Translator's note:

Dr. Arakatsu's speech, given by someone who lived through the revolutionary era of physics in the first half of 20th centyry, appears to have been transcribed by someone who did not understand physics very well.

The reasons why the translator thinks so are given below.

-There are omissions of key words in the written speech.

Examples include:
線 as in アルファ線（alpha rays）
核 as in 原子核 （atomic nucleus） The lack of distinction of atom vs atomic nuclei is very confusing at first.
ボルト as in 100 萬ボルト one million volts

-There are typos regarding numbers (atomic mass). Dr. Arakatsu would have corrected them before publication. No review of the draft before publication seems to have taken place. The observation makes the translator think that the speech was transcribed and not carefully proof-read.

-There are many omissions of so-called case-making particles that are placed after nouns, too. The translator inserted them after guessing the intended meaning.

-Also, the scribe who transcribed the speech did not use commas very often, making the written speech very difficult to read. The translator added commas here and there.

-Perhaps due to the nature of transcription, the speech does not have neatly broken paragraphs. It is very hard to read.

General Problems:
Language-wise, modern Japanese has evolved, so the transcribed speech of close to 90 years ago uses many uncommon words in somewhat old-fashioned combinations of kanji and kana. The translator needed to adjust them to decipher the old writing. The names of atoms are written differently in today's Japan.

old	today	
ヘルム	ヘリウム	(helium)
ラヂューム	ラジウム	(radium)
トリューム	トリウム	(thorium)
アクチニューム	アクチニウム	(actinium)

etc.

The scribe who recorded the speech wrote "原素"instead of "元素" (more commonly accepted rendition) when "element" was referred to. Atom in Japanese is "原子". The unfortunate similarity of characters made some part quite confusing, too.

- Dr. Arakatsu's use of 気象 is very confusing to 21st-century Japanese (and for that matter Japanese in the latter half of the 20th century). 気象 today almost always refers to the climate/weather of the Earth. However, Dr. Arakatsu seemed to use the word to refer to natural events that can occur in space (i.e., interstellar space even?).
One could argue that maybe Dr. Arakatsu was referring to the interaction of particles (cosmic rays hitting oxygen or nitrogen) in the upper atmosphere to emit muons, etc. BUT muons were discovered in 1936 AFTER the speech was given. So that is NOT the case. The translator leaves the mention of 気象 simply as referring vaguely to the upper atmosphere (or high altitude) where cosmic rays were detected more often.

Historical Note:
We must bear in mind that knowledge of physics regarding atomic structure was emerging when Dr. Arakatsu gave the speech. Otherwise, some paragraphs in his speech are hard to understand for 21st-century physics or chemistry students.

- Only several years before the speech was given, knowledge of atoms was mainly understood through the properties of electrons within each atom. Detailed knowledge of atomic nuclei was just emerging, with the discovery of neutrons as mentioned in Dr. Arakatsu's speech.

- The concept of isotopes seemed to mature in the dozen years preceding the speech. The stability of nuclei when specific numbers of protons and neutrons combine began to be recognized just before the speech was delivered.

Given these historical issues, it is doubtful that the attendees of Dr. Arakatsu's talk understood the up-to-date bleeding edge topic of physics in 1930s.

Recent Advances in Research on Atomic Transmutation

Lecture by Professor Arakatsu, Taipei Imperial University

Today marks the auspicious opening ceremony of the Taiwan Sugar Research Institute (TSRI). It is a great honor for someone like me to be given the opportunity to speak. The topic I shall discuss may seem rather time-consuming and, I fear, not particularly relevant to the sugar industry. However, it is a story about how human effort and scholarly diligence can achieve even what at first glance seems like a mere fantasy.

I wish to speak about the struggle with atomic transmutation. And I wish to offer my blessings for the future of TSRI. The human endeavor to transform something of very little value into something of extremely high quality is something that has been pursued since ancient times, and was particularly prominent during the age of alchemy. After conducting experiment upon experiment, exerting effort upon effort, and conducting various studies, what was the result? It was that transforming lead into gold, for example, was simply impossible.

All substances are aggregates of the ninety-odd elements we have named; it is impossible for one element to transform into another element with a different name. This is how things have turned out this way, and modern chemistry has gradually developed accordingly. This is how things have come to be, and modern chemistry has gradually developed accordingly.

However, it has developed in a direction different from the initial expectations. As you all know, all elements are beautifully arranged in the periodic table. Some rather clever people began to think that there must be some connection between each element, and that it should be possible to transform one element into another by some appropriate method. This ambition, bordering on the wildest of human desires, could not be achieved by the alchemists who immediately set their hands to it. Instead, it was conquered by those pursuing research in entirely different fields. As you know, chemical elements are composed of the ultimate small particles we now call atoms.

Research into these ultimate tiny particles has become the primary focus of modern physics and chemistry. These particles exhibited extremely peculiar properties, and from the late nineteenth century through the twentieth century, a succession of strange phenomena were observed, the likes of which had scarcely been seen throughout the long history of humanity.

In 1895, as you know, X-rays were discovered, and radioactive substances like uranium were studied in depth, followed by the discovery of electrons. Gradually, the physics and chemistry of atomic structure developed, and the structure of the atom, which had been considered the ultimate tiny particle, was revealed, and the electron was also studied.

Gradually, physics and chemistry concerning the so-called atomic structure developed, and we came to know that the structure of the atom, which was the ultimate tiny particle as I explained just now, is composed of these electrons. The way of viewing atoms through the characteristics of these electrons represented the efforts of physics up until last year and the year before, creating a very beautiful field of study.

However, what I wish to discuss today is not the physics of the atom's outer shell—that is, the atom composed of electrons—whose theory had developed until last year and the year before. Rather, I wish to speak primarily about the topic that has developed from last summer through this year.

The general structure of this elemental atoms resembles the solar system. The atom's most central point occupies the position of the Sun, and around it are electrons, which we might think of as Earth, Mercury, Jupiter, Venus, etc.

The part we have primarily studied in chemistry has been the properties of these outer planets. Until last year, research focused mainly on the outer regions of these planetary bodies, i.e. electrons, and the core, which corresponds to the Sun at the center of the atom, remained unclear.

We only weighed individual atoms. This was done as part of the study of radioactive material such as radium, and the internal structure of the nucleus remained unknown.

However, what did we learn from studying radioactive substances? We discovered that radioactive materials like radium, even when left alone, naturally emit strong radiation in a highly regular pattern—alpha rays and beta rays. These alpha rays are what we now call

Helium's atomic nucleus, and beta rays are the electrons we know. All of these are emitted with tremendous force. This alpha particle, which we now call the Helium's nucleus, and the beta particle are what we know as electrons. They emerge with tremendous force, and when left to emit naturally, they do so at a constant rate unaffected by any human intervention, regardless of how much pressure or temperature is applied.

The energy of these ejected alpha and beta particles is immense. If one were to attempt to produce them artificially, it would require approximately five to six million volts, and in some cases, nearly ten million volts. Therefore, when we speak of radioactive phenomena using more common terms, we are describing chemical reactions occurring at the energy of voltages of several million to tens of millions of volts.

However, this chemical action xxx (illegible) is not the kind of chemical action described in ordinary chemistry. Therefore, rather than simply calling it a chemical action, it should be said that the atom itself, even when left to its own devices, collapses from within.

As fragments from this collapse, Helium atoms emerge, and electrons are emitted. This perspective gradually developed, and extensive research on the respective series of radium, thorium, and actinium has led to the well-known concept of radioactive transmutation today.

The story culminates in the idea that an atom ejects a helium atom, emits an electron, known as the beta ray, and itself transforms into another substance. It undergoes successive transformations, ultimately changing into lead. This was a profoundly novel and seemingly terrifying idea at the time when it came out, but today it has become commonly accepted knowledge.

Thus, the results of research into radioactive action have taught us that even atoms, once thought to be the ultimate tiny particles of elements, can be extremely unstable. Left to themselves, they gradually disintegrate from within. Studying how they disintegrate means we come to understand the process of their disintegration. What did we learn by studying this disintegration? As I mentioned earlier, it involves the emergence of helium. We discovered that within the atoms of what we called elements, helium exists as a building material. If we base our thinking solely on experiments, there can be a school of thought to understand that all atoms are perhaps formed solely from helium, or that helium itself is the building material. Indeed, if we were to measure the weight of each and every atom, we would notice that they are two or three times heavier than helium atoms.

Therefore, devising a method to measure the weight of each individual atom became extremely important. Such research was flourishing when I graduated from university, and I myself engaged in this work, practically carrying it out myself. Research on this topic, and the attempt to measure the weight of each individual atom, has made it clear that not all atomic weights are multiples of the Helium atom.

On the other hand, if we take the atomic weight of oxygen as sixteen, almost all atoms appear to be represented by approximately integer values. Helium is four, Lithium is 6, 7 (Translator's note this should read 6.7. The person who transcribed the speech seemed to use European continental notation of number with decimal point, which is quite confusing since Japan uses American style numerical notation BTW, the chemical atomic mass of Lithium is about 6.9 in today's chemical database.), carbon is twelve, and nitrogen is fourteen, and so on.

Chlorine, which deviates significantly from integer values, was actually found to consist of two types: 35 and 37. There is no such thing as atoms that have atomic mass of 35.5 (translator's note: original was 35, 5 in European continental notation.)

From this, we see that when measuring the weight of a single atom using oxygen's weight as reference (16), weight of all elemental atoms is integer multiples of a unit weight. As mentioned earlier, the nucleus, the core of the atom, is a structure built from bricks of atomic weight one. Thus, the idea that all atoms are built from hydrogen, which has an atomic weight of one, has become experimentally clear. The idea that all atoms are built from hydrogen, which has a mass of one, was deduced from the mass of each individual atom. But the question of whether, when split open, they are indeed made of this "one" substance is something even a physicist with an ordinary mind would ponder.

I shall refrain from detailing the precise methods used to achieve this. However, as mentioned earlier, when they tried hitting atoms with alpha rays emitted by radium—each carrying energy of 50 million or 10 million electron volt, particles resembling hydrogen emerged with tremendous force.

Upon examining this phenomenon using various specialized techniques, it became clear that this was not merely a random occurrence, but rather the result of some kind of "chemical reaction" within the nucleus triggered by the impact. Upon examining this with various specialized techniques, it became clear that this was not simply something we had struck and let it emerge. Rather, it must have been the result of some kind of "chemical reaction" occurring within the nucleus of the struck atom.

We proceeded to test aluminum and other relatively light substances. With the exception of lithium, beryllium, carbon, and oxygen, nearly all elements from boron to potassium exhibit this phenomenon. That is, we came to understand that hydrogen is being ejected as a building block.

In this way, about fifteen or sixteen years ago, when we bombarded atoms with radiation emitted from radium, we discovered that hydrogen emerged from within them as the building material inferred from its mass. Experimentally, it became clear that the nucleus, the core of the atom, is composed of two elements: hydrogen and helium, the lightest and second lightest elements in the atomic chart. However, we found that lithium and beryllium did not exhibit this phenomenon. When alpha rays were directed at them, hydrogen was not observed to escape. Instead, German researchers found that extremely strong gamma-like rays, along with very intense gamma rays, were emitted from them. Finding this intriguing, the daughter of the renowned Madame Curie in France conducted extensive research and discovered something peculiar. When gamma-like rays emitted from elements like lithium or beryllium after being bombarded with helium atoms (translator's note: helium atomic nucleus actually) were observed by placing an absorber near it, they did not appear to be absorbed but instead emerged even stronger. This was something we could not possibly understand and seemed like a highly mysterious phenomenon where they were not absorbed and came out intensified. Chadwick in England found this to be highly mysterious and carried out many experiments. —I won't delve into the details—and what he discovered was this: it wasn't strong gamma rays at all, but a type of particle humanity had never encountered before. What we had known until then were the electron and what we thought might be the building blocks of the atomic nucleus. We only knew of the hydrogen nucleus, i.e., proton, the helium nucleus, and we thought the atoms formed from these building blocks. Last summer, we began observing this mysterious unknown particle of matter, whose weight resembles that of a hydrogen atom, and which is completely uncharged. Humans had not known such a particle exists.

The electron carries a negative charge, and the hydrogen nucleus, i.e., proton carries a positive charge. For us humans, matter and electricity seemed bound together and inseparable; we could never separate them or extract them.

However, various phenomena have led us to conclude that this newly discovered particle is completely neutral, possessing neither positive nor negative charge That is, it has become clear that there exists a neutral substance, a neutral hydrogen (translator's note: I think this should read as neutral hydrogen atomic NUCLEUS, sort of.), which possesses neither positive/negative charge. This was named "neutron".

In this way, we have discovered a substance not charged with electricity, something never before found in human history. This is, on one hand, truly astonishing. Let us think about the implication considering the atom, as mentioned earlier, is a structure built brick by brick, It is now clearly understood through experiments that there exists one such building block, the neutron, as mentioned earlier.

In this way, it has become clear that the fundamental building blocks of matter are composed of hydrogen and the neutron I just mentioned.

We have understood such a structure, but then, can we transform one of these atoms into another using appropriate industrial methods? For example, can we transform lead into gold? We see the possibility of this being achieved industrially in the future. For instance, we are considering how we might conduct research to explore the possibility of transforming lead into gold through human effort as an industrial process in the future. If radium were abundant in the world like coal or iron, it might be possible. If we could bring it from the mountains and, by applying appropriate methods, and immediately let it cause atoms break down in the afore-mentioned manner, with atoms changing one after another, we could do it.

However, since there is not such an abundance of radium in the mountains, it cannot be established as a conventional industry based on mining. Therefore, if we somehow manage to achieve this using human labor, that is, if we create the high-speed alpha rays mentioned earlier using human effort, then, in principle, the possibility of our hoped-for industrial atomic transmutation project becomes academically feasible. Furthermore, this would provide a clear pathway to understanding the path taken by the elements, which must have formed at the beginning of the universe,

So, what would it mean to artificially produce the alpha rays that form the basis of this? In electrical engineering, it would require the development of technology capable of handling millions of volts. Current electrical engineering can only handle up to two million volts. Until now, while we have achieved high voltage in the conventional sense, artificially producing alpha rays from radium, which occur naturally, has not been possible.

Therefore, nations have endeavored to generate high-voltage electricity, and for a long time, each country has worked on electrical engineering designs that break from conventional designs. However, at Cambridge where these efforts were most vigorous, significant progress was made last summer alongside neutron research, culminating in the completion of a major study.

Rather than attempting to artificially produce alpha rays using extremely high voltages like several million or tens of millions of volts, they ingeniously devised apparatus capable of operation at voltages of up to about eight hundred thousand or six hundred thousand volts.

Using such apparatus producing voltages around six hundred thousand volts, they artificially created hydrogen particles of very high velocity, substituting hydrogen for helium. (translator's note: here the particles are actually atomic nuclei only. No electrons, i.e., ions.)

The design plan was creating up to a maximum of 800,000 volts. Their original plan was to observe something entirely different. They tried bombarding the lightest substances, lithium and beryllium, for a starter with accelerated hydrogen. But it led to the discovery of a very strange thing. They had thought that research into such atomic disintegration and transmutation could only be done with several million volts, yet when they struck it with hydrogen with the kinetic energy of only several hundred thousand electron volts, helium emerged from lithium unexpectedly, and helium also emerged from beryllium. This was unforeseen. It was not an expected outcome for the experimental goal.

As I mentioned earlier, human effort was rewarded when they applied several hundred thousand volts of electricity and observed it shatter atoms unexpectedly.

So what exactly happened? Results from various specialized technical methods showed that when hydrogen nucleus hits Li, a very small amount of hydrogen nucleus enters the Li atomic nucleus. At that point, a new atomic nucleus temporarily emerges, possessing an atomic mass of eight, or something of that sort. After all, hydrogen, with tremendous force, causes new disturbances within the core of the Li atom, triggering a revolutionary process that eventually stabilizes. That is how it has come to be. However, no such element with atomic weight 8 exists. Since the laws of nature and physics do not seem to permit such an entity to exist, it became clear that this entity with weight 8 split into two halves, each with weight 4. That is, a transmutation occurred such that the chemical equation Li1 + H1 = 2H4e could be expressed as a reaction. This has been clearly established. The same holds true for beryllium. When dealing with lighter elements, this process proceeds extremely simply.

Gradually testing with various elements, they found that even elements like aluminum, calcium, nickel, copper, and the like generally release helium when hit by hydrogen ion with kinetic energy of 400,000 electron volts.

Particularly interesting is that substances like uranium (translator's note: hard to read from the scan. But I think it refers to Uranium) possess radioactive properties. When hydrogen nucleus smashes into it, it emits nearly four or five times the radioactivity. Until now, radioactivity could NOT be weakened or strengthened by human effort. (translator's note: I think the original transcript is wrong. It lacks "not". "not" was added.), they observed that accelerating hydrogen with a mere voltage of several hundred thousand volts increases radioactivity. This means that atoms, whether they are copper or gold, break apart with extreme ease. It became clear that with just a slight stimulus, atoms we thought stable break down and mutate into another one.

Around 1880 to 1900, we experienced the natural phenomenon of matter spontaneously decaying and transforming. This continued until about fifteen or sixteen years ago, when we first learned of the "superchemistry", so to speak, that atoms artificially break down using alpha rays, and from last summer onward, as I mentioned, it was discovered that when alpha rays smash into atoms, neutrons emerge.

It was only through alpha rays that we first learned of this superchemistry: artificially breaking down matter produces hydrogen. Then, starting around last summer, as I mentioned, we discovered that when alpha rays are used, neutrons emerge. That is, we learned of the emergence of a particle never before experienced by humankind. This too was an experiment conducted starting around last summer, revealing that artificially bombarding an atom with hydrogen produces helium.

Now, let's see what happens during these phenomena. Academic examination/explanation is as follows. For example, when alpha rays, i.e., helium nucleus smashes into nitrogen, hydrogen emerges. What happens is this. The chemical atomic weight (Translator's note: The original text only says "化学" (Chemistry), which doesn't make sense. I took it to mean chemical atomic weight) is fourteen (original) plus four (from helium), making eighteen in total. This nucleus of eighteen atomic mass appears very difficult to exist. So one atom (hydrogen nucleus i.e. proton) flies out, leaving nucleus of seventeen atomic mass —a form of oxygen. This is how we think about what happens. Alternatively, if we take nitrogen and smash it with a hydrogen mentioned earlier, the hydrogen enters nitrogen nucleus and makes a nucleus of fifteen atomic mass (translator's note: original says five. It should read 15.) This element with fifteen atomic mass, as you may know, has never been found. Such a nucleus must be unstable. Therefore, it gradually became clear that it produced different kind of boron, and today this "superchemistry" or "superchemistry within the nucleus", seems to have become relatively well understood.

As I mentioned, it was largely a matter of vague speculation (Translator's note: ほう. I think that should read ぼう.　Translated as "vague speculation") regarding what emerges when atoms are artificially disintegrated and what remains afterward.　However, this has now been clearly understood and established.

Moreover, around March or April of this year, we came to understand another phenomenon. This is not artificial but a mysterious result of a natural process. As briefly reported in the newspapers, rays of immense penetrating power have been arriving on our Earth. It is remarkably potent, not merely akin to radium gamma rays, but possessing tremendous penetrating force. Such rays can penetrate small mountains from one side to the other. It penetrates thirty to forty meters of water, and the strongest ones can pass through several hundred meters of water even. This highly penetrating ray has been arriving on our Earth. This has been known for quite some time, and research in this area has been quite thorough. However, what exactly this highly penetrating ray is remains unclear, and consequently, its origin and the path it takes to reach us are also not clearly understood. Thus, it was called cosmic rays, or upper sky rays（上空線）because its intensity increases at higher altitudes. However, we are constantly exposed to this highly penetrating radiation, day and night. It is extremely powerful; from one perspective, it is far stronger than ordinary gamma rays. It arrives on Earth with considerable intensity, and we live within it.

The first major research focus was determining their energy. Around March of this year, the first reports on measuring this energy were published. Measuring them revealed their energy levels. As mentioned earlier, the energy involved in superchemistry occurring within nuclei is in the range of millions, or tens of millions of volts. But these rays are not of that magnitude. The weakest ones are around tens of millions of volts. Even if we were to artificially generate them, the weakest would be tens of millions of volts. The strongest reach hundreds of millions or even billions of volts. It is an energy so immense that we have no idea how human effort could possibly generate it. We have come to understand that these are highly penetrating rays possessing tremendous energy. These energy rays, requiring an average of hundreds of millions of volts—an immense electrical charge—to be produced, originate somewhere in the universe.

However, we do not yet know where they are generated or the path they take to reach us. However, methods for measuring this energy gradually revealed the effects of cosmic rays. It became clear that nearly all elements on the earth, constantly bombarded by these powerful rays, are being broken down day and night. Among the fragments observed were electrons and protons. Particularly intriguing was the discovery that positively charged electrons (electrons previously known only as negatively charged) emerge during this process. Thus, we are constantly exposed to these cosmic rays. Because of this, destructive processes—emitting helium, hydrogen, and positively charged positrons— are occurring day and night, and this has become clearly established.

In this manner, I believe that in the near future, artificial electrical engineering will be employed industrially to destroy and transmutate matter. Then, as a natural atmospheric phenomenon, as a meteorological phenomenon of our entire universe, I believe it will become clear which elements are formed one after another.

If we imagine going back in time, what path was taken when all the matter that constitutes the universe was created, and what meteorological and astronomical phenomena gave rise to yin and yang, or perhaps neutrality, and thus formed our universe? (Translator's note: Dr. Arakatsu mixed "climate" of earth's atmosphere with the physical process of interstellar gas, etc. of the universe. I cannot fathom what he exactly tried to mention based on what cosmological view he had.) I believe the time will come, not too far in the future, at least within my lifetime, when we will understand this sequence of creation events.

Thus, even speaking of such matters feels like a tall tale of grasping at clouds. Yet, precisely because human endeavors since the beginning of this century have culminated in tangible momentum, i.e., "superchemistry of atomic" nuclei has advanced significantly over the past two years, when the establishment of the TSRI has become a reality, and as I stated at the outset, I wish to emphasize that human endeavor and the diligence of students can achieve what initially seems almost like a fantasy. I believe that within the next year or two, this laboratory will already begin to yield the effects of advancement of science and technology, which I mentioned in my talk producing sugarcane that is almost taller than Mount Jade (玉

山、Mt. Yù Shān). I spoke to bless the future, anticipating that such an era will come. (Transltor's note: Dr. Arakatsu was aware that to many in the audience, the talk was mumbo-jumbo. So he inserted a joke about the sugacane taller than the hightest mountain in Taiwan. This was certainly to be understood.)