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Stevens Point, Wisconsin

THE SIGMA ZETAN

Official organ of Sigma Zeta, a National Honorary Science Society

National Officers

National President .... W. H. Eller, Kappa Chapter
National Vice-president .... D. E. Miller, Xi Chapter
National Recorder-Treasurer .... G. W. Faust, Zeta Chapter
National Editor .... A. S. Lyness, Zeta Chapter
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FENCES VS FREEDOM

An Editorial

About a year ago, a song that was popular over the radio and elsewhere was "Don't Fence Me In". In this cowboy song the sentiment expressed was one of sincere affection for the great open spaces and a contempt for fences that would curtail the freedom of riding the ranges.

There are many other instances in life where limitations, that are comparable to fences, operate to diminish or destroy freedom. In preparation for a vocation in the sciences, whether it be to teach science, or to hold a position as an industrial scientist, the tendency in this country at present is to become an extreme specialist, devoting no time or effort whatever to the acquisition of what might be regarded as a general education. This is not an argument for courses in General Science or General Mathematics but is a plea for college and university curricula which will insure against the possiility of a student being graduated with a major in Education, Law, or Medicine without considerable study of English and Mathematics, or with a degree in English or History or Political Economy without taking any of the sciences. A too specialized curriculum fences the student in.

Our national leaders who wanted the Atlantic Charter to give to us the Four Freedoms might have increased the list to more than four although others are implied as being incident to the preservation of our democratic way of life. We want independence from fences that hedge us about so that we do not have absolute freedom of speech, press, radio, suffrage, conscience, thinking, worship, cooperative bargaining, education, love, marriage, and the list can be prolonged indefinitely, being longer for some persons than for others.

In our conversations with returning service men we have been impressed with their changed attitudes. It is logical to suppose that the extensive travelling most of them have done and the enervating experiences through which most of them have passed would make them restless and discontented with any ordinary life situations but the opposite sentiment seems to predominate most of their thinking. Many may have changed their vocational plans but they want to settle down and, if possible, to take advantage of the opportunities for advancing their education under the G. I. Bill of Rights. They want to be sure that the courses taken in higher institutions will give adequate preparation for contemplated future life work, so they will not be fenced in and delimited by education that cannot later be utilized to advantage.

However there is another angle to this problem that must not be neglected. Any idea carried out to its fullest possible state of realization usually does not produce a wholesome reaction. If there were no curricula with many requirements and a more or less generous array of electives in our educational institutions there would be grave danger of too many classes, many of which would be too small to justify their existence.

There must be some regimentation in a democracy, and the public school system being a significant portion of such a form of government, must come in for its share. Both fences and freedom are apparently necessary. The ideal situation for which we should strive is freedom within the boundaries defined by the fences. Such a doctrine, if rendered operative, should guarantee to every individual a chance to discover what particular talents he possesses and permit him to develop them to the point where he can engage successfully in work that he enjoys, perform his share of the world's work, and come to the end of a successful career with the satisfaction of knowing that the world is a better place because he has lived and labored in it.

NEWS FROM THE CHAPTERS

BETA

McKendree College,
Lebanon, Illinois
November 28, 1945

Dear Editor:

The Beta chapter opened the first semester of 1945-46 with only faculty members. All active student members of last year have graduated. The active faculty members are Dr. H. P. K. Agersborg, Professor H. C. Gutekunst, and the writer. Dr. E. R. Spencer and Professor S. M. McClure, former members of the McKendree faculty, are residents of Lebanon and have retained their membership in the Beta chapter. There are no student candidates for initiation this semester. It is possible that next semester there may be one or more among returning service men. Pending the building up again of student membership there has been no election for president, but the undersigned is carrying on the correspondence.

Sincerely yours,
C. J. Stowell,
Recorder-Treasurer,
Beta Chapter

EPSILON

Miss Esther H. Smoot, Secretary of Epsilon Chapter at Otterbein College, Westerville, Ohio reports six active members at the beginning of this college year as follows: Marian Jeanette Henderson, Jane Sturgis Hulett, Esther Lou Learish, Anna Jean Walters, Elizabeth Lucille Walters, and Janet Nellie Hinkle. There is a noticeable absence of men.

ZETA

Officers for 1945-46
President, Edward Nigbor
Vice President, Betty Furstenberg
Historian, Betty Haberkorn
Recorder-Treasurer,
Arthur S. Lyness

At a regular meeting on October 17th Dr. R. A. Trytten and Miss Rose Barber of the faculty were elected to active membership. Bess Jones was also elected to active membership.

The following were elected to associate membership:

Betty Ruth Crawford
Dolores Jelinek
Elizabeth Maki
Kathryn Peterson
Nelda Dopp
Frances Alice Kuchenriter
Doris Ockerlander
Patricia Thorpe

Dr. Trytten of the Chemistry Department gave an interesting talk on the development and practical uses of atomic energy. (See copy of his paper elsewhere in this issue.) A report of the secretary on the action of the committee appointed to revise the rules for awarding the Sigma Zeta Trophy was given and approved by the chapter. Miss Marie Eisenhammer also gave a report of the committee appointed to amend the Chapter Constitution. The amendment was voted on and adopted at the next meeting of the chapter, Novemer 14th. It provides for the addition of Historian to the list of chapter officers each year and sets forth the duties of this officer.

Arthur S. Lyness
Recorder-Treasurer

KAPPA

Dear Editor,

This is the report for the Kappa Chapter of Sigma Zeta at the Western Illinois State Teachers College, Macomb, Illinois. The officers for this year are:

President, Earlene Kimler
Vice-President, Gaylord Zimmer
Secretary-Treasurer, Virginia Thomas
Historian, Bill Moulton
Editor, Martha Becker

In the October meeting we initiated eleven new members, three of them being faculty members. This brings our membership up to thirty-six.

We have had two very interesting talks, one given by Dr. R. Maurice Myers of the Biology Department on "The Color of Fall Leaves", and the other by Dr. Joseph Kenney of the Geography Department on "Tornadoes". The Agriculture Department has charge of the Christmas program. Since Mr. W. H. Eller is the National President we have had the privilege of using the national gavel at our meetings.

I hope this will be satisfactory.

Sincerely,
Earlene Kimler, President

Editor's Note:—From the report sent in by Virginia Thomas, Chapter Secretary it is interesting to observe the spread of the fifteen faculty members within the departments of the college. The following departments are represented in Sigma Zeta by one or more faculty members: Chemistry, Biology, Mathematics, Home Economics, Geography.

MU

Dear Editor,

Since the number of upper-class students in science is small it is not anticipated here that we shall have any new members to report until possibly some time in the spring.

The members of Sigma Zeta are meeting with the Science Club this year since we have so few members.

Yours truly,
Leonard A. Ford, Faculty Sponsor
State Teachers College
Mankato, Minnesota

NU

November 29, 1945

Dear Editor:

I am enclosing the list of our eleven new members for 1945-46 together with a check for $13.75 to cover their initiation fees.

This year the Nu chapter of Sigma Zeta at the Northern Illinois State Teacher's College has a membership of twenty-two members. Of this number ten were initiated last spring into associate membership. The enrollment here at Northern is steadily increasing and we are confident that this increase will soon be reflected in our chapter membership.

Officers for the Nu chapter who were elected at the close of school last spring are as follows:

President, Harvey Schweitzer, Malta, Ill.
Vice-President, Mary Jane Eaton, DeKalb, Ill.
Secretary, Shirley Carlson, Rockford, Ill.
Treasurer, Eugene De Clark, Chicago, Ill.

As vice-president, Mary Jane Eaton is acting as chairman of our program committee and she and her group have planned some interesting meetings for the year. On October 3 our chapter held its first regular meeting of the school year. Dr. Howard Gould who is our chapter adviser gave a splendid talk on the "Theory of Atomic Energy" which answered many of our questions and at the same time gave us an insight of things yet to come from atomic energy. Then on November 20 the chapter was privileged to hear from Dr. E. W. Telford of DeKalb who had just returned to his practice of medicine after having served with the Army Medical Corp for many months in both the southwest Pacific and European areas. He spoke on the use of drugs, blood and plasma in modern warfare and also gave us his own interesting experience as an army doctor.

During December our chapter of Sigma Zeta will hold its annual Christmas party with the Mathematics Club on the campus. Other events scheduled for the year include a trip to the Chicago Museum of Science and Industry and a chapter picnic near the end of the school year which we plan to hold at one of the nearby state parks.

Of interest to other chapters of Sigma Zeta might be our plans for the first Ira Jenks Memorial Science Lecture to be held here at the college sometime in February. Mr. Ira J. Jenks, who for twenty-three years was a professor of chemistry at Northern and held the close friendship of every chemistry student here, died last February 24 after an illness of about a year. Our chapter last year voted to institute an annual science lecture to be given here on the campus in his memory. Mr. Jenks was born February 16, 1886, at Fenton, Illinois. He received his A.B. degree from Wheaton College and his Masters degree from the University of Chicago in 1921. During the last war, Mr. Jenks was research chemist for the Brunswick-Balke-Collender Company at Muskegon, Michigan. In 1921 he came to DeKalb as professor of chemistry at the college. He was a member and an active supporter of Sigma Zeta.

We will appreciate receiving enough copies of the Sigma Zetan for our members when the December issue comes out. Those of us who have received copies in the past have been very well pleased and desire to have the publication put out as often as possible.

Sincerely yours,
Shirley Carlson,
Secretary, Nu chapter of Sigma Zeta
Northern Illinois State Teachers College, DeKalb, Illinois

XI

Ball State Teachers College
Muncie, Indiana

Dear Editor:

I am pleased to report, on a separate sheet, the election and initiation of three active, nine associate members to Xi chapter. The initiation took place last evening in the west lounge of our Arts building. Following the induction Dr. Floy Hurlbut discussed briefly with us 'What Happened to Science Education during the War'. Tentative plans for the remainder of the year include six meetings of a varied nature — a panel discussion on the interrelation of the sciences and mathematics, two field trips, two meetings with student programs and a final social event of some kind.

Student officers for the current year are as follows:

President, Harriett Simmons
Vice-pres., Donald Alexander
Secretary, Nora Fuller

To which I suppose I might add that I am the new member on our executive council and the Recorder-Treasurer for the year.

We are in need of a fresh supply of the little booklets giving some history and other general information and entitled 'The Sigma Zeta, National Honorary Science Society'. I think we could use fifty within the next few years. Also please send us a similar quantity of national Constitutions.

I am enclosing a check in the sum of three dollars seventy-five cents to pay the percapita for the three new active members. I am also enclosing a brief item which you may use as a news item if you wish.

Yours truly,
Robert L. Shelley
Recorder Treasurer

P.S.—Xi Chapter recently initiated three new active members and nine new associate members. The ceremony took place in the west lounge of our Arts Building. Following the induction Dr. Floy Hurlbut discussed briefly "What Happened to Science Education During the War". Tentative plans for the remainder of the year include six meetings — a panel discussion of the interrelation of the sciences and mathematics, two student programs, two field trips, and a social meeting of some kind. You may also be interested in the fact that Dr. P. D. Edwards, National President of Sigma Zeta in 1939, has been teaching in the University of the Armed Forces (I'm not sure of that name) in London, England since it was started. He is having a wonderful experience.

PI

James Millikin University
Decatur, Illinois
November 30, 1945

Dear Editor:

Your letter of October 5, 1945 and your recent card has been placed on my desk for reply. Dr. Galligar and I have acted as faculty sponsors during the past two years, thus your letter came to us since there is no active Sigma Zeta organization on this campus at present. Miss Larsen, to whom you addressed your letter was married last summer so is not in college, and James Fritz graduated in June, thus he is not on the campus.

I think some disposition should be made of this chapter by the National before long; either put it back into active organization or plan to suspend until such time as an active chapter can be formed.

Very truly yours,
Earl C. Kiefer,
Prof. of Mathematics.

Ready to leave for the meeting of Texas Academy of Science Meeting in Waco. These five Sigma Zetans of Our Lady of The Lake College pose for their pictures. (Left to right) Nancy Morris, Alda Gianotti, president, Patricia Salzman, Onice Feille, and Mary Saratori. Mrs. Feille took the girls in her car.

RHO

Indiana Central College
Indianapolis, Indiana

Dear Editor:

The following officers have been elected by our chapter:

Chairman—Marjorie Jo Langford, Major in Biological Sciences from Metcalf, Illinois

Vice-Chairman—Mark Bradford, Alumnus, Indianapolis, Indiana

Recorder-Treasurer, Dr. William P. Morgan, Head of Biology Department, Indianapolis, Indiana

I am sorry this report did not get in sooner.

Yours sincerely,
Marjorie Jo Langford

SIGMA

Our Lady of the Lake College
San Antonio 7, Texas
November 19, 1945

Dear Editor:

Enclosed you will find a copy of the cut I am sending under separate cover. If you would like to use it, you may. If not, just return it.

Also enclosed is a paper entitled "Wood Wastes" by Alda Gianotti and presented at the meeting of the Texas Academy of Sciences which was held in Waco, Texas November 8, 9, and 10. Those attending were Onice Feille, Alda Gianotti, Pat Salzman, Mary Sartori, Nancy Morris, and Sisters Mary Clarence and Mary of Grace.

Sincerely yours,
Onice Feille
Sigma Chapter

WOOD WASTES UTILIZATION RESEARCH

"Of course, it is **utterly** impossible to transform a piece of wood into a rubber tire."

Several years ago, such a statement might have been true, but not today, for in 1942 began the series of events which brought sawdust and other wood wastes out of the realm of the valueless and useless into the spotlight as the most prized and serviceable raw materials of the future. Now it **is** possible to transform a piece of wood into a synthetic rubber tire and into many other things besides, even into rayon for women's stockings.

The events which brought these startling facts to light started when Erwin M. Shaefer, anti-Nazi German industrialist now in the United States, visited the Washington office of Dr. J. Alfred Hall, principal bio-chemist of the United States Forest Service in November, 1942. He told Dr. Hall that in the 20's a German chemist, Heinrich Scholler, had discovered a process for utilizing wood waste; a process by which the huge quantities of alcohol needed by the Allies for war purposes could be easily and economically obtained. He related, further, to Dr. Hall, that a plant had been erected at Tornesch, near Hamburg, to make use of the process. Schaefer had been proprietor of the plant. But Nazi overlords also became interested in the process and in the plant, and in 1938 they took over. Scholler turned informer against Schaefer, and the latter was placed in a concentration camp. On being set free later on he lost no time in leaving

Germany. After arriving in America in 1941, he tried vainly to place his knowledge of this valuable process at the disposal of the United States. Not until he visited Dr. Hall was he listened to, and then action began. Twelve of Scholler's patents had been registered in the United States and had been taken over, as all German patents were, by the United States Alien Property Custodian. These were dug out and worked over by Dr. Hall and Schaefer for many months. Finally Hall presented the case to the Chemical Reference Board, the government's supreme court in problems of war chemistry. The Board ordered that tests be made on the process at a plant at Marquette, Michigan.

And so it was that on July 13, 1943, some of the foremost chemists of the United States were assembled in the pilot plant at Marquette to witness the demonstration of the process that Dr. Hall had arranged. The Forest Products Laboratory at Madison, Wisconsin, had provided the chemists necessary to supervise the operations, which, only eight hours after the observers had assembled, had converted 500 pounds of sawdust into 250 pounds of sugar. The routine process of changing sugar into alcohol was not gone through at the pilot plant, for all the assembled chemists knew that from the 250 pounds of sugar one could get twelve and a half gallons of 190-proof "grain" alcohol in 24 hours. In terms of tons this means that one ton of sawdust will yield a half-ton of sugar, from which 50 gallons of ethyl alcohol can be made.

After this first demonstration, samples of sawdust from all the leading lumber regions of the United States were brought in and tested. These tests showed that the softwoods which comprise 75% of American trees yield 50 to 60 gallons of alcohol to every ton of waste. Now it was known before this test on the Scholler process that sugar could be gotten from wood by treatment with sulfuric acid under the right conditions. But Dr. Hall's demonstration proved that twice as much sugar can be obtained, and at a less cost with simpler equipment by this method than by any American process. American ingenuity has now shortened the time for the process to six hours, whereas it took the Germans eighteen hours.

The demands of war turned the ingenuity of scientists toward the possibility of new uses for wood.

In America the abundance of raw materials of all sorts has for a long time overshadowed this new development, but in Germany, where the raw materials have not been so plentiful, German chemists have been at work since about 1936 trying to find new uses for wood and its constituent parts. Exhaustive German surveys of the various fields of wood utilization, as a whole, has brought the conviction that the world's forests comprise an everrenewable and, therefore, inexhaustible mine of the most versatile raw material available to modern industry.

In past years returns from forestry have been rather low, due chiefly to the fact that only a fraction of every forest consists of trees that have sufficient qualities to live up to modern technical standards. On the average, only a third to a half of each tree cut would wind up as lumber. "Low-grade" wood could only be disposed of at a loss, because the price for fuel-wood scarcely covered the wages involved. The same situation prevailed with sawdust, trimmings, and other by-products of manufacturing operations. For West Coast operations alone waste parts amount to a woodpile estimated at about 50,000,000 tons a year.

In 1930 a young Idaho engineer, Robert T. Bowling, produced something new in fuel—an artificial log compressed from sawdust and shavings; these logs are called "Pres-to-logs". In one year 30 million logs were sold, which means 120,000 tons subtracted from our annual waste.

Bowling designed a machine that crushes waste into a thin layer, com-

pletely collapsing the cells of the wood, then forces it into tubular molds under terrific pressure, and heats it to 350°-450° Fahr. The logs are then water-cooled, solidifying the wood particles, thus imitating nature's own process in making coal.

Pres-to-logs produce neither smoke nor sparks, leave very little ash, are clean, splinterless, easy to handle, possess a high heat value, and require no kindling — just a few chips from one end of the log itself. Each log is the equivalent of an arm-load of ordinary wood.

"Rainbo Logs," which burn with a blue, green or violet flame, are also used for decorations as far East as New York.

Another machine developed by Bowling makes several narrow boards into one wide one by applying heat and pressure to synthetic resin spread on the edges of the board to bond them securely. These built-up boards have been soaked 100 hours in water, dried, soaked again, etc., and then put under pressure to test their strength. Each time they split in the grain rather than the seam.

Dr. Stevan Ruzicka, who came to America from Yugoslavia in 1935, told the National Farm Chemurgic Conference of a new process of making a satisfactory blast furnace fuel. The wood wastes are burned into charcoal, and then ground into powder. An organic binder is applied to the powder, and with heating it is cemented back into lumps. This product has been tested in blast furnaces and performs quite satisfactorily.

In California the previously discarded Redwood bark is now shredded and used as a filler for roofing papers and insulation, an outlet which takes 10 to 20 percent of the total bark available each year. This bark has also been tested as floor covering in poultry scratching pens, indoor tennis courts, and polo arenas.

From 30 to 40 thousand tons of wood flour are made annually from sawdust and shavings, this being used as a filler for linoleum, explosives, and plastics.

> "To my mind, the broad field of synthetic boards holds great possibilities," says Dr. E. C. Jahn, professor of wood chemistry at the New York College of Forestry. "The idea that wood waste can be torn apart and recast into any desired shape and serve as a substitute for wood itself is the incentive behind the growing nationwide interest in wood waste utilization research."

He has made pieces of lumber by converting wood waste in a putty-like paste, molding it and curing the pieces under heat and pressure. These cured pieces are twice as strong as the original wood, resist water, can stand much banging around, and yet can still be sawed and worked like ordinary wood. By adding chemicals to the paste, different color effects can be obtained. Various kinds of synthetic boards are produced, depending on different pressures. A high pressure and the hottest temperature give a dark-colored board resembling mahogany, while lesser pressure results in a lighter-colored board, like oak. To improve the grades of knotty lumber, veneer manufacturers are using plugs or wood flour from sawdust to fill the holes after the knots have been cut out.

In making sugar and alcohol from sawdust there is an interesting and important by-product. The residue from a ton of sawdust, after it is converted into sugar, is five hundred pounds of lignin, a substance that acts in the living tree as a binder for the cellulose cells. Lignin is rich in natural resins and already has been used as a raw material for numerous plastics. Compressed into briquettes, it has the same calorific value as good anthracite coal, and burns without ash. Experimentally it has been used as an "extender" in rubber and in building material.

Another use of lignin now being explored is its use as a soil-conditioner. One of its outstanding characteristics as a soil conditioner is that it is absorbent. Because of this quality and its close relationship to humus, it will absorb and hold chemicals which are valuable as plant nutrients, and will release them in a form that is readily utilized. Insoluble lignin has been used in most of the experiments in this field, but lignin isolated from sulfite liquor wastes may also be used after special treatment.

Its absorbent qualities also suggest its use as a purifier. From the air it will take acid, benzine, and other gases; from solution it will absorb metals, phenols, and other chemicals often found in water around chemical manufacturing plants. The insoluble form of lignin thus may prove of value in the war against stream pollution.

Through the research of Dr. Roebrt A. Hardin of the University of Oklahoma, one of the outstanding authorities on lignin plastics, a plastic having a tensile strength of 9,000 pounds per square inch, highly resistant to the action of acids and not inflammable, was prepared. It has one disadvantage in that the plastic must be black because in the process the lignin turns black. But because his process calls for much less resin than do other processes, it can be manufactured at a much lower cost than prevailing plastics.

Lignin may someday be the source of gasoline, dye stuffs and insecticides. Metals may be kept from rusting by a coating of lignin, and bridges and buildings can be made of odd pieces of wood bonded together by lignin.

The future of lignin depends on the skill, ingenuity and knowledge of chemists.

The atomic proportions in lignin are, roughly, Carbon 46, Hydrogen 48, and Oxygen 15. Just how these are linked together is a question chemists today are trying to solve. After it is separated from wood, lignin is found chiefly in the form of dissolved lignin or insoluble lignin. It may be concentrated and in this form has been used rather extensively as a road binder to control dust.

Insoluble lignin is derived chiefly as a residue from the wood sugar process. In the saccharification of wood, the cellulose is converted into sugars by hydroylsis and these sugars may be fermented to ethyl alcohol or used to produce feed yeasts and thus make protein feed for livestock.

Lignin when separated from the other constituents of wood is more plastic, although it tends to crack and crumble when used alone. Much attention is being given to the use of lignin as a plastic when combined with plasticizers and fibers.

Sheets of laminating paper, made by running pulp with a high lignin content on a paper machine, can be banded together under heat and pressure. A very hard, board-like material results which is quite different from the paper itself. This material, which has been named papreg, is being used for electrical insulating panels. It can be sawed, turned and drilled just like hard wood. It is durable enough to be used for skids for planes which land on ice or snow.

In 1940 about 40 percent of the nation's production of pulp came from the South. Research there is now trying to convert tops and waste from pine logging operations into pulp. At the University of Washington, scientists have developed a new process by which a strong paper can be made from Douglas fir waste, which up to this time has not been considered suitable for the pulp industry.

The process of manufacturing camphor from turpentine obtained from pine stumps is another example of our release from dependence upon costly

products. The Nazis have discovered methods for deriving lubricants from tree stumps. Two years ago Sweden was producing yearly twenty-five thousand tons of heavy motor oils from this process. The only obstacle at that time of an increase in output was the lack of sufficient labor to dig up the tree stumps.

The needles of conifers yield some excellent oils which have been used for perfume. There are many chemical ingredients in logging slash which may prove to be of great value to mankind. Chemicals have been recovered as a by-product of the wood utilization method employed in the Polytechnic Institute in New York. The recovery of the chemicals is done by a special treatment of the waste liquors under pressure. This breaks down their molecular structure; other chemicals are then added to absorb the valuable constituents, and by a special washing process water and impurities are eliminated.

These are briefly some of the uses, and there will be many more uses for wood wastes in the future. Extensive research is being carried on in all parts of the United States by the lumber industry in order to wipe out its huge waste piles. Industrial chemists will not be happy until all parts of the tree have been profitably utilized.

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THE DEVELOPMENT OF ATOMIC POWER

by

Dr. Roland A. Trytten

Chemistry Department,

Central State Teachers College, Stevens Point, Wis.

A talk delivered at the regular meeting of the Zeta Chapter 7:30 P.M. Wednesday, October 17, 1945

Those of you who have been reading the newspapers and magazines of the past six months will probably be surprised to learn that up until the year 1900 the atom was mostly a figment of the chemist's imagination. Scientists spoke of the "atomic hypothesis"—which, to put it plainly, means that the atom was an imaginary particle, invented because it was convenient in solving certain problems, but never really believed in. Even as late as 1908, Wilhelm Ostwald, the great German chemist, argued vigorously that atoms could not and did not really exist.

This concept of the atom was completely changed by two discoveries, both made in 1898. First of these was the discovery of the electron, by the Englishmen. Thomson and Crooks. We will not be able to say much about this work; suffice it to remark that it started off a chain of experiments that not only proved the existence of atoms but even succeeded in weighing them with the instrument known as the mass spectrograph. Thus it is now known to be a fact that every material substance is composed of very small particles called atoms. Let me emphasize the words "very small". The number of atoms in one ounce of common table salt is 6 followed by 23 zeroes, or 600 billion trillion.

The other important discovery in 1898 was made by the Frenchman Henri Becquerel. He found that uranium ore, pitchblende, spontaneously gave off rays that blackened a photographic plate, caused zinc sulfide and several other substances to glow or fluoresce, made the surrounding air conduct electrcity, and injured or killed any living tissue with which they came in contact. He soon found that several other minerals gave off the same kind of rays, and these minerals he called radioactive. Following these discoveries, Pierre and Marie Curie isolated two of our most important radioactive elements, radium and polonium. The long and difficult process by which a fraction of an ounce of radium was prepared from several tons of pitchblende is well known to many of you from the movie, "Mme. Curie".

From the Curies in France the spotlight turns to Ernest Rutherford in England. Rutherford found that a magnetic field would divide the rays from radium into three parts: alpha rays, positively charged, which are stopped by a piece of tinfoil like that on a package of prewar cigarettes; beta rays, negatively charged, which are stopped by a piece of iron an inch thick; and gamma rays, which will pass thru a foot of lead. Investigations into the origin of these rays led to the proof that they come from the disintegration of the atoms of the radioactive substance. From time to time, small particles of matter break loose from the atom and are hurled out at terrific speed. The alpha, beta, and gamma rays are streams of these particles. The disintegration proceeds at its own speed, and, at that time at least, there was no known way of either starting or stopping, speeding up or slowing down, the process. The particles breaking off are only a small part of the atom. The largest of them, the alpha particles, are only about 1/60 of the atom from which they come; the beta particles are about 1/800 as big as an alpha particle, and the gamma rays are composed of particles only a few millionths as big as a beta particle.

In the course of his experiments, Rutherford found that aluminum, when exposed to alpha rays, became radioactive; it gave off rays of its own, even after the source of alpha-rays was taken away. Like natural radioactivity, this was found to be due to disintegration of the atoms of aluminum. It was the first case of atom-smashing in the world's history.

Some of you have heard of the metal beryllium, a rare metal that has some use as a hardening agent for copper and its alloys. When exposed to alpha rays, beryllium becomes radioactive in a peculiar way: it gives off neutrons. Neutrons are small particles, about one-fourth the weight of an alpha particle and carrying no electric charge. This completely new kind of radiation, which does not occur in nature as far as we know, was discovered jointly by Chadwick in England and Irene Curie in France.

Neutrons turned out to be a powerful weapon for atom-smashing. Many substances, for instance ordinary table salt, when exposed to neutrons become radioactive and disintegrate. The interesting thing to us, however, is the action of neutrons on uranium. There are two forms of uranium in existence: uranium 238, which forms over 99% of the uranium in the world, and uranium 235, which is less than 1%. The action of neutrons on uranium 235 was discovered by the German physical chemists, Hahn and Meitner. Instead of breaking off a small part of the atom, as in the usual form of radioactivity, neutrons cause the atoms of uranium 235 to split in two, forming two approximately equal fragments, releasing enormous amounts of energy and about a dozen neutrons for every one used in starting the reaction. Each of the dozen neutrons released can theoretically split another uranium atom, releasing another dozen neutrons; and so on. The reaction gathers speed until it reaches exlposive violence.

As soon as this reaction was discovered, its potential military and engineering uses were realized. The only difficulty with it was that uranium 235 occurs in nature mixed with 140 times its weight of uranium 238; it must be separated from uranium 238 in order to make the explosion possible, and that separation is so difficult as to be impractical. It was fortunate, therefore, that another reaction was discovered which was a little more workable. Neutrons react with the ordinary variety of uranium, 238, producing a series of changes which finally result in the production of the new element plutonium. Plutonium reacts with neutrons in the same way as uranium 235, splitting the atom in two with the release of energy and neutrons. The energy released in the disintegration of plutonium is fully as great as that obtained from uranium 235. Furthermore, plutonium is entirely different chemically from uranium, so that separation is possible.

For military purposes, the plutonium reaction was decided upon. The experimental difficulties to be overcome were enormous. For one thing, at the time the reaction was discovered only a few hundred atoms of uranium had been disintegrated and so only a few atoms of plutonium had been produced. Research was concentrated on the reaction, and in a little while a microgram of plutonium was isolated. A microgram is about half of the weight of the dot on the letter i in your name, if written with a fairly soft lead pencil. With this small quantity of the element to work with, a thoro study of the chemical and physical properties of plutonium was undertaken. Enough was learned about it so that laboratory production of plutonium in milligram lots was possible; then pilot-plant production of one gram, or 1/28 of an ounce, was accomplished. On the basis of what was known about the technique of production of that one gram, the construction of a plutonium plant for production of large enough quantities for military use was undertaken.

Neutrons are peculiar bullets. They do more damage the slower they go, just the opposite of a rifle bullet or a cannon ball. When neutrons are produced by the action of alpha particles on beryllium, they are released with about one-fourth the velocity of light, or 40,000 miles per second. At that high speed, neutrons do very little atom-smashing. They must be slowed down by passing them thru a material, called a moderator, with which they do not react. Such substances are not numerous. The Germans used paraffin and heavy water as moderators; the Americans used graphite. Furthermore, the conversion of uranium to plutonium is accomplished by means of neutrons, and the explosion of plutonium is also done by neutrons. One reaction takes moderately fast neutrons, the other very slow ones. In the production of plutonium, the problem is to slow down the neutrons just enough to produce plutonium from uranium but not enough to explode the plutonium. To do this, a pile of uranium mixed with graphite, of exactly the right size, shape, composition, and arrangement, is exposed to neutrons from a radium-beryllium source. It is allowed to react for a few days, at the end of which time the uranium contains 1% or so of plutonium. The uranium is then taken out, the plutonium separated from the uranium, and the uranium put back into the pile to react further.

In the bomb itself, a pile of plutonium mixed with graphite is used, of exactly the right size, shape, composition and arrangement so that the neutrons are slowed down enough to explode the plutonium. The bomb is detonated by neutrons from a radium-beryllium source. Details of the trigger mechanism have not been released. There would have to be some sort of screen to protect the plutonium-graphite pile from the neutrons until the time when the bomb was supposed to explode. Then some mechanism would remove the screen and the detonation would be under way.

The success of the manufacture of atomic bombs, and the results of their use in the war just ended, as well as the implications in connection with the next war, are too well known to require comment here. Let me conclude by mentioning two peacetime applications of the facts now known about the atom. First, the production of steam, for heat or for power, by heating water with atomic energy. In order to do this, an atomic reaction must be found that does not release all its energy at once, but is slow enough to keep a boilerful of water hot over a long period of time. Even then it will not become a commercial reality until a pound of steam can be produced more cheaply by atomic energy than by burning coal. When that will happen, we can only guess.

The other peacetime application depends on the ability of neutrons to make substances radioactive. Very sensitive instruments, known as geigers, are available for detecting radioactive atoms. Suppose, for instance, a sample of salt is exposed to neutrons and made radioactive, and then eaten. A geiger may be used to trace the course of that salt thru the digestive system, the blood stream, and the tissues, until it is finally eliminated from the body. The experiment is not quite as simple as that, and there are many difficulties to iron out, but that is the basic principle. One can easily see that such an experiment would lead to more accurate knowledge of the exact function of salt in nutrition. A few experiments of that kind have been conducted, and many more will be done in the future. In this way, scientists expect to find out much more about the human body than they know now.