1990 MIT Undergraduate Chemistry Lab Factors the Number 15 With Chloroform in an NMR

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In the spring of 1990, a group of MIT undergraduates embarked on an unprecedented journey within the confines of their chemistry lab. Under the guidance of Professor Juvon, they were presented with a challenge that seemed more suited to the realms of quantum physics than to a chemistry lab: to factor the number 15 using nothing but 13-C chloroform and an NMR machine. With no further instructions, their task was a test of ingenuity, interdisciplinary collaboration, and perseverance. Diving into the depths of quantum mechanics, NMR spectroscopy, and computational theory, these students ventured beyond the traditional boundaries of their respective fields. Their journey from confusion to clarity, skepticism to breakthrough, embodies the spirit of innovation that MIT prides itself on. This narrative not only highlights their academic endeavor but also showcases the untapped potential of quantum computing, explored through the lens of an undergraduate chemistry lab in 1990.

Keywords: MIT, undergraduate chemistry lab, quantum computing, 13-C chloroform, NMR spectroscopy, factoring numbers, interdisciplinary collaboration, innovation, quantum mechanics, computational theory, academic endeavor, 1990, perseverance, breakthrough, Professor Juvon.

The Cryptic Challenge

INT. MIT CHEMISTRY LABORATORY - DAY

The camera sweeps across a room filled with rows of benches cluttered with beakers, test tubes, and Bunsen burners. The walls are lined with shelves crammed with chemical reagents and textbooks. At the front, **PROFESSOR JUVON**, a figure of quiet authority with a penchant for challenging the norm, addresses a room full of undergraduate students. His tone is serious, his demeanor, composed.

PROFESSOR JUVON "Your project for this semester," he begins, pausing for effect, "is to factor the number 15 using 13-C chloroform in an NMR."

The statement hangs in the air, met with puzzled looks and the scratching of pens as students jot down the challenge. The simplicity of the statement belies its complexity, leaving a murmur of confusion in its wake.

STUDENT 1, leaning over to whisper to a neighbor, "Is that even a thing? Sounds more like a puzzle than chemistry."

STUDENT 2, with a look of intrigue, "There's got to be more to it. He's never straightforward."

Professor Juvon scans the room, his expression unreadable. He's known for his unorthodox teaching methods, often pushing his students beyond the confines of traditional coursework.

PROFESSOR JUVON "There will be no further instructions. How you approach this challenge is entirely up to you. Consider it an opportunity to explore, to question, and perhaps to discover something entirely new."

The class is silent, a mix of apprehension and excitement. Some students look overwhelmed, others, notably **STUDENT 3**, a known tinkerer and problem solver, seem galvanized by the challenge.

STUDENT 3 mutters under his breath, "Alright then, game on."

CUT TO:

EXT. MIT CAMPUS - DAY

Groups of students emerge from the chemistry building, animatedly discussing the project. The confusion from the classroom has evolved into speculative excitement.

STUDENT 4, always eager to dive into research, "Let's hit the library. If there's any logic to this, it's buried in the journals or maybe some old quantum mechanics texts."

STUDENT 5, practical and grounded, "And we should get some time with the NMR. If we're supposed to use it, we need to know exactly what it can do."

As they disperse, their paths diverge, symbolizing the beginning of a collective yet individual journey towards unraveling the enigma laid out by Professor Juvon. The challenge has set the stage for a semester of intellectual curiosity, pushing the students to explore the boundaries of chemistry, physics, and perhaps fields they haven't even considered relevant to their task.

This moment encapsulates the essence of the cryptic challenge: an invitation to step into the unknown, to collaborate and compete, to experiment and theorize. It's a test not just of their scientific knowledge, but of their creativity, perseverance, and willingness to venture beyond the conventional boundaries of their education.

Initial Bewilderment

INT. MIT DINING HALL - EVENING

The dining hall buzzes with the energy of students gathered for dinner, but one table stands out. Here, the group from Professor Juvon's class congregates, their meals forgotten as they delve into the perplexing assignment. The mix of majors—chemistry, physics, and engineering—provides a wide range of perspectives, yet all share a common confusion.

STUDENT 1, a chemistry major, forks at her food, puzzled. "How does one even begin to factor a number using chloroform and NMR? It sounds more like a riddle from a fantasy novel than a chemistry assignment."

STUDENT 2, from physics, leans in, equally baffled but visibly excited. "There's got to be a catch. Factoring numbers is math, quantum computing stuff, isn't it? How does NMR fit into this?"

STUDENT 3, an engineering major, taps his fingers on the table, thinking aloud. "NMR... Nuclear Magnetic Resonance... it's about magnetic fields and nuclei. But using it to factor numbers? Is Juvon expecting us to invent a new kind of computer or what?"

Laughter breaks out, a release of tension, but it's clear none of them finds the situation truly amusing. The challenge feels like being asked to solve a puzzle without knowing the rules.

STUDENT 4, more contemplative, gazes out the window. "Maybe that's the point. He's not just teaching us chemistry; he's teaching us how to think differently, to connect dots that aren't even on the same page."

The group falls silent, contemplating this. The realization that they're not just facing a scientific challenge but also an intellectual one shifts the mood from frustration to intrigue.

STUDENT 5, ever the optimist, claps her hands together. "Alright, then. If we're going to do this, we'll need to dive into everything we know about NMR, quantum mechanics, maybe even cryptography. Let's break this down. What do we know, and where are our gaps?"

The scene transitions as they start to organize their thoughts, pulling out notebooks and laptops. They begin listing what they know about NMR spectroscopy, the properties of 13-C chloroform, and the basics of quantum mechanics. The table is a mosaic of equations, diagrams, and notes.

CUT TO:

INT. MIT LIBRARY - NIGHT

The group, now equipped with stacks of books and papers, settles into a corner of the library. The bewilderment has given way to a focused determination. They split tasks, some diving into the principles of NMR, others exploring the quantum mechanics behind entanglement and superposition, and a few looking into mathematical algorithms for factoring numbers.

The initial skepticism and confusion have transformed into a collective quest for understanding. The scene captures a pivotal shift from bewilderment to the beginnings of a plan. They're still in the dark about how exactly to tackle Juvon's challenge, but the path forward is becoming clearer: they'll need to explore the intersections of their fields in ways they hadn't considered before.

This transition from confusion to collaboration sets the tone for their journey ahead, highlighting the educational value of embracing the unknown and leveraging interdisciplinary perspectives to tackle complex problems.

Forming the Team

INT. MIT LIBRARY - LATE AFTERNOON

The vast, quiet spaces of the MIT library are a stark contrast to the bustling dining hall. Here, under the warm glow of desk lamps and the towering shelves of books, the core group of students from Professor Juvon's class reconvenes, their initial bewilderment now replaced with a budding sense of purpose.

STUDENT 1, the chemistry major with an analytical mind, is the first to speak. "We need a plan. This isn't just about chemistry or any single subject. It's about how we can use what we know from all our fields to crack this."

STUDENT 2, from physics, with a passion for quantum mechanics, nods in agreement. "Exactly. And we're going to need a diverse set of skills. Chemistry for the NMR and chloroform part, physics for the quantum mechanics, and maybe even some computer science for the factoring algorithm."

STUDENT 3, the engineering major with a knack for building and understanding machinery, chimes in. "Don't forget about the practical side. We'll need to get hands-on with the NMR machine, figure out how to use it in ways it's probably not meant to be used."

As they talk, it's clear that their varied academic backgrounds are not a barrier but a boon. They each bring a piece of the puzzle, and together, they start to see a way forward.

STUDENT 4, who has been quietly listening, adds a strategic perspective. "We should start mapping out what we know and identify what we need to learn. Let's assign roles based on our strengths but stay flexible. We're going to be learning a lot of this as we go."

The group nods, rallying around the plan. **STUDENT 5**, always the organizer, pulls out a notebook and begins to sketch a rough project timeline and role assignments.

STUDENT 5 "Okay, let's break it down. We'll need a team working on understanding the NMR machine inside and out. Another group should dive into the quantum mechanics theory, and we'll all need to loop back regularly to share what we've learned."

The dynamics of the group are a reflection of MIT's collaborative culture, driven by curiosity and an unwavering commitment to solving problems, no matter how daunting. Their diverse backgrounds in chemistry, physics, and engineering converge in a shared goal that transcends disciplinary boundaries.

CUT TO:

INT. MIT LIBRARY STUDY ROOM - EVENING

The team has commandeered a study room, the walls now adorned with whiteboards covered in chemical structures, mathematical equations, and schematics of NMR machines. The room buzzes with the energy of intense focus and collaboration.

As they debate, theorize, and calculate, the camera pans over their work, capturing the essence of their budding partnership. They are more than just a group of students; they are a team united by a challenge that tests the limits of their knowledge and creativity.

This formation of the team marks the beginning of an intellectual adventure, one characterized by late nights, breakthroughs, and setbacks. But above all, it is defined by their collective determination to unravel the mystery laid out by Professor Juvon, a testament to the spirit of innovation and discovery that defines MIT.

Diving into Research

INT. MIT LIBRARY - DAY

The library, a sanctuary of knowledge with its towering stacks and the pervasive scent of old books, becomes the primary battlefield for the students' quest. The scene unfolds with the team dispersed among the aisles, their arms laden with volumes of scientific journals, textbooks on quantum mechanics, and manuals on nuclear magnetic resonance (NMR) spectroscopy.

STUDENT 1, the chemistry major, is seated at a large wooden table, surrounded by open books on organic chemistry and NMR techniques. She meticulously takes notes, underlining passages about the properties of 13-C chloroform and its use in NMR spectroscopy. Her focus is intense, her brow furrowed as she deciphers the complex information, trying to bridge the gap between the chemical properties of chloroform and the cryptic assignment.

STUDENT 2, passionate about physics, has found a quiet corner. He's engrossed in a thick, worn-out textbook on quantum mechanics, a notepad filled with equations and diagrams beside him. He occasionally pauses, staring into space, as he wrestles with the concepts of quantum states and entanglement, trying to connect these abstract principles to the practical challenge of factoring numbers using NMR.

STUDENT 3, the engineering major, flips through a technical manual on the operation of NMR machines. He's looking for anything that might hint at unconventional uses of the technology, jotting down notes on the machine's capabilities, limitations, and the process of manipulating nuclear spins. His engineering mindset is focused on how to practically apply the theoretical and chemical information his teammates are gathering.

Meanwhile, **STUDENT 4** is at a computer terminal, searching through digital archives of academic papers. Without the convenience of modern internet search engines, she relies on keyword searches through academic databases, piecing together articles on early quantum computing efforts, NMR applications, and any cross-disciplinary research that might shed light on their project.

The camera pans over the group, capturing the intensity of their focus and the collaborative spirit that drives them. They reconvene periodically at the table, sharing findings, debating theories, and slowly piecing together a coherent strategy. Their dialogue is a mix of technical jargon and speculative ideas, reflecting the depth and breadth of their research.

STUDENT 5, who has been sifting through a stack of cryptography journals, shares an exciting find about the mathematical foundations of factoring numbers and its implications for encryption and security. Though the connection to NMR and quantum mechanics is still tenuous, it sparks a lively discussion about potential intersections between their findings.

As the day wears on, the pile of annotated papers and books grows. The team has created a makeshift research hub, with sections of the table dedicated to different aspects of their project: NMR operation manuals, quantum mechanics theories, chemical properties of chloroform, and cryptographic algorithms.

This intensive research phase, carried out in the pre-digital age library, highlights the students' resourcefulness and determination. They are driven by curiosity and the thrill of discovery, navigating through stacks of physical documents to uncover the information they need. It's a testament to their commitment to solving the puzzle posed by Professor Juvon, a journey of intellectual exploration that is both challenging and exhilarating.

Connecting the Dots

INT. MIT STUDY ROOM - EVENING

The study room is alive with the energy of discovery as the team gathers around a sprawling mass of notes, diagrams, and open textbooks. The walls are adorned with whiteboard sketches of molecular structures, NMR spectra, and quantum mechanical equations. Each member brings a piece of the puzzle to the table, their diverse academic backgrounds now converging in a shared mission.

STUDENT 1, the chemistry major, points to a diagram of the 13-C chloroform molecule she's drawn on the whiteboard. "The key here is the carbon-13 atom. It's the heart of our NMR experiments. Its magnetic properties are what we're going to leverage."

STUDENT 2, with a background in physics, jumps in, excitement in his voice. "Exactly, and if we think about it through the lens of quantum mechanics, the spin states of the carbon-13 nucleus could act like qubits in a quantum computer."

The room buzzes with excitement as the theoretical implications start to take shape. **STUDENT 3**, the engineering major, lays out a schematic of the NMR machine. "So, if we can manipulate the spin states of the carbon-13 atom using the NMR, we might be able to mimic the quantum computing process needed to factor numbers."

STUDENT 4 adds, "And that means we'd essentially be using the NMR as a quantum processor, right? By controlling the radiofrequency pulses, we could put the carbon-13 nucleus into superposition and maybe even achieve entanglement."

STUDENT 5, who has been quietly absorbing the discussion, looks up from a stack of papers. "But how do we go from manipulating spin states to actually factoring the number 15? There's a gap between the quantum behavior we're theorizing and the computational outcome we're aiming for."

The team falls silent, contemplating this challenge. The connection between the quantum mechanical behavior of the chloroform and the mathematical process of factoring numbers remains elusive.

STUDENT 2 breaks the silence with a thought. "What if we look at it from the perspective of quantum algorithms? Even though we're not working with a conventional quantum computer, the principles should still apply. We need an operation that translates the manipulation of spin states into a form of computation."

Inspired by this insight, the team dives back into their resources, sketching out potential experimental designs on the whiteboard. They discuss the concept of phase coherence and how manipulating it through NMR could parallel the process of quantum algorithms.

As the evening progresses, the team's diverse expertise begins to knit together a coherent, if speculative, theory. They hypothesize that by carefully designing a sequence of NMR pulse experiments, they might induce quantum-like computations within the chloroform's nuclear spin system, potentially leading to the ability to factor numbers.

The scene captures a pivotal moment in the team's journey: the transition from fragmented understanding to a unified hypothesis. It's a testament to the power of interdisciplinary collaboration, where chemistry, physics, and engineering intersect to explore the frontiers of quantum computing. The excitement of discovery is palpable, fueling their determination to turn their theoretical model into a practical experiment.

Experimental Trials

INT. MIT NMR LABORATORY - DAY

The NMR lab, a room dominated by the large, cylindrical NMR machine, becomes the team's experimental playground. The machine's humming and the occasional clink of glassware provide a constant backdrop to their work. The team, equipped with a basic but groundbreaking understanding of quantum principles, is ready to embark on the practical phase of their challenge.

STUDENT 1 and **STUDENT 3** are huddled around the NMR console, reviewing the setup for their first experiment. They've prepared a sample of 13-C chloroform, carefully measured and placed in a slender NMR tube.

STUDENT 1 (adjusting the settings) "Based on our theory, we need to hit the carbon-13 nucleus with a sequence of RF pulses that should, in theory, manipulate its spin states."

STUDENT 3, the engineering major, nods, his eyes on the manual. "Right, and the timing and duration of these pulses are crucial. We're trying to create a specific quantum state, which is something this machine wasn't exactly designed for."

They initiate the first sequence of pulses. The team watches the monitor intently, but the results are not what they expected. The data is confusing, a far cry from the clear-cut quantum behavior they hoped to observe.

STUDENT 2, leaning over the printouts, frowns. "This doesn't look right. The signal's all over the place. It's like we're not getting any coherent response from the chloroform."

STUDENT 4 chimes in, "Let's not forget, we're in uncharted territory here. It was always going to be trial and error. Maybe we need to adjust the pulse frequency or the interval between pulses."

The team regroups, discussing adjustments to their approach. They pore over their notes and theories, tweaking the experimental parameters. **STUDENT 5** suggests, "We might also need to consider the temperature and the magnetic field strength. Everything could affect the coherence of the quantum states we're trying to achieve."

CUT TO:

INT. NMR LABORATORY - LATER

After several iterations, each experiment refining their approach based on the results of the last, the team begins to see promising signs. A particular sequence of RF pulses yields data that, when analyzed closely, shows hints of the quantum superposition they've been aiming for.

STUDENT 2, analyzing the latest data, can't hide his excitement. "Look at this! These peaks... It's still rough, but it could be indicative of superposition. We're actually manipulating the quantum state of the carbon-13 nucleus!"

The mood in the lab shifts from frustration to cautious optimism. The experimental trials, a series of painstaking adjustments and recalibrations, are starting to bear fruit.

STUDENT 3 looks up from the console, a smile breaking through his concentration. "We're not there yet, but this is real progress. If we can replicate this and refine it, we might just crack the quantum behavior part of the puzzle."

The scene encapsulates the essence of scientific exploration—perseverance in the face of uncertainty, the iterative process of hypothesis and experiment, and the thrill of glimpsing the unknown. The team's journey through these experimental trials, marked by setbacks and small victories, mirrors the broader process of discovery in the field of quantum computing. It's a testament to their determination and their belief in the potential of merging quantum principles with NMR technology, pushing the boundaries of what's possible with the tools and knowledge at their disposal.

A Breakthrough in Theory

INT. MIT STUDY ROOM - NIGHT

Under the soft buzz of fluorescent lights, the study room is strewn with papers, textbooks, and laptops. The atmosphere is charged with anticipation as the team gathers around a cluttered table. They've been poring over their experimental data, the principles of quantum mechanics, and the mathematical underpinnings of factoring numbers. It's here, amidst this chaos of collaboration, that a theoretical breakthrough begins to emerge.

STUDENT 2, the physics enthusiast, is the first to vocalize the budding idea. "Based on our experiments, we're seeing signs of quantum superposition in the 13-C chloroform. What if we could extend this to quantum entanglement?"

STUDENT 1, with her deep understanding of chemistry, adds, "And if we're achieving entanglement, even briefly, we might be able to manipulate these states to perform computations. The same way quantum computers use qubits to process information."

The room falls silent as the magnitude of their speculation sinks in. It's **STUDENT 4**, known for her mathematical acumen, who connects the dots to their ultimate goal.

STUDENT 4 "Let's think about this. Factoring numbers, at its core, is about finding a solution from a set of possibilities. Quantum computers do this by exploring multiple possibilities at once. If our entangled chloroform nuclei could be manipulated correctly..."

She trails off, but **STUDENT 3** picks up the thread, excitement building in his voice. "Then, theoretically, we could use the NMR to perform a simple computation! It would be a primitive quantum algorithm, but if we're right, it could actually factor a small number like 15 by exploring its factors simultaneously, in a quantum state."

The team dives back into their notes, drawing on everything from their successful and failed experiments to scraps of quantum computing theory they've managed to understand. They sketch out a basic algorithm, a series of steps that could potentially manipulate the entangled states of the chloroform nuclei to perform a rudimentary form of computation.

STUDENT 5, ever the skeptic, tempers the excitement with caution. "This is groundbreaking, but it's purely theoretical. We've got a long way to go from a theoretical algorithm to actual quantum factoring."

Yet, the breakthrough in theory reinvigorates the team. Their diverse backgrounds have allowed them to see beyond the limitations of their individual disciplines, to a place where chemistry, physics, and mathematics intersect in ways they hadn't dared to imagine.

CUT TO:

INT. STUDY ROOM - LATER

The team is now deeply engaged in refining their theoretical model. They debate every aspect of their proposed algorithm, from the sequence of NMR pulses to the interpretation of the quantum states. The whiteboards are a testament to their progress, covered in complex diagrams, equations, and notes.

This segment of their journey is a testament to the power of interdisciplinary thinking and the essence of discovery in science. They've moved beyond the constraints of their coursework into a realm of speculative, yet plausible, scientific innovation. The breakthrough in theory is not just a step towards solving Professor Juvon's challenge; it's a leap into the unknown possibilities of quantum computing.

Overcoming Doubts

INT. MIT COMMONS AREA - DAY

The commons area, usually a bustling hub of student activity, today hosts a different kind of gathering. Word has spread about the ambitious project undertaken by the team, and a mix of curiosity and skepticism draws a crowd. Among the onlookers are fellow students and faculty members, including some who are openly dubious about the feasibility of the team's endeavor.

PEER 1, a fellow student not involved in the project, leans in towards **STUDENT 3**. "You're really trying to use NMR for quantum computing? That sounds more like science fiction than science."

FACULTY MEMBER, overhearing the conversation, adds a more critical perspective. "I've heard about your project. While innovative thinking is encouraged, you must understand the principles you're proposing are highly speculative. Quantum computing is a field in its infancy, and what you're attempting might be beyond the capabilities of current technology, especially with an NMR machine."

The team feels the weight of these doubts. The skepticism is not just a challenge to their project but to their capabilities and vision. However, it's this skepticism that galvanizes their resolve.

STUDENT 2, with a determined look, addresses the crowd. "We understand the skepticism, and yes, it's a long shot. But every piece of data we've gathered leads us to believe it's possible. We're not claiming to build a fully functional quantum computer. We're exploring the potential of quantum states induced by NMR to perform basic computations. It's about pushing the boundaries of what we know."

CUT TO:

INT. NMR LABORATORY - DAY

Back in the lab, the team doubles down on their efforts. They refine their experimental setup, meticulously adjusting the NMR parameters based on their theoretical model. The room is tense as they initiate another round of experiments, this time with a small group of skeptics in attendance.

As the NMR machine whirs to life, the team and onlookers watch the monitors closely. Minutes pass like hours until, finally, the data begins to emerge. Among the noise, a distinct pattern appears, a clear indication of controlled quantum behavior that aligns with their theoretical predictions.

STUDENT 1, unable to contain her excitement, points to the screen. "Look! This is what we've been working towards. These results suggest we've achieved a form of quantum manipulation, a step towards computational operations."

The room, initially filled with doubt, now buzzes with intrigued murmurs. The faculty member who had expressed skepticism steps closer, examining the data.

FACULTY MEMBER (softening) "I must admit, this is more than I expected. It's preliminary, but you've demonstrated something quite remarkable here. Your approach, while unconventional, has merit. I'm looking forward to seeing where this leads."

The team's small yet significant experimental success becomes a turning point. It doesn't just validate their theoretical model; it shifts the narrative from doubt to possibility. The acknowledgment from peers and faculty, even those who were skeptical, fuels their determination to pursue their project to its conclusion.

CUT TO:

INT. STUDY ROOM - EVENING

The team gathers post-experiment, the day's success casting a new light on their work. They're invigorated, ready to tackle the next phase of their project with renewed vigor.

STUDENT 4 "This is just the beginning. We've shown that our idea has potential. Now we need to refine it, to move closer to factoring numbers. Today, we've proven not just to everyone else, but to ourselves, that we're on the right path."

This moment of overcoming doubts underscores the essence of scientific inquiry—perseverance in the face of skepticism, the courage to explore the unknown, and the joy of discovery. The team's journey reflects the innovative spirit of inquiry, a testament to what can be achieved when curiosity meets determination.

Refining the Approach

INT. NMR LABORATORY - WEEKS LATER

The NMR laboratory has become a second home to the team as the semester progresses. The once-daunting machine now bears the marks of their persistent efforts: notes and diagrams taped to its sides, settings meticulously marked for quick reference. The team, more confident and coordinated in their actions, moves with a purposeful energy, their initial experimental setup now significantly more sophisticated.

STUDENT 3, the engineering mind of the group, is adjusting the NMR's settings with precision. "Based on our last round of experiments, I've recalibrated the pulse sequences. We should get a more defined manipulation of the spin states this time."

STUDENT 1 prepares another sample of 13-C chloroform, her hands steady and practiced. "And I've refined the sample preparation, ensuring our chloroform is as pure as possible. Any contamination could skew our data."

The improvements are not just technical. The team's theoretical understanding has deepened, with their strategy for approaching the problem now more nuanced. **STUDENT 2** pores over a complex equation on a whiteboard, a testament to their advancing grasp of quantum mechanics.

STUDENT 2 "Look, if we adjust our approach to factorization by integrating the latest quantum theory we've been studying, we could enhance the algorithm's efficiency. It's about optimizing every step of the process."

As they initiate another experiment, **STUDENT 4** and **STUDENT 5** monitor the data in real-time, their eyes flicking between the screens and their notes. The atmosphere is tense but hopeful; each test is an opportunity to edge closer to their goal.

CUT TO:

INT. STUDY ROOM - LATE EVENING

The team congregates for a debrief, surrounded by the fruits of their labor: reams of data printouts, annotated diagrams, and a labyrinth of mathematical models. The room is a hive of activity, with each member contributing to the analysis of the day's results.

STUDENT 4, the mathematician of the group, highlights a promising pattern in the data. "This sequence here, it's mirroring the expected outcomes of our theoretical model more closely than before. We're definitely refining our approach in the right direction."

STUDENT 5 updates a complex flowchart that tracks their experimental iterations. "With every adjustment, we're learning more about how to control and interpret the quantum states we're generating. It's like we're slowly tuning a radio to the right frequency."

The iterative process of their experimentation is evident in the layers of annotations and corrections that litter the room. Each round of tests, each failure, and success, has contributed to a refined methodology that is increasingly aligned with their theoretical ambitions.

CUT TO:

INT. NMR LABORATORY - ANOTHER DAY

The team is back in the lab, their demeanor a mix of focus and quiet confidence. This time, they're not just running another experiment; they're conducting a carefully planned demonstration of their refined approach for a small audience of peers and faculty, including some of their initial skeptics.

As the NMR machine hums to life and the data starts to flow, the room holds its breath. The results begin to appear on the screens, clearer and more coherent than any they've achieved before. There's a collective sense of anticipation as the team explains the significance of what they're seeing.

STUDENT 1 "This is it. These results are the closest we've come to a practical demonstration of our theory. By refining our approach, adjusting our techniques, and deepening our understanding, we've managed to use the NMR to manipulate quantum states in a way that suggests computational potential."

The audience, once skeptical, now nods in appreciation and genuine interest. Questions are asked, discussions ensue, and the team's work is seen in a new light—a pioneering effort to bridge the gap between quantum theory and practical application.

This moment of refinement and demonstration marks a turning point. The team has not only advanced their project but has also contributed to a broader understanding of quantum computing's potential. Their journey from confusion and skepticism to clarity and validation underscores the transformative power of persistence, collaboration, and intellectual curiosity.

The Final Experiment

INT. NMR LABORATORY - DAY

The laboratory is charged with an electric sense of anticipation. Today, the team is poised to conduct their most ambitious experiment yet—a climactic attempt to factor the number 15 using their NMR setup, a testament to their innovative approach to quantum computing. This final experiment is not just a test of their hypothesis but a culmination of the semester's work, their persistence, and the intellectual journey they have embarked upon.

The setup for today's experiment is the most complex yet. The NMR machine, the centerpiece of their efforts, has been meticulously calibrated. The team has fine-tuned every variable, from the concentration of the 13-C chloroform sample to the sequence and timing of the radiofrequency pulses, based on their refined understanding of quantum mechanics and the insights gained from their previous experiments.

STUDENT 3, overseeing the technical setup, double-checks the equipment. "Everything's calibrated according to our latest parameters. This is as close to our theoretical model as we can get with the equipment we have."

STUDENT 1 carefully loads the chloroform sample into the machine. Her hands are steady, but the tension is palpable. "This is it. Let's see if all our work translates into reality."

The rest of the team gathers around the control console, where **STUDENT 2** and **STUDENT 4** are ready to initiate the experiment. They've attracted a small audience of supportive peers and intrigued faculty members, drawn by the buzz surrounding their project. Among them is **PROFESSOR JUVON**, whose initial challenge sparked this entire endeavor. His expression is inscrutable, but his interest is evident.

STUDENT 5, acting as the spokesperson for the group, addresses the onlookers. "What we're attempting to do today is use the quantum states induced in our 13-C chloroform sample by the NMR to perform a basic computation—factoring the number 15. It's a small step in the grand scheme of quantum computing, but a giant leap for us."

With a collective breath held, **STUDENT 4** initiates the sequence. The machine comes to life, its hum a constant backdrop to the tense silence that fills the room. The team watches the monitors closely, where the data from the experiment begins to stream in real-time.

Minutes pass, the data flowing, patterns emerging, and then, amidst the lines and peaks of the NMR spectrum, the first signs of success appear. The manipulation of the chloroform's quantum states through the carefully orchestrated pulse sequence yields results that, when decoded, align with the factors of 15.

The room erupts into a mix of applause and disbelief. **STUDENT 2** turns to the team, a wide grin spreading across his face. "We did it. We actually did it. It's rough, but the data doesn't lie. We've managed to factor 15 using quantum principles and NMR."

PROFESSOR JUVON steps forward, his gaze sweeping over the team. "Congratulations. What you've achieved here today is remarkable. You've taken an abstract challenge and turned it into a tangible demonstration of quantum computing's potential. This is just the beginning, but it's an impressive start."

The final experiment is more than a success; it's a validation of the team's innovative approach and a showcase of their resilience and collaborative spirit. They've not only managed to bridge the gap between theory and practice but have also laid the groundwork for future explorations into the realm of quantum computing.

As the team discusses the results and the implications of their work, there's a sense of accomplishment but also a recognition that this is merely the first step on a much longer journey. They've opened a door to new possibilities, challenging the boundaries of what's achievable and inspiring others to follow in their footsteps.

Success and Reflection

INT. NMR LABORATORY - POST-EXPERIMENT

The laboratory, still buzzing with the residual excitement of the successful experiment, sets the stage for reflection. The team, surrounded by their peers and Professor Juvon, takes a moment to absorb the magnitude of their achievement. The successful demonstration of factoring the number 15, while a modest computational task, represents a significant leap forward in their understanding and application of quantum principles using NMR technology.

STUDENT 1, looking around at the team, breaks the contemplative silence. "When we started this project, I wasn't sure what to expect. We were stepping into uncharted territory, trying to marry concepts from chemistry, physics, and mathematics in ways that felt, at times, like reaching for the impossible."

STUDENT 3 adds, his voice tinged with pride. "But look at us now. We took that challenge head-on. It wasn't just about the technical skills we developed along the way, but learning to persevere, to keep pushing forward even when the path wasn't clear."

Professor Juvon, who had quietly observed the team's celebration, now steps forward. His expression is one of satisfaction, witnessing the growth and transformation of his students.

PROFESSOR JUVON "You've demonstrated something far more valuable than the ability to factor a number. You've shown the power of interdisciplinary collaboration, of leveraging diverse perspectives and expertise to solve complex problems. This project was about more than quantum computing; it was about teaching you to think beyond the boundaries of your disciplines, to approach challenges with creativity and resilience."

The team listens intently, their faces a mix of exhaustion and exhilaration. The journey had been arduous, filled with moments of doubt and frustration, but also discovery and innovation.

STUDENT 2, reflective, shares a thought that resonates with the group. "We started as a group of students from different majors, each of us looking at the problem from our own academic silo. But we're ending this project as a team that has found a common language in the pursuit of something groundbreaking. It's been an incredible lesson in the value of looking at problems from multiple angles."

STUDENT 4, the quiet observer throughout the project, finally speaks up. "And let's not forget the role of mentorship and guidance. Professor Juvon, you challenged us, but you also trusted us to find our way. It taught us not just to rely on what we know, but to be open to learning from each other and from the process itself."

The reflection session turns into a broader discussion about the future—of quantum computing, of their academic careers, and the potential interdisciplinary projects that lie ahead. The experiment's success has opened their eyes to the untapped potential not only within the field of quantum computing but also within themselves as emerging scientists and innovators.

As the gathering disperses, the team stays back, lingering in the laboratory that has been the crucible of their transformation. The experiment may have concluded, but for them, the journey into the realms of discovery and innovation is just beginning. They leave the lab not just as students who managed to factor a number using quantum principles but as pioneers of a new interdisciplinary approach to problem-solving, inspired to explore the vast, uncharted territories of science and technology.

Actor Paul Reubens as "Pee-Wee Herman" at the 60th Academy Awards – photo by Allan Light