ABBOTT JACOB

ROLLO'S PHILOSOPHY. [AIR]

Jacob Abbott

Rollo's Philosophy. [Air]

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PREFACE

The main design in view, in the discussions which are offered to the juvenile world, under the title of The Rollo Philosophy, relates rather to their effect upon the little reader's habits of thinking, reasoning, and observation, than to the additions they may make to his stock of knowledge. The benefit which the author intends that the reader shall derive from them, is an influence on the cast of his intellectual character, which is receiving its permanent form during the years to which these writings are adapted.

The acquisition of knowledge, however, though in this case a secondary, is by no means an unimportant object; and the discussion of the several topics proceeds accordingly, with regularity, upon a certain system of classification. This classification is based upon the more obvious external properties and relations of matter, and less upon those which, though they are more extensive and general in their nature, and, therefore, more suitable, in a strictly-scientific point of view, for the foundations of a system, are less apparent, and require higher powers of generalization and abstraction; and are, therefore, less in accordance with the genius and spirit of the *Rollo* philosophy.

As teachers have, in some cases, done the author the honor to introduce some of the preceding works of this class into their schools, as reading books, &c., considerable reference has been had to this, in the form and manner of the discussion, and questions have been added to facilitate the use of the books in cases where parents or teachers may make the reading of them a regular exercise of instruction.

CHAPTER I.
LOST IN THE SNOW

One pleasant morning, very early in the spring, Rollo's cousin Lucy came to call for Rollo to go on an expedition, which they had planned the day before. It was near the end of March, and the snow had become so consolidated by the warm sun in the days, and the hard frosts at night, that it would bear the children to walk upon it. The children called it the crust; but it was not, strictly speaking, a crust, for the snow was compact and solid, not merely upon the top, but nearly throughout the whole mass, down to the ground.

Rollo and Lucy were going to have an expedition upon the crust. Rollo had a sled, and they were going to put upon the sled such things as they should need, and Rollo was to draw it, while Lucy and Nathan, Rollo's little brother, were to walk along by his side.

Rollo's sled was ready at the back door, when Lucy came. Lucy brought with her some provisions for a luncheon, in a basket. This was her part of the preparation. Rollo got his axe, and one or two boards a little longer than the sled, which he said were to make seats. He also had a tinder-box, and some matches, to enable him to make a fire. When all things were ready, the three children set out together.

Rollo drew the sled, with the boards, the basket, and some other things upon it, all bound together securely with a cord. The load appeared to be considerable in bulk, but it was not heavy, and Rollo drew it along very easily. They were not obliged to confine themselves to the roads and paths, for the snow was hard in every direction, and they could go over the fields wherever they pleased. In one place, where the snow was very deep on the side of a hill, they went right over the top of a stone wall.

It was a cloudy day, but calm. This was favorable. The sky being overcast, kept the sun from thawing the snow; but yet their father told them that probably it would begin to grow soft before they came home, and, if so, they would have to come home in a certain sled road, which Jonas had made that winter by hauling wood. He advised them not to encamp at any great distance from the sled road.

They came at last to a pleasant spot on the margin of a wood, near where there was a spring. The rocks around the spring were all covered with snow, and the little stream, which in summer flowed from the spring, was frozen and buried up entirely out of sight. But the spring itself was open, which Rollo said was very fortunate, as they might want some water to drink.

Here they encamped. Rollo cut some stakes, which he drove down into the snow, and contrived to make a rude sort of table with his boards. He also cut a large number of hemlock branches, which Lucy and Nathan dragged out and spread around the table for them to sit upon. Then Rollo built a fire of sticks, which he gathered in the wood. The ground was covered with snow, so that it would have been very difficult for him to have found any sticks, were it not that some kinds of trees, in the woods, have a great many small branches near the bottom, which are dead and dry. These Rollo cut off, and Lucy and Nathan dragged them out, and put them on the fire when he had kindled it. The fire was a little way from the table, with the carpet of hemlock boughs between.

There was a high hill covered with snow at a little distance, and, after they had eaten their luncheon, Rollo said,—

"O Lucy, we will play go up the mountains. There is a hill for us. That shall be Chimborazo."

"Well," said Lucy, "if you will cut us some long staves."

Accordingly Rollo went into the wood, and selected some tall and slender young trees, about an inch in diameter, and cut two for Lucy, two for Nathan, and two for himself. These he trimmed up smoothly, and each of the children took one in each hand. They played that Rollo was the guide, and Lucy was the philosopher. Nathan was the philosopher's servant. Rollo conducted them safely to the summit; but just after they got there, it began to snow.

The snow descended in large flakes, and Rollo was delighted to see it; but Lucy seemed a little anxious. She said that, if there should be much snow, it would make it hard for Nathan to get home, and she thought that they had better go down the mountain immediately, and set out for home. Rollo was rather unwilling to go, but he allowed himself to be persuaded, and so they all came down the mountain together.

They packed up their things as quick as they could, leaving the fire to burn itself out, only Rollo first piled on all the hemlock branches,—which made a great crackling. The snow began to fall faster. The air was full of the large flakes, which floated slowly down, and lodged gently upon the old snow.

The children went along very successfully for some time, but at length Rollo lost his way. The air was so full of snow-flakes, that he could see only a very little way before him; and the old snow covered the ground, so as to hide all the old marks, and to alter the general aspect of the fields so much, that Rollo was completely lost. He, however, did not say anything about it, but wandered on, Lucy and Nathan wondering all the while why they did not get home; until at length they came across a track in the snow.

"O! see this track," said Rollo. "Here is a track, where somebody else has been along with a sled."

"Yes," said Lucy, "some boys, who have gone out to slide, perhaps."

The track was partly obliterated by the snow which had fallen upon it since the boys that made it had gone along. Rollo wondered whose track it could be. He said that he thought it very probable it was Henry's. Lucy thought that it might be the track of some children, that had gone out to find them.

"At any rate," said Rollo, "we will follow the track a little way, and see what it leads to. Perhaps we shall overtake the boys."

Accordingly Rollo turned along in the track, but Lucy stopped.

"No, Rollo," said she, "we must go the other way if we want to find the boys;—the track is going the other way. But never mind," she added, "I don't want to find the boys; I want to go home; so we will go this way."

Rollo went on, secretly pleased to find the track, for he supposed that by retracing it, as he was doing, it would lead him back home. He had, however, a great curiosity to know who could have made it; and in fact the mystery was soon unraveled.

For, after following the track a short distance, they saw before them a large, dark spot upon the snow, and, on drawing near to it, to see what it was, they found it was the place of their own encampment; and the track which they were following was their own track, leading them back to the mouldering remains of their own fire. They had gone round in a great circle, and come back upon their own course. Rollo looked exceedingly blank and confused at this unexpected termination of the clew, which he had hoped was to have led him out of his difficulty. What he was to do now, he did not know.

The fact, however, that they were lost, was no longer to be concealed; and Lucy proposed that they should go into the woods, where the tops of the trees would act as a sort of umbrella, to keep the snow from falling upon them, and wait there until it stopped snowing; and then the air would be clear, and they could find their way out.

"O," said Rollo, "I can easily make a hut of hemlock branches, and we can go into that for shelter."

"But, Rollo," said Nathan, "how do you know but that it will snow all day? We can't stay in the woods all day."

"No," said Rollo; "when it snows in great flakes, it is not going to snow long. Jonas told me so."

So the children went into the woods, and Rollo began to make his hut; but he was soon interrupted, and the attention of all the children was called off by a little bird, which they saw there, hopping about, and appearing benumbed with cold. After some effort, Rollo succeeded in catching her in his cap.

"We'll carry her home," said Nathan; "we'll carry her home, and show her to mother."

"Yes," said Rollo, "I'll carry her in my cap."

"No," said Lucy, "you must have your cap on your head, or you will take cold. Let me carry her in my hands."

"No," said Rollo, "you will have to lead Nathan. I'll tell you what we will do. We will put her into the basket, for a cage."

Lucy, on the whole, liked this plan, and they accordingly put the bird in the basket, and Rollo contrived to make a cover of boughs, to keep her from getting away.

By the time that this was all arranged, the children found, to their great satisfaction, that it had ceased snowing; and they immediately set out for home. Rollo drew the sled, with the basket and bird upon it, secured as before with the cord; and Lucy led Nathan. They now had no difficulty in finding their way, and soon reached home in safety.

They kept the bird until the next day, and then, as it was mild and pleasant, they let her fly away.

QUESTIONS

By what process had the snow become hardened at this time? Did Rollo's father expect that it would continue hard till noon? Why not? Did it continue hard? What prevented its melting? How did Rollo get sticks for his fire? What name did he give to the hill which they ascended? What occasioned the difficulty in the way of Rollo's finding his way home? What conversation took place when he found the track? Was this track in the new snow, or in the old snow? How had it become partly obliterated? How did they carry the bird home?

CHAPTER II.
FLYING

Nathan became very much interested in the bird, and that evening, as his father was sitting by the fire, with a book in his hand, which he had been reading, Nathan came up to him, and said,—

"Father, are you busy now,—thinking, or anything?"

"No," said his father.

"Because," said Nathan, "if you are not, I want to read you something out of my little book."

So Nathan's father took him up into his lap, and Nathan opened his little book, and began to read as follows:—

"'With fins for the water, and wings for the air,
And feet for the ground, I could go everywhere.'

"Isn't that funny?" said Nathan.

"Rather funny," said his father.

"I wish I had wings," said Nathan.

"Why?" said his father.

"Why, then I could fly."

"That is not certain," said his father. "There are two difficulties which prevent boys from flying. One is, they have no wings; and the other is, they have not strength to use them."

"O father," said Nathan, "I could use them; I am pretty strong. I can wheel Rollo's wheelbarrow."

His father smiled. "Very possibly," said he; "but I do not think that you would be strong enough to use wings, even if you had them."

"Why, at any rate, I am stronger than a bird," said Nathan.

"Yes," said his father, "you have more actual strength than a bird, but not more in proportion to your size. You are absolutely stronger, but not relatively."

"What do you mean by that?" said Nathan.

"Why, you have actually more strength than a bird,—a robin, for instance; you could hold him so that he could not get away; and you could lift more than he could too. But then you are a great deal larger, and you are not as much stronger than he is, as you are larger. If you are a hundred times as heavy as he, you are not a hundred times as strong. That's what I mean by saying that you are absolutely stronger, but not relatively. That is, you are not as many times stronger, as you are larger and heavier. You are absolutely stronger, but not relatively; that is, in proportion to your size and weight.

"Now I can prove to you," continued his father, "that you would not be strong enough to fly with wings, even if you had them. Suppose there was a pole fastened across the room, and another pole just above it; could you pull yourself up, from one pole to the other, by your hands alone, without touching your feet?—Or a ladder," continued his father,—"it will be better to suppose a ladder. Now, if there was a ladder leaning up against a building, could you climb up on the under side by your hands, drawing yourself up, hand over hand, without touching your feet?"

Here Rollo, who was reading in a little chair at the back part of the room, when his father first commenced the conversation with Nathan, but who had been listening for a few minutes past to what his father had been saying, jumped up, and came across the room to his father, and said,—

"Yes, sir, yes, sir; I can. I have done it often in the barn."

"How high up could you go?" said his father.

"O, almost up to the loft," said Rollo. "Only, you see, father, the rounds are too far up. I can't reach up very well. If they were nearer together, I could climb up so, very well."

"Well," said his father, "a bird, when flying, has to climb up in much the same way. He has to pull himself up by the *air*, with his wings, just as you do with your hands and arms, by the rounds of the ladder; only the air is not fixed, like the ladder, but constantly gives way under his wing; and so, to make the case the same, you must suppose that the ladder is not firm, but is floating in the air, and sinks down with your weight, so that you have to climb up faster than you pull the ladder down. Do you think you would have strength enough in your arms to do that?"

Rollo and Nathan looked very much interested in what their father was saying, but they both admitted that they could not climb up such ladders as those.

"The air," added their father, "gives way continually under the bird's wing; and yet they have to pull themselves up by it. And this is very hard. They must either have very large wings, and prodigious strength to use them, so as to pull upon the air with very hard and heavy strokes, or else, if they have small wings, they must have strength to strike very quick and often with them.

"The wings of sparrows move so quick, that you cannot count the strokes; and those of humming-birds, which are smaller still, so fast that you cannot see them. They make a hum."

"I could make my wings go so fast," said Nathan; and he began to imitate the flapping of the wings of a bird, with his arms, as rapidly and forcibly as he could.

"So can I," said Rollo; and he made the same motions. "That is as fast as crows' wings move, when they are flying."

"Yes," said his father, "crows move their *wings* as fast as that, whereas you only move hands and arms. If you had great wings, as long, in proportion, as the crows, you could not move them so fast."

"How large would they be?" said Rollo.

"O, I don't know,—perhaps as big as the top of the dining-table."

"O father," said Rollo, "I don't think they would be as big as that. The crow's wings are not longer than his body, and so mine would not be longer than my body."

"Perhaps you never saw a crow's body," said his father. "His feathers and his tail, which are very light, swell out his body, and make it appear much larger than it really is. I presume his wings, when they are spread, are twice or three times as long as his body. If you had wings in proportion, it would be with the utmost difficulty that you could use them at all. You certainly could not strike the air with them fast enough to pull yourself up by them."

"I did not think that the birds pulled themselves up by the air," said Nathan. "I did not know that the air was anything *real*."

"O yes; it is something real," said his father.

"I've seen birds fly without moving their wings at all," said Rollo.

"Yes," said his father, "and so have I seen a stone."

"A stone!" repeated Rollo.

"What, a stone fly?" said Nathan.

"Yes," replied his father; "did you never see a stone fly through the air, without any wings at all?"

"Why, yes," said Rollo, "when somebody threw it."

"Very well," said his father. "If you set the stone in motion, it will continue in motion for some time, without any wings; and so will a bird."

"But, father, they don't throw birds," said Nathan; and he laughed aloud at such an idea.

"Birds throw themselves," said his father; "that is, they strike their wings upon the air, hard and quick, and thus get into very quick motion, and then they can keep their wings still for a time, and go on, as long as the impulse they have given them lasts. This shows what prodigious strength they have in their wings. They can not only strike the air hard and frequently enough to raise themselves up, and move along, but they can do it so easily, as to get such a velocity, that they can rest their wings for some time, and sail away through the air, only expending the impulse they had accumulated."

Rollo and Nathan were silent. Rollo was thinking how he had seen the swallows sailing swiftly round and round in the air, with their wings spread out motionless by their side.

"So, you see," continued his father, "the difficulty in the way of a boy's flying, is not the want of wings, but the want of strength to use them. It would be very easy to make wings."

"Would it?" said Nathan.

"Yes," said his father. "At least it would not be very difficult. Ingenious mechanics would soon find out modes of making something to answer the purpose of wings, to strike upon the air, if there was the necessary power to work them. The great difficulty in almost all cases in mechanics is, in getting the power; there is very little difficulty in applying it to any purpose it is wanted for. So, you see, next time, Nathan, when you want to fly, you must wish, not that you had wings, but that you were strong enough to use them."

"Well, father," said Rollo, "men are strong enough to paddle themselves along in the water; why can't they in the air?"

"Because," said his father, "water supports them by its buoyancy, and they have nothing to do but to move themselves along upon it. But air cannot support them; and, of course, a great part of the effort which they would make, would be required to keep them up. And then, besides, the water is generally nearly at rest, but the air is generally in a state of rapid motion."

"Why, father," said Rollo, "I'm sure water is sometimes in rapid motion. The rivers run very swiftly, often."

"Yes," replied his father; "but then, when they do, men cannot paddle, or row boats upon them. A current that should run at the rate of four or five miles an hour, would be very hard to row against. But the air is seldom in a state of less motion than that. It is very often moving at the rate of fifteen or twenty miles an hour; sometimes sixty. So, you see, there is a double reason why men cannot fly in the air, as well as paddle on the water."

"If we were only light enough," said Rollo, "to float in the air, then we could fly."

"We could paddle about in it, when it was calm," replied his father, "but that would not be flying."

"Is there anything light enough to float in the air?" said Rollo.

"No," said his father, "I don't think of any visible substance that is."

"What do you mean by visible substance?" said Nathan.

"Why, anything that you can see," replied his father. "There are some other kinds of air, which are lighter than common air, but there is nothing else, so far as I know."

"Why, father, there are clouds. They float, and they are visible, I am sure."

"Yes," said his father. "There is some mystery about the floating of clouds. I don't fully understand it. Clouds are formed of small globules or little balls of water; and water, I should think, whatever the size of the little drops might be, would be heavier than air. And yet they seem to float. If they are large, like rain drops, they fall quickly to the ground. If they are small, like mist, they fall slowly. That I should expect. If they are finer still, like vapor or fog, I should think that they would fall still more slowly; but still I should suppose that they would descend. But they do not appear to descend; they seem to float, nearly at rest; though perhaps all the clouds we see, may be slowly descending all the time, while we do not perceive it."

"The smoke goes up from the top of the chimney," said Rollo.

"Yes," said his father, "there is no difficulty about that. The vapor from a fire is carried up by the warm air, no doubt. Air swells when it is heated, and so becomes lighter, and rises; and the hot air from the top of the chimney carries the vapor up with it, no doubt. After it rises a little way, and becomes cool, it ceases to ascend, but floats away horizontally. Perhaps it begins to descend when it gets cool, though very slowly; and perhaps all clouds are really descending all the time, though too slowly for us to perceive the motion."

"Only," said Rollo, "after a little time, they would get down to the ground."

"Perhaps not," said his father; "for, when they get down nearer the earth, where it is warm, they may be gradually dissolved, and disappear, and thus never reach the earth. I should think they would descend, being composed of globules of water, which, however small, must, I should think, be heavier than air."

"A soap bubble will float in the air," said Rollo.

"I never saw one that would," said his father, "unless it got into a current, which carried it up. A soap bubble—make it ever so thin—shows a tendency to descend, unless you put it out in the open air, where there are currents to carry it up. It descends very slowly, but still it descends. It is heavier than the air. I am not absolutely certain, but I believe there is no visible substance that is lighter than the air; and it is very well for us there is not."

"Why, father?" said Rollo.

"Because, if there were any, they would immediately rise from the earth, and float upwards, till they got up where the air was so light and thin, that they could not go up any higher."

"And so," said Rollo, "we should lose them."

"That would not be all," said his father. "They would float about, above us, and, if there were enough of them, they would form a perpetual cloud over our heads, to keep out the sun, and to make the world dark and gloomy. There seems to have been no way to keep all the solid and visible substances of the earth down upon its surface, but to make them all heavier than the air.

"And thus," continued his father, "all solid substances being heavier than the air, they sink in it, like stones or iron in water. Only those that are very much expanded in surface, sink very slowly, and sometimes almost seem to float."

"What do you mean by *expanded*, father?" said Nathan.

"Spread out," said his father. "An umbrella, for example, when it is spread out, is said to be expanded; other things are expanded in a little different way. A feather is expanded, that is, it is spread out in fine filaments, which extend, in every direction, into the air, all around the stem of it. Things that are expanded take a great deal of air with them when they descend, and so can only descend slowly."

"And water is expanded in a soap bubble," said Rollo.

"Yes," replied his father, "and there is a great deal of air included in it, which all has to be brought down when the bubble itself descends. And thus, you see, the bubble must descend slowly. Water is expanded, too, in clouds; for, in that case, it is divided into millions of small particles, by which it is spread out over a great deal of air, and cannot descend without bringing a large portion of the air with it. Men have contrived, on this principle, to make an apparatus to prevent being hurt by falling from great heights."

"What is it?" said Rollo.

"Why, it is called a parachute. It is a sort of umbrella; in fact, it is an umbrella, only made very large. It is folded up, and fastened under a balloon, just over the car, which the man is in. Then, if the balloon bursts, or any other accident happens to it, and the man begins to fall, the parachute opens and spreads, and then the man falls very slowly. The reason is, that the parachute takes hold of a large mass of air, and brings it down with it; and so it cannot descend very fast."

A few days after this, Nathan said to Rollo, as they were playing in the yard, that he wished that he had a parachute.

"I know where there is one," said Rollo.

"A parachute," said Nathan; "a real parachute?"

"Yes," said Rollo, "or, what is the same thing, a great umbrella."

"Is that just the same?" said Nathan.

"Yes," said Rollo; "for father said that a parachute was in fact only a large umbrella; and father has got a large umbrella in the closet, and I have a great mind to go and get it for a parachute."

"But you haven't got any balloon," said Nathan.

"O, no matter for that," said Rollo.

"Then how are you going to get up into the air?" asked Nathan.

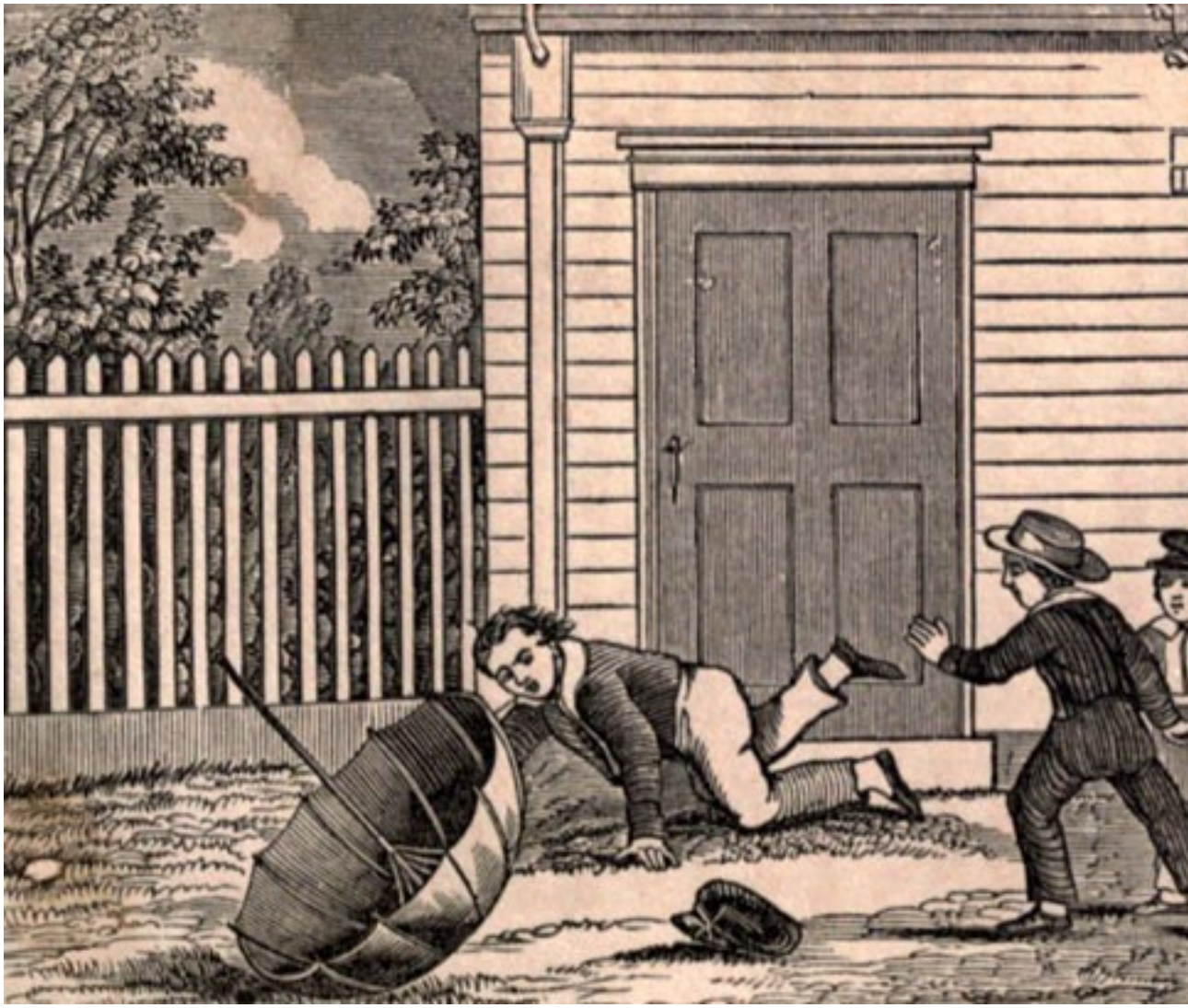
"Why, I can climb up on the shed, and jump off that, and hold the umbrella over my head."

Just at this moment, Rollo's cousin James came into the yard, and Rollo ran to him, to explain to him about the parachute. After describing to him the construction of it, and its use by men who go up in balloons, he said he was going to get his father's umbrella, which would make an excellent parachute.

"And then," continued he, "I am going to get upon some high place, and jump off, and hold the parachute over my head, and then I shall come down as light as a feather."

"O Rollo," said James, "I don't believe you will."

"Yes I shall," said Rollo: "you see the parachute is expanded, and so brings down a great deal of air with it, and this makes it come very slowly. Air is a *real thing*, James, and it keeps the parachute back a great deal."



"James and Nathan both ran towards him, thinking that he must be hurt."—Page 37.

So Rollo ran off after the umbrella, very much interested in proving to James, by actual experiment, that the air was a real thing. When he came with it, he was himself inclined to make the first experiment from the low side of the shed. He could climb up, by means of a fence at the corner. James advised him, however, to try it first from the end of a woodpile, which was pretty high, but yet not so high as the shed. James was not quite sure that the experiment would succeed, and he was afraid that Rollo might get hurt.

Rollo said that he was not afraid to jump off the shed. He knew the parachute would bear him up. He did not believe but that he could jump off the house with it; and, at any rate, he could jump off the shed, he knew. He accordingly clambered up, and, taking his station upon the eaves, he spread the umbrella over his head, and then jumped off.

Down he came with great violence; his cap flew off in one direction, and his umbrella rolled away in another, as he had to put out both his hands, to save himself, when he reached the ground. As it was, he came down upon all fours, and in such a way, that James and Nathan both ran towards him, thinking that he must be hurt.

"Did you hurt yourself, Rollo?" said James.

"No," said Rollo, "not much."

"I don't think the umbrella did you much good."

"No," said Rollo, as he got up rubbing his elbows, "it didn't, and I don't see what the reason is."

"You came down just as hard as you would without it."

"Yes," said Nathan, "and he almost broke his back; I don't believe the air is any real thing at all."

The fact was, that the umbrella did do *some* good. Rollo did not come down quite so hard as he would have done without it. It retarded his descent a little. But it was not large enough to enable him to descend in safety. When his father said that a parachute was in fact only a large umbrella, he meant a great deal larger than Rollo had supposed. A parachute, such as is used with balloons, is a great deal larger than any umbrella that ever was made.

QUESTIONS

What was Nathan's wish, after he had read his father something out of his book? Did he think that he could fly if he had wings? Did his father think so? What deficiency did his father think was even more important than that of wings? Did Nathan think that a boy was stronger than a bird? Is a boy *absolutely* stronger than a bird? Is he *relatively* stronger? What is the meaning of *relatively* stronger? Would a man be strong enough to work wings that were sufficiently large to bear him up into the air? Would there be any great difficulty in constructing wings for him if he were strong enough?

Is any visible substance lighter than air? What would be the consequence if any of the loose substances about the earth's surface were light enough? What are clouds composed of? What difficulty did Rollo's father point out, in regard to their floating in the air? What is a *parachute*? Describe Rollo's experiment with the umbrella.

CHAPTER III.
VALVE MAKING

One morning, when Rollo awaked, he heard a sharp clicking against the window.

"Nathan," said he, "Nathan, I believe there is a snow-storm."

But Nathan was too sleepy to hear or understand.

Rollo looked up, but there was a curtain against the window, and he could not see very well. He listened. He heard a low, moaning sound made by the wind, and a continuance of the sharp clicking which he had heard at first.

When he had got up, and dressed himself, he found that there was a violent snow-storm. At first he was glad of it, for he liked snow-storms. But then, pretty soon, he was sorry, for it had been winter a long time, and he was impatient for the spring.

After breakfast, he and Nathan read and studied for two hours, under their mother's direction. When they were released from these duties, Rollo proposed to Nathan that they should go out into the shed, and see how the storm came on. There was a large door in the shed, opening towards the street, where they could stand, protected from the wind, and see the drifts of snow.

They accordingly put on their caps, and went. They found that the snow was pretty deep. It was heaped up upon the fence and against the windows; and there was a curious-shaped drift, with the top curled over in a singular manner, running along from the corner of the shed towards the garden gate.

"Ah," says Rollo, "when it clears up, I mean to go and wade through it."

"And I too," said Nathan.

"O Nathan," said Rollo, "it is over your head."

"Hark!" said Nathan; "who is that pounding in the barn?"

"It is Jonas, I suppose," said Rollo. "I mean to go out and see what he is doing."

"How are you going to get there?" said Nathan.

"O, I can put on my boots," said Rollo, "and go right out through the snow."

"I wish *I* could go," said Nathan.

"Well," said Rollo, "I can carry you on my back."

Nathan clapped his hands at this proposal, being doubly pleased at the prospect of both getting into the barn to see what Jonas was doing, and also of having a ride, on the way.

So Rollo put on his boots, while Nathan went and got Rollo his straps, to fasten his pantaloons around them. When all was ready, Rollo sat down upon the step of the door, in order that Nathan might get on easily.

"We'll play that I am a camel," said Rollo, "and that I'm kneeling down for you to get on."

"Do camels kneel down," said Nathan, "when the men want to ride?"

"Yes," said Rollo; and so saying, he rose laboriously, with his heavy burden upon his shoulders. He staggered along with some difficulty, but yet safely, until he came to the great drift; and, after wallowing into the midst of it, he lost his balance, and both camel and driver rolled over together into the snow. The snow got up under Nathan's sleeve, and he began to cry.

"O Nathan," said Rollo, "don't cry. I'll run and get Jonas to come and carry you in."

So Rollo ran into the barn, and called to Jonas to come quick. Jonas laid down his hammer upon the bench, and followed Rollo. He found Nathan in the snow, and took him up in his arms, and carried him into the barn.

As soon as he got him under cover, he brushed the snow off, and told him not to cry. "I've got a fire in the shop," said he, "and you shall see me do my work. I'm mending the bellows."

So he led Nathan through the barn, and thence along under a shed to a sort of shop-room, where there was a large fireplace and a fire. Rollo put on some sticks, which made a great blaze; and

so Nathan soon got warm and dry, and forgot all his troubles. Then Jonas sat him up, upon a high stool, near the bench, where he could see him work. He was just drawing out some of the nails, by which the leather of the bellows was nailed to the sides.

"What is the matter with the bellows?" said Nathan.

"The valve is out of order," replied Jonas.

"The valve," repeated Nathan; "what is the valve?"

"The valve is a kind of clapper," said Jonas. "I will show it to you in a few minutes."

So Jonas proceeded to take off the leather from one of the sides of the bellows. There was a hole in one of the sides, but no hole in the other. Nathan had often noticed the hole, but he did not know what it was for.

"What is the hole for?" said Nathan.

"That is to let the air in," said Jonas.

"What do they want the air to come in for?" said Nathan.

"To make wind of," said Jonas.

"Do they make wind out of air?" said Nathan.

"Yes," said Jonas, "they get the bellows full of air, and then blow it out through the nose, and that makes wind."

"Wind is air, put in motion," said Rollo. "I read it in a book."

By this time, Jonas had taken off the leather so far that Nathan could see into the bellows. He saw that there was a little clapper over the hole, in one of the sides of the bellows.

"Is that the valve?" said he to Jonas.

"Yes," said Jonas.

"What is it for?" said Nathan.

"It is to keep the wind from coming out of that hole."

"Why don't they want the wind to go out of that hole?" said Nathan.

"Because," said Jonas, "they want it to go to the fire,—to blow the fire."

"You see," said Rollo, "it can't go out of the hole, and so it has to go out of the long nose, which is pointed towards the fire."

"What makes it go out at all?" said Nathan.

"Why, when we blow the bellows, we press the two sides together, and that presses the wind out. It can't go out of the hole whence it came in, because the clapper stops it up, and so it goes out the long nose, right into the fire, and makes the fire burn."

By this time, Jonas had got the leather off so far, that he could get at the clapper to mend it. He told the boys that it was old and worn out, and he must make a new one.

"How are you going to make it?" said Rollo.

"You'll see," said Jonas, "if you watch me closely."

So Jonas took some leather, and cut out a piece, of an oblong shape, a little wider than the hole, and about twice as long. Then he laid this down over the hole. It covered it entirely. Then he took some small carpet nails, and nailed one of the ends of the leather down to the board. Then Jonas put his hand down under the board, and run one of his fingers up through the hole, and pushed the leather up a little way.

"There," said he to the boys, "you see I have nailed the leather, so that, when it lies down in its place, it covers the hole completely; and yet I can push it up a little with my fingers, so that there will be an opening."

Then Jonas cut a small leather strap, and nailed one end of it down upon one side of the clapper, and the other end upon the other side of the clapper. He put one little carpet nail into each end of the strap. The strap, when it was nailed, passed directly across the clapper or valve. It was not drawn tight across, but it lay upon the clapper loosely. The ends were nailed tight, but the middle rested loosely upon the clapper.

"Now," said Jonas, "I can push the clapper up a little way, but I can't push it far. The strap keeps it from coming up far."

"But why," said Nathan, "do you want it to go up at all?"

"To let the air in," said Jonas. "When I get the leather all nailed on again, I'll show you the whole operation of it."

"And you can be telling us about it in the mean time," said Rollo.

"Well, then," said Jonas, "when I lift up the upper side of the bellows by the handle, to blow, the air comes in by the hole. The clapper lifts up a little way, and lets it in. Then, when I press down the handle again, it presses the air out through the nose, because it can't go back through the valve hole."

"Why not?" said Nathan.

"Because," said Jonas, "the valve falls down over the hole, and stops it up. It is made so as to lift up easily, and then to fall down and cover the hole exactly, and prevent the air going out the same way it came in. So, as it cannot get out by the valve, it has all to go out through the nose. If the nose were stopped up, it could not get out at all."

"And what then?" said Rollo.

"Why, then," replied Jonas, "you could not bring the two sides of the bellows together again. The air between would keep them apart."

"I should like to try," said Rollo.

"Well," said Jonas; "and there are some other experiments you may perform with it too."

At length, Jonas said that he had got the leather all nailed on, and they might try the experiment. He took hold of the nose of the bellows, and held his thumb near the end of it, ready to stop up the hole.

"Now, Nathan, you may take hold of the handles, and pull them apart as if you were going to blow."

Nathan did so. He pulled the handles apart, and held them open.

"Now," said Jonas, "I will stop up the nose, and the valve will close itself; and then you will find that you cannot bring the sides together again."

So Jonas put his thumb over the hole, and told Nathan to blow.

Nathan pressed hard, and the sides came together again, about as easily as usual.

"What!" exclaimed Jonas with surprise. He did not know what to make of the failure of his experiment.

"There must be a leak somewhere," said he. And he took the bellows out of Nathan's hand to look for it.

He found there was a corner, on the side opposite to the one where he had been working, where the leather was open, he having forgotten to nail it down.

"Ah!" said he, "here is the difficulty. When I have nailed this down, we will try again."

"Is that a leak?" said Nathan.

"Yes," said Jonas. "When you worked the bellows, you pressed the air all out through there. I did not know that that was open. Let me nail this down, and then we will begin our experiment regularly."

QUESTIONS

What was Jonas doing in the shop, when Rollo and Nathan went out to find him? What part of the bellows was out of order? How did he make a new valve? How did he fasten it to its place? Did he nail down only one edge, or both edges? Why did he want the other edge to be left at liberty? How did he prevent its lifting up too far? What was the first experiment which he performed with the bellows, after he had finished the mending? Did it succeed at first? Why not? In working a pair of bellows, where does the air come in? Where does it go out? Why cannot the air escape through the valve where it comes in?

CHAPTER IV.
EXPERIMENTS

When Jonas had finished nailing down the corner, he said, "Now there are several experiments, which we can perform with the bellows. I will be the professor, and you two shall be my class in philosophy, and I will direct you how to make the experiments.

"First," said Jonas, "you, Rollo, may take hold of the nose of the bellows with your hand, in such a way as to put your thumb over the end of it, to stop it up, and then let Nathan try to blow."

Rollo did so, and Nathan tried to blow. He found that he could open the bellows very easily; but when he attempted to press the sides together again, he could not. He crowded the handle belonging to the upper side down, as hard as he could, but it would not move.

"What makes it do so?" said Nathan.

"The air inside," said Jonas. "We have stopped up all the places, where it could get out. The valve stops itself. Rollo stops the nose with his thumb, and I have nailed the leather down close, about all the sides. And so the air can't get out, and that keeps you from bringing the sides together again."

Nathan tried again with all his strength. The sides came together very slowly.

"They're coming," said he.

"Yes," said Jonas. "They come a little, just as fast as the air can leak out through the little leaks all around."

"I thought you stopped all the leaks," said Nathan.

"Yes," replied Jonas, "I stopped all the real leaks, but still I can't make it perfectly tight. Some air can escape between the leather and the nails all around, and just as fast as it can get out, so fast you can press the sides together, and no faster."

Here Nathan tried again with all his strength; but he could only bring the sides together very slowly.

"Now comes the second experiment," said Jonas. "While Nathan is trying to press the two handles together, you, Rollo, may run your finger into the hole, and push up the valve a little."

Rollo did so. He pushed up the valve a little with his finger, and that allowed the air to escape through the opening. The consequence was, that the bellows collapsed at once under the pressure which Nathan was exerting upon them.

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