Scientific Partnership: James Prescott Joule, William Thomson, and the mechanical equivalent of heat.

James Prescott Joule, a Manchester owner of a brewery stood in the lecture hall and looked into the faces of the audience that was going to listen to his talk. It was the annual meeting of the British Association for the Advancement of Sciences, the conference where most scientists presented their latest achievements. However, Joule felt a bit uncomfortable, as he was not a trained scientist and considered himself a bit as an outsider. Moreover, it seemed to him that the audience was not really waiting for him to start, but seemingly more eager for him to stop. He seemed to see disinterest in most of the faces that were looking at him. Before starting his communication, Joule took a deep breath and thought about what had him brought here.

Even as a child, he was extremely interested in the sciences. Due to his weak health, he got private tuition, and despite his weakness, he carried out scientific experiments since his childhood days, Actually, he had been able to publish some short papers on a newly invented device – the electrical motor – but like so many other researchers, he could basically just demonstrate that the machine was inefficient from the economic point of view. However, this study had raised his attention to a certain aspect of a well-known principle: The conversion of mechanical work or electricity into heat. Even though this convertibility was established, what puzzled Joule was the quantitative aspect of this relation. In the last years, he had spent a substantial amount of time in developing experiments that should establish that in this conversion there is a quantity that is conserved, and thus there is a direct ratio between the mechanical work and the heat that can be produced by the work.

Joule started to talk, and while he was talking he felt more and more that his initial perception of the audience's complete disinterest in his topic was justified. He presented the numbers he had determined in his careful experiments, and used them to draw his conclusion. When he stopped, there was initially silence, but then a young man in the back started to raise questions. Joule did not know this man, yet, from his questions he realized that the man had a profound knowledge in the sciences of heat. And even though Joule had to confess that he could not answer all the questions (and he was not even sure whether he understood them properly), the young man kept insisting. Others started to get interested, Joule was not sure whether they wanted to ask him out of interest, or whether the young man's interest made them think that his topic must have some relevance.

When the time for discussion was over, Joule was relieved – he had the feeling that the topic of his talk had finally gotten the attention of some scientists, and at the same time he was glad that he could relax a bit after this series of questions. But at least the latter feeling vanished immediately as the young man approached to him and introduced himself as William Thomson. Joule had already heard of him, Thomson was a newly appointed professor of physics in Glasgow, he had studied in Cambridge and afterwards worked with the French Victor Regnault, the leading experimentalist in the sciences of heat. Having gained the attention of this young scientist, who was said to become a leading figure in the field, cheered up Joule. Despite his initial skepticism it seemingly had not been just a waste of time to attend this meeting.

After introducing himself, Thomson started some more discussion, asking details about his experimental procedures, questioning Joule's ability to read thermometers with an (admittedly hard to believe) accuracy of 1/200°F, and pointed out contradictions between Joule's claims and the established understanding of steam engines that was based on the so-called Carnot cycle. Finally, when everyone else had already left the room, Joule took a deep breath. He asked whether Thomson would like to come to Manchester to see and examine his experiments. Whilst

Thomson was quiet for a short moment, Joule became doubts again – what if Thomson would reject his invitation? But then a smile went over the face of the young man, and he said "Yes, why not. I have some commitments in the next days, but I shall be able to come for a day or two to Manchester to see your experiments."

A few weeks later, Joule was able to show Thomson his experiment that had been set up in the cellar of his brewery. The experiment had to be done in the room as it required a uniform temperature, and in the respect, the cellar of a brewery was almost ideal. One of the workman of the brewery was already standing behind the screen that was supposed to protect the apparatus from the heat radiation of his body. Joule put one of his thermometers into the water that was kept in the copper vessel, whilst the second was standing next to it. He waited some time, then read the instruments, removed them and, with a nod of his head, made the workman wind up the weights, let them go down again whilst the water in the vessel was stirred through their mechanical force, and repeat this 20 times. Joule read always the exact height of the weight, and produced a column containing 20 numbers. Then, the workman stopped, Joule replaced the thermometers into their positions and, after a few minutes, read the temperatures again.

He handed the sheet with the data to Thomson who did some quick calculations, and then started to smile at Joule: "I guess, Mr. Joule, you really have found one of the deep truths that structure nature. Even though I have some conceptual problems with your results, they appear to be valid, and I will support your findings in the future." Joule smiled back, and a feeling of deep satisfaction was in this smile: he knew, he had been right all the time, and he knew that after convincing Thomson, other scientists would also start to believe his findings.

James Prescott Joule, the owner of a Manchester brewery, succeeded in determining experimentally the value of the mechanical equivalent of heat. It took almost eight years from his first attempt to his publication in the prestigious Transactions of the Royal Society London. His work on the mechanical equivalent of heat was crucial for the development of the concept of energy (how mechanical force was called by then) and the principle of energy conservation. From the contradiction between Joule's findings and the established Carnot cycle, scientists – among them William Thomson – developed the concept of entropy. Due to Joule's achievements, he was honored particularly: the unit of energy was given his name while he was still alive, so far, he is the only scientist who was ever honored in such a manner during his lifetimes.

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Story: Scientific Partnership: James Precott Joule, William Thomson, and the mechanical equivalent of heat was written by Peter Heering, with the support of the Lifelong Learning Programme of the European Union and the University of Flensburg, Germany.