

then took up the paper carefully by the two sides, bending the two sides upward at the same time, to keep the filings in the middle of the paper. In this way he raised the paper above the lamp, which was upon the table before him, and then holding it in an inclined position, he let the sand slide down into the flame of the lamp. To Rollo's surprise and delight, it produced a column of sparkles rising up from the flame, which were of the greatest brilliancy and beauty.

"Yes," said Rollo, "they burn, they burn most beautifully. File me some more, Jonas, and let me carry them in and show them to my mother."

Jonas accordingly filed some more filings, and Rollo went in with them very eagerly, to show to his mother.

"Just look," said Rollo; and so saying, he held the paper over the lamp in such a manner as to let the filings slide down into the flame just as Jonas had done. The experiment succeeded perfectly well, as it had done before.

"So you see that it will burn," said Mr. Holiday, "if you heat it hot enough."

"If you make it small enough, you mean," said Rollo.

"I suppose the smallness of the particles is of no consequence," replied his father, "excepting to make it easier to heat them."

"Why, father," said Rollo, "I might put the end of a knitting needle in the lamp, and I don't see why it wouldn't become as hot as one of the iron filings."

"Because," said his father, "a part of the heat would be conveyed away through the knitting-needle towards your hand, and that would keep the end which was in the flame cooler."

"Would it, sir?" asked Rollo.

"Yes," said his father. "The heat moves off very fast in such a case. You know, if you take a pin between your fingers, and hold the head of it in the lamp, the heat will almost immediately move along the metal, so as to heat the end that you are holding, and burn you."

"Yes, sir," said Rollo; "I have got burned so, very often."

"And of course much more heat would be conveyed away when the metal was as thick as a knitting-needle."

"Well, father," said Rollo, "suppose a piece of the knitting-needle was broken off, and made so small that it could all be in the flame; then would it burn?"

"How could you keep it there?" asked his father.

"Why—I don't know," said Rollo, hesitating. "Couldn't we contrive some way to keep it there?"

"I don't know of any way."

"Couldn't we put it on the end of the wick?" asked Rollo.

"Yes," said his father, "perhaps we might; but then the end of the wick is cool, and that would cool it."

"O father," said Rollo, in a tone of great surprise, "the end of the wick cool, when it is right in the middle of the blaze?"

"I mean," replied his father, "that it is cool compared with the heat necessary for inflaming the iron. It would feel very hot to your fingers, I have no doubt, for it is filled with boiling oil. But then even the heat of boiling oil is less than that necessary to inflame iron; and so the contact of the wick with such a piece of iron as you propose, would keep it cool, or rather keep it from getting hot enough to take fire."

"Suppose there was any way," said Rollo's mother, "of suspending a piece of iron as large as the end of a knitting-needle in the lamp; do you think it would take fire?"

"No," said Mr. Holiday, "I don't think it would be heated hot enough. For some reason or other, I don't understand exactly what, a large piece of iron cannot be heated very hot in a small fire, even if the fire entirely covers it. I don't think that any fragment of iron much larger than one of Jonas's filings, could be heated in a lamp so as to take fire. But it could be heated hot enough in a forge. The end of the iron which a blacksmith heats, is often in a state of combustion when he takes it out of the fire."

"There, now, father," said Rollo, "you have not explained to me yet about combustion and burning."

"No," said his father; "we had almost forgotten that. I will explain it now. It will only take a few minutes. Let me see—I began to tell you, didn't I?"

"Yes, sir," said Rollo; "but I couldn't understand very well."

"I was telling you that the language which we use in common conversation, is not precise. It is often ambiguous."

"What does that mean, sir?" said Rollo.

"Why, language is ambiguous when it has two meanings,"

said his father. "For instance, the word *burning* is used in conversation to express two or three very different things. If you put your finger upon hot iron, you say you have burned it. *Burn*, in that case, is the name of a painful feeling. But if you say you burned a piece of paper, you mean that you put it into the fire, and allowed it to be consumed. In that case, *burning*, instead of being the name of a painful feeling, is the name of a peculiar process by which the paper is consumed and destroyed. Thus the word *burn* is used to denote two very different effects. In fact, it is used in other senses besides these."

"What others, sir?" asked Rollo.

"Why, when we say that a little girl was out in the sun, and burned her face and neck, we do not mean that her face and neck were consumed, or that they felt a painful sensation,—but that the skin was reddened by the sun's heat. So, when we say that the grass was all burned up in the drought, we mean that it was dried and withered. Thus *burned* and *burning* are used to denote a great variety of effects produced by heat, which effects are very different from each other in their nature. So that, you see, when we are going to speak philosophically of that peculiar process by which bodies are actually consumed by fire, it becomes necessary to have some term to denote that process alone, and not all the other kinds of burning. Now, the word the philosophers use for this purpose is *combustion*. The burning of a stick of wood upon the fire is combustion; but the burning of your finger against a hot iron is not combustion, and the burning of bricks in a brick kiln is not combustion."

"Nor the burning of the grass in the drought," said Rollo.

"No," said his father. "Thus you see that *combustion* is a term of precise and definite meaning; it denotes a particular process, and that alone. But *burning* is a vague and ambiguous term. It has a great many meanings, or, rather, it stands for a great many different effects, very much unlike in their character. In fact, they seem to be alike in no respect, except that they are all produced by heat."

"Yes, father," said Rollo, "I understand."

"Sometimes," added his father, "the word used in common life doesn't mean enough, instead of meaning too much. For example, there is the word *freeze*. What is the meaning of the word *freeze*?"

"Why, it means," said Rollo,—"freeze!—it means—water turning into ice."

"Yes," replied his father; "when water is cooled below a certain point, it becomes solid. It is just so with lead. Melted lead, when it is cooled below a certain point, becomes solid. The hardening of the melted lead into solid lead, and the hardening of water into ice, as they cool, seem to be phenomena of precisely the same character, and yet the word *freeze* applies only to one. We say the water freezes, but we can't say the lead freezes."

"Why not, sir?" asked Rollo.

"Because it is not the customary use of the word. If we use the terms of common life, we must use them as they are customarily used, or we shall not be understood. *Freezing*, therefore, will not answer to express all cases of the hardening of a liquid by cold, because that is a term which is only applied to a few of the cases. Now, philosophers want a term which will apply to all cases of the same kind."

"And what is their word?" asked Rollo.

"*Congelation*," replied his father.

"*Congelation*?" repeated Rollo.

"Yes," said his father. "When water becomes ice, the philosophers say it *congeals*. So when lead hardens in cooling, they say it *congeals*. Different substances congeal at very different degrees of heat. If we had melted iron and melted lead, equally hot, and let them cool together, the iron would congeal first; and if they continued cooling, by and by the lead would congeal. Water would remain liquid long after lead would congeal; but if it was placed where it would grow colder and colder, the temperature would at last reach the point where water would congeal too. But whatever the liquid is, and whatever the point is at which it changes from a liquid to a solid form, it is called *congealing*."

"And the word *freezing*, then, is only used in respect to water," said Rollo's mother.

"Why, yes," said Mr. Holiday; "we speak of other things freezing beside water, at it is only such things as become solid under great degrees of cold. We say ink freezes, and oil, and if it were cold enough to freeze brandy, or mercury, we should say