and Urey in 1958. In 1960 she accepted a regular appointment as Professor of Physics at the University of California at San Diego when both she and her husband had the opportunity to go there.

Her appointment as a full professor in her own right at a major university was very gratifying to her, and she looked forward to the stimulation of this newest interdisciplinary group of scientists that was being drawn together there. However, shortly after arriving in San Diego, she had a stroke, and her years there were marked by continuing problems with her health. Nevertheless, she continued to teach and to participate actively in the development and exposition of the shell model. Her last publication, a review of the shell model written in collaboration with Jensen, appeared in 1966; and she continued to give as much attention to physics as she could until her death in early 1972.

In addition to being elected to the National Academy of Sciences in 1956 and receiving the Nobel Prize in 1963, Maria Goeppert Mayer's honors included being elected a Corresponding Member of the Akademieder Wissenschaften in Heidelberg and receiving honorary degrees of Doctor of Science from Russell Sage College, Mount Holyoke College, and Smith College.

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