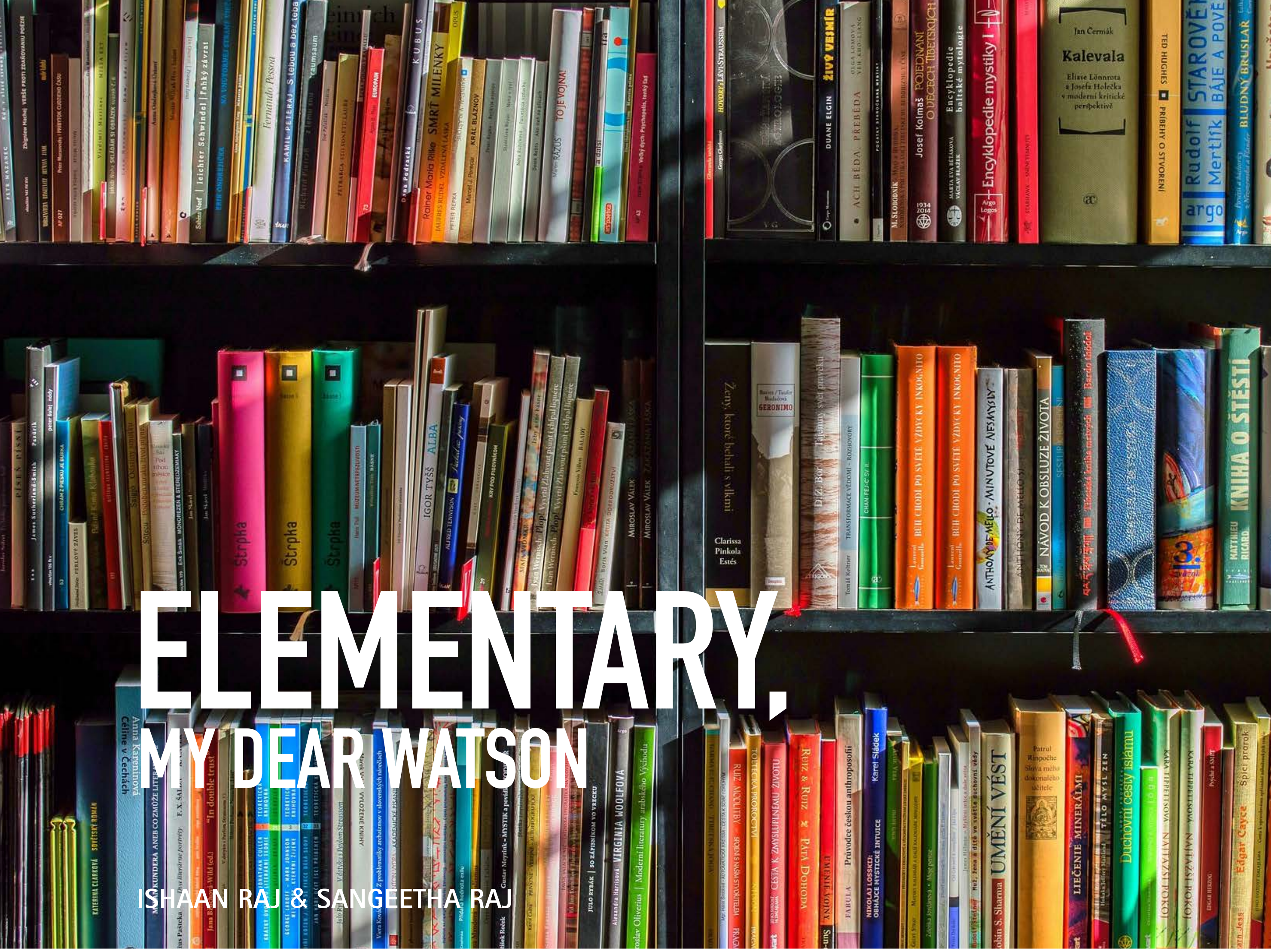


ELEMENTARY, MY DEAR WATSON

ISHAAN RAJ & SANGEETHA RAJ

Can a book of science experiments provoke curiosity and playfulness? Can it inspire children and adults to explore science in their everyday world? A 12-year-old boy and his mother share their experience.

'The Agenda of the Apprentice Scientist' is a collection of 365 hands-on activities. Written by Nicole Ostrowsky and illustrated by Theresa Bronn, this book is designed to be approached as a yearlong workbook for budding or 'apprentice' scientists (see **Box 1**). Originally written in French, the book has also been translated into English and Kannada (see **Fig. 1**).

Ishaan's review

I first saw a copy of 'The Agenda of the Apprentice Scientist' with Yasmin Aunty, who is my mother's friend and teaches chemistry at my school. After looking through her copy and doing a few experiments, I wanted my own copy.

Many science books focus on concepts from one discipline. But the experiments in this book involve fundamental concepts from physics, chemistry, and biology. While the book is not divided into thematic sections, activities around common themes, like temperature and sound, are clubbed together. Since there is an activity for each day of the year, the book is organised by dates (such as March 3 or June 10) instead of page numbers. Some activities are related to each other and appear in sequence. But most activities are just a page long. You can do these in the order in which they appear in the book or choose an activity at random.

Each day's activity starts with a question. This is followed by instructions for a simple experiment to explore the question. The blurbs of many books claim to include experiments that can be done at home. Not all of them are true to their word. I recently came across a book with an activity that required two gallons of liquid nitrogen to freeze homemade ice cream! But the experiments in 'The Agenda of the Apprentice Scientist' only need materials

Box 1. The author and illustrator:

Nicole Ostrowsky is a researcher and teacher. She has worked at the French National Centre for Scientific Research at the Ecole Normale Supérieure Laboratory in Paris and Harvard University, USA. She is the former head and Professor Emeritus at the Laboratory of Physics and Condensed Matter at the University of Nice, France. She wrote this book to stoke curiosity about our natural world and encourage the discovery of the scientific principles underlying familiar situations and phenomena.

Theresa Bronn graduated from the Ecole Superieure des Arts Decoratifs de Strasbourg in art history and French. She works as an illustrator for children's books.

as easy to get and use as paper, straws, balloons, and ice cubes.

The blurb of the book says that these experiments are designed around concepts that make sense to children in the age group of 9-13 years. But I think these activities can appeal to anyone—even those who are not interested in the world of science. Because they inspire curiosity and playfulness. Even experiments that seem very simple to do can have exciting results. For example, the experiment on November 24 is about using a cardboard tube to blow smoke rings and the one on May 25 is about making different kinds of airplanes!

Below the instructions for each experiment is a large white space for the reader to record their observations. Towards the bottom of each page is a hilarious illustration of apprentice lab coats experimenting, comparing results, and making funny remarks. To the side of each page is a quote related to the experiment. These quotes can be funny, philosophical, or inspirational. But every page has a different one. For example, the activities on both August 22 and August 23 are around freezing. While the quote for August 22 is: *"True friendship doesn't freeze in winter"*, the one for August 23 is: *"He who got burnt with hot milk will blow on his ice cream to cool it down"*.

Each activity is wrapped up with an explanation. This is another reason I like the book. Not only does it tell you what happens, but also how and why it happens. For example, the activity for March 8 is about inflating a balloon with vinegar and baking powder (see **Activity Sheet I: Inflating a Balloon**). The explanation tells you that when the baking powder in the balloon mixes with the vinegar in the bottle, the vinegar will start bubbling and the balloon will start inflating. It also tells you that this happens because the baking powder reacts with vinegar to produce carbon dioxide.

The only thing that I find confusing about the book is its index. For example, to find the experiment on making smoke rings, I searched the index for keywords, like 'smoke' or 'rings', only to find the experiment listed under 'Incense'. When I searched the index for the vinegar and baking soda experiment, I found it listed under 'Balloon'. On another day, I wanted to show my friend the wineglass experiment. In this experiment, you make a wineglass sing by slowly moving a wet finger along its rim (see **Activity Sheet II: Singing Wineglasses**). I searched the index under W for wineglass, but found it under P for pitch. An index that lists the titles of the different experiments may have been easier to search.

I would like to end by saying that 'The Agenda of the Apprentice Scientist' is one of the best books I have read. Every activity in the book is worth trying.

Sangeetha's review

I opened 'The Agenda of the Apprentice Scientist' tentatively, as I do all books related to science. The book had two forewords—one written for the French edition by the French Nobel laureate Georges Charpak and the other written for the English edition by the Indian scientist CNR Rao. As I read these, my apprehension was replaced by mild curiosity. But the moment I turned to

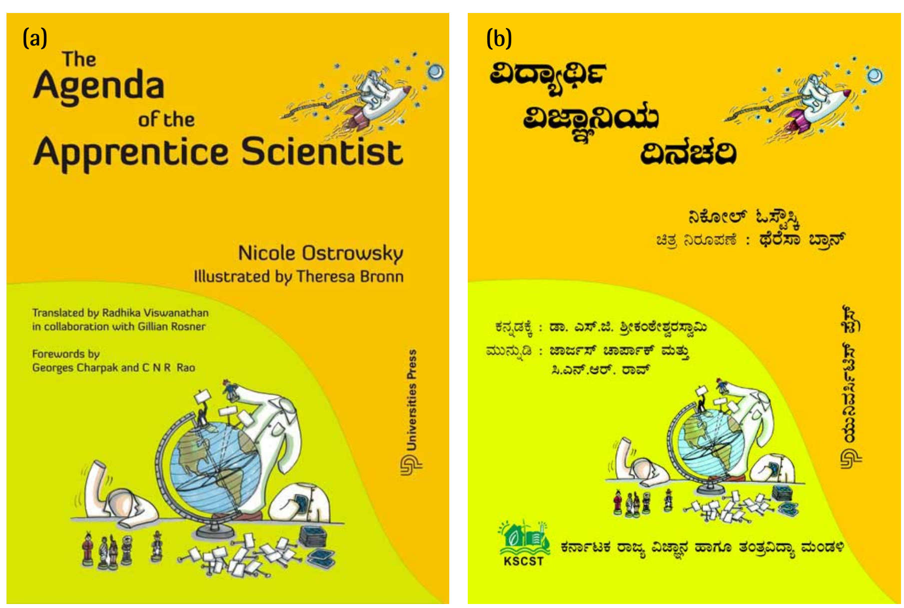
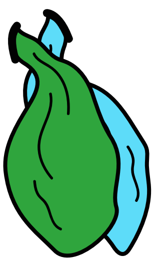


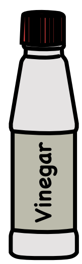
Fig. 1. 'The Agenda of the Apprentice Scientist' is published by Universities Press, Hyderabad, in association with the French Embassy in India. (a) It has been translated into English and adapted to the Indian context by Radhika Viswanathan (a development communication specialist) and Gillian Rosner (who specializes in academic translations). You can get a copy of the English translation by writing to the distributors at: info@universitiespress.in or bangalore@orientblackswan.com. It is also available on Flipkart. (b) It has been translated into Kannada by Dr SGS Swamy (a Fellow at the Karnataka State Council for Science and Technology, Bengaluru). You can get a copy of the Kannada translation by contacting Prabhakara Reddy at: prabhakara.reddy@orientblackswan.com.

ACTIVITY SHEET I : INFLATING A BALLOON

Aim:
Can we inflate a balloon without having to blow air into it?

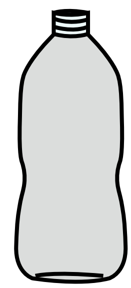
You will need:

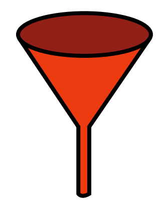

Balloons



Vinegar (preferably white or distilled)

Baking soda

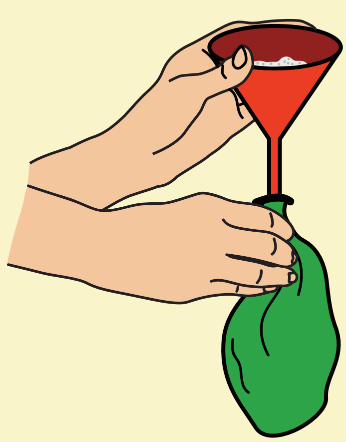

A bottle (preferably plastic) with a narrow neck


A funnel (optional)


Some rubber bands

What to do:

1. Blow some air into the balloon to stretch it out a bit. Then use the funnel to fill the balloon to about one-third or half its volume with baking soda.
2. Clean the funnel and use it to pour some white vinegar into the bottle. Fill the bottle to less than one-third of its height.
3. Gently stretch the mouth of the balloon with both hands and attach to the mouth of the bottle in such a way that the balloon hangs outside the bottle. Be careful to not spill any of the baking soda from the balloon into the bottle. Use rubber bands to secure the balloon to the mouth of the bottle.
4. Gently lift the balloon over the bottle so that the baking soda falls out of it, through the neck of the bottle, and into the vinegar at its bottom. Step back to steer clear of the reaction.
5. Observe the bottle for any change. Gently swirl the bottle to mix its contents. You will see the balloon inflating.
6. If the balloon does not expand to its full volume, wait for about 1-2 minutes. Empty the bottle out and clean it. Pour fresh vinegar into it and repeat the experiment with a new balloon.


1. Pour some baking soda into the balloon


2. Pour some vinegar into the bottle

3. Attach the balloon to the mouth of the bottle

4. Lift the balloon up to let the baking soda fall into the bottle

Observe and explore:

Tip: Read the questions listed below one-by-one. Take a few minutes to guess what you think you will see if you tried this out. Then try the experiment out. Make note of your guesses and observations in the table in the 'Record' section.

A. When the baking soda from the balloon mixes with the vinegar in the bottle:
   a. What changes will you observe?
   b. How will the vinegar in the bottle smell and look by the end of the experiment? How different will this be from what you started the experiment with?

B. What would happen if you were to reduce or increase:
   a. The volume of vinegar that you pour into the bottle?
   b. The amount of baking soda that you fill into the balloon?

C. What if you were to replace the vinegar with another acidic liquid, like lemon juice? How will this change the rate at which the balloon fills up?

Record:

Question	Your guess	What you observe
A.		
B.		
C.		

Think about and discuss:

- If you were to fill a balloon by blowing air into it, what gases do you think it would be likely to contain? Compare this with the balloon that you have just filled up using vinegar and baking soda. What gases do you think this balloon contains? Where do you think these gases come from? Share reasons for your guess with your peers.
- Regular party balloons are filled up with helium. Compare one of these with the balloon you have just inflated using vinegar and baking soda. Do you think the two balloons would be different in any way? For example, would one be able to rise higher than the other? What tests would you use to identify differences between the two?

Contributed by:
Chitra Ravi who works at Azim Premji University, Bengaluru.

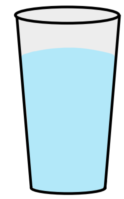
Book Review

ACTIVITY SHEET II : SINGING WINEGLASSES

Aim:
Can we make a wineglass sing?

You will need:

4-5 wineglasses (crystal ones with thin walls work best) of the same kind



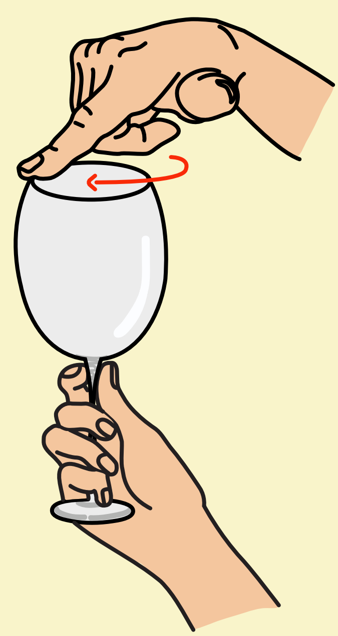
Some water

What to do:

1. Use one hand to hold the wineglass by the base of its stem.
2. Wet the tip of the index finger of your other hand with water.
3. Lightly rub your wet fingertip along the rim of the wineglass in a slow, circular motion.

1. Hold the wineglass by its stem

2. Dip a finger in a glass of water



3. Rub the wet fingertip along the rim of the wineglass

Observe and explore:

Tip: Read the questions listed below one-by-one. Take a few minutes to guess what you think you will see if you tried this out. Then try each experiment out. Make note of your guesses and observations in the table included in the 'Record' section.

A. How will the quality of sound from the empty wineglass change:
   a. As the pressure that you apply with your finger changes?
   b. As the water on your fingertip dries up?
   c. When the way you move your fingertip over the glass changes?

B. Fill a second wineglass with some water. Repeat Steps 1-3.
   a. Will the quality of sound be different from the sound you get from the empty glass? If yes, in what way?
   b. Will the water remain still while the wineglass sings?

C. Line up the remaining 3-4 glasses. Add increasing volumes of water to each glass. Repeat Steps 1-3 with each glass in sequence, starting from the empty glass and ending with the glass with the maximum volume of water.
   a. Will the quality of sound change in any way?
   b. Is there a relationship between the amount of water in the glass and the sound you hear?
   c. Play around with these sounds a bit. Can you come up with a sequence of sounds from these glasses that is like a song?

D. How would the quality of sound change if you tried this activity with:
   a. An empty glass with a marble in it?
   b. A glass with some water and a marble in it?
   c. A glass filled with a different liquid?

E. How would the quality of sound change if you tried this activity with:
   a. Glass rather than crystal?
   b. Wineglasses with thick walls rather than thin ones?
   c. Taller or shorter glasses?
   d. Wider or narrower glasses?

Record:

Question	Your guess	What you observe
A.		
B.		
C.		
D.		
E.		

Think about and discuss:

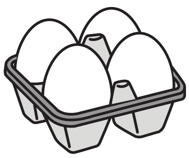
1. Why do you think the glass sings?
2. Why do you think you need to have a wet fingertip to make it sing?
3. Sing a song. Place your fingers on the side of your throat. What do you feel? How does this compare with the singing wineglass?
4. The 'Observe and explore' section shares some things you can change in the original experiment (shared in the 'What to do' section). Pick one other thing to change.
   - Predict how this one thing would change the quality of sound produced by the wineglass.
   - How would you test your prediction? (Once you come up with an experiment, do try it out!)

Contributed by:
Chitra Ravi who works at Azim Premji University, Bengaluru.

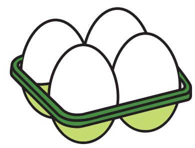
ACTIVITY SHEET III : TELLING EGGS APART

Aim:
How do we tell a boiled egg apart from a raw one without cracking their shells?

You will need:



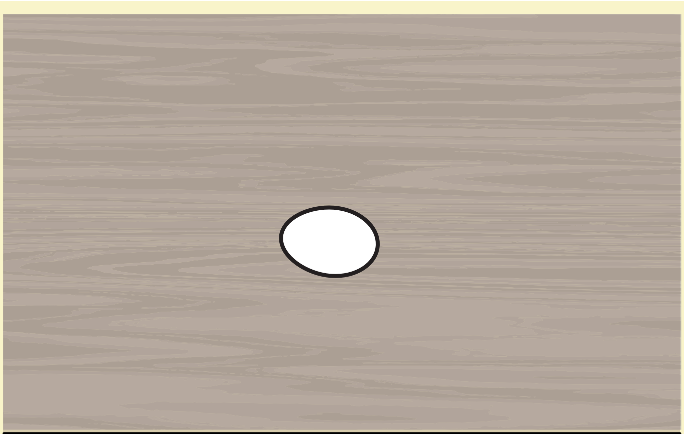
Some raw eggs



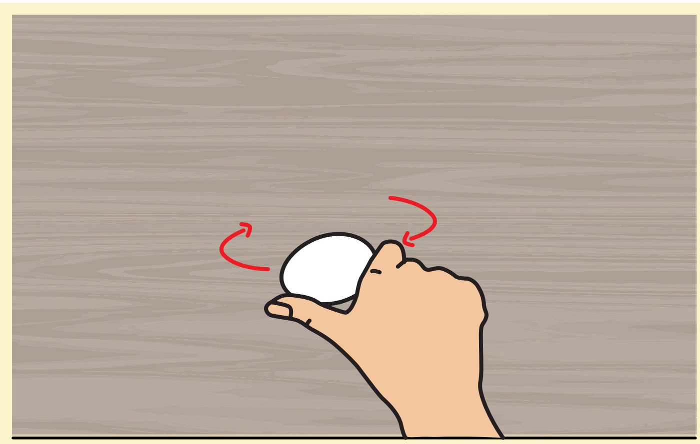
Some hard-boiled eggs

What to do:

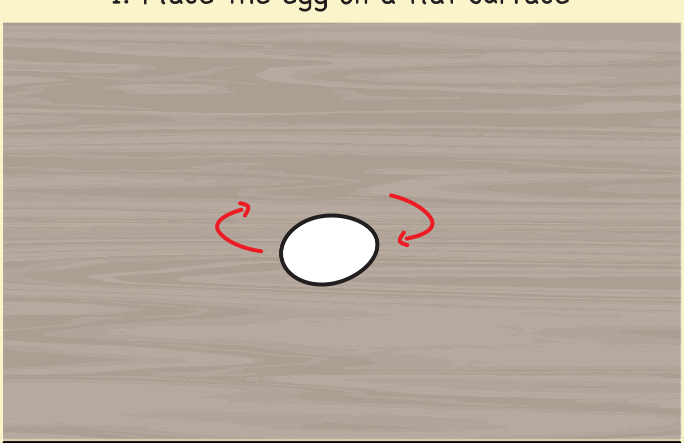
1. You will be spinning eggs in this experiment. So start by finding a flat surface like a table top to do this. Try to choose a place that reduces the chances that the egg will fly off the surface and splat on the floor or on you.
2. Set a raw egg on the flat surface. Pinch it between your fingers and spin it like a top. Ensure that it moves at a steady pace.
3. While the egg is spinning, place the tip of your finger close to the middle of the spinning egg with just enough pressure to make it stop. As soon as the spinning stops, remove your finger from the egg.
4. Repeat Steps 2 and 3 with the hard-boiled egg.



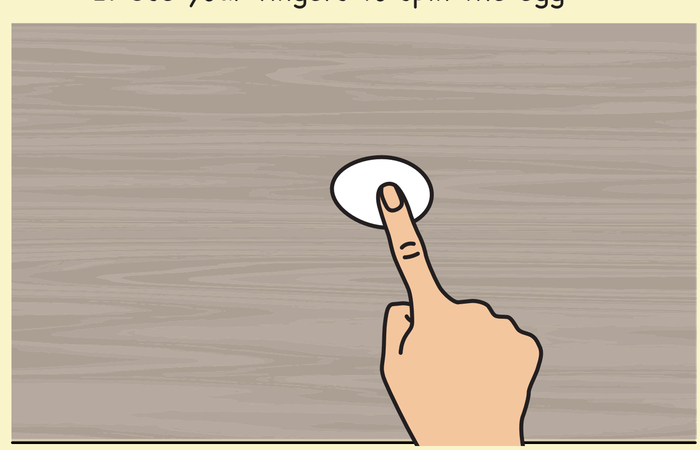
1. Place the egg on a flat surface



2. Use your fingers to spin the egg



3. Withdraw your hand and allow the egg to continue spinning



4. While the egg is spinning at full speed, place a finger on it, near its centre, to stop it

Observe and explore:

A. Observe the spins of the raw egg and the boiled egg. Do you see any differences?
B. Observe each of the eggs immediately after you withdraw the finger you use to stop their spins. Do both eggs come to a standstill?
C. Repeat the same experiment with other raw and hard-boiled eggs. Do you observe any patterns?

Record:

Question	Your guess	What you observe
A.		
B.		
C.		

Think about and discuss:

- Is there a clear difference between the spins of raw and hard-boiled eggs? What is this difference and what do you think causes it?
- Is the spin test a reliable way of telling the difference between raw and hard-boiled eggs? Share reasons to support your response. Remember: In science, an observation is called reliable if you see it every time you repeat an experiment using the same method and under the same conditions.
- Is the spin test enough to tell the difference between raw and hard-boiled eggs? Or would you feel surer if you could check your results out with other methods? Share reasons to support your response.
- What if you were asked to come up with one other test to tell a raw egg apart from a hard-boiled one? How would you go about it? (Once you think of a method, do try it out!)

Contributed by:
Chitra Ravi who works at Azim Premji University, Bengaluru.

the first activity (for January 1), I was transported to my Grade VIII classroom, sitting absently in the back row, doing my best to go unnoticed by the science teacher. The illustration on page one has a lab coat drawing a snowflake and saying, "*I am a scientist, not an artist*". Oh! Another book, I thought, that defines and categorises the world to make sense of it. I closed the book and forgot about it.

But the book kept making an appearance. It was with Ishaan while he was sitting at our dining table, reclining on our sofa, raiding the kitchen for things like eggs, salt, vinegar, and ice cubes, rummaging in shelves for stuff like candles, twine, and bits of copper wire, or searching my barely-alive potted plants for earthworms. While I admit that the book was not responsible for **all** of Ishaan's raids, **many** of them were inspired by it. Incomprehensible words, ones that I had gladly erased from my memory, like inertia, diffusion, density, gravity, electrons, and friction, began to appear at mealtime conversations and on long drives.

My curiosity was whetted again. Over time, I found myself waiting, a little anxiously, for the outcome of this or that experiment and enthusiastically participating in discussions around them. For example, to be able to tell the difference between a raw and boiled egg without having to crack them seemed like a useful skill (see **Activity Sheet III: Telling Eggs Apart**). Plus, it amused me to see how the boiled one kept spinning, but the raw one toppled over. I learnt that this difference is because the liquid within a raw egg does not move at the same speed as the shell. This gave me a better sense of the properties of matter that were associated with the terms 'solid' and 'liquid'. The only property that I knew till then was one that I remember from my school textbook—solids have definite shapes while liquids take the shape of their containers.

My first impression of 'The Agenda of the Apprentice Scientist' was that it was a book of science experiments. It proved to be more than that. The book takes science out of the lofty labs that I associated it with and makes it part of our everyday experience—accessible and commonplace. Not something I need to 'get through', but something that I enjoy like I would a good story or poem.

Key takeaways

- 'The Agenda of an Apprentice Scientist' is a book with 365 science experiments, one for each day of the year.
- While the experiments are designed to make sense to 9-13 year-old children, they can appeal to people across ages and even those with little interest in science.
- The experiments are simple enough to be done at home with easily available and inexpensive materials. Each experiment is accompanied by clear explanations for what we observe.
- This book encourages readers to explore science in their everyday lives.

Notes:

1. This article was first published in i wonder..., June 2016, pp. 109-111. The original draft can be found here: https://publications.azimpremjiuniversity.edu.in/1281/. The version included in this issue has been reviewed and modified for school teachers. It includes new material and three activity sheets.
2. Source of the image used in the background of the article title: Book reading. Credits: LubosHouska, Pixabay. URL: https://pixabay.com/photos/books-bookstore-book-reading-1204029/. License: Royalty Free.

Ishaan Raj is currently completing his BSc in Math and Physics at St. Joseph's University, Bengaluru. When this article was first published, he was a 12-year-old boy with a keen interest in science. He was schooled at home.

Sangeetha Raj is Ishaan's mother. She currently teaches IGCSE- and A-level English Language and Literature as well as History online. When this article was first published, she was teaching English at Annaswamy Mudaliar School, Bengaluru.