

READ THIS FIRST

IN EVERY GENERATION, our rabbis have taught us that Torah study is of paramount value, both as a means to an end (i.e., to enable the proper performance of all the other mitzvos) and as an end in itself. Many of those rabbis have emphasized the value and benefits of understanding the workings of the natural world—what we today would call science.¹ The Hebrew title of this *sefer*, ספר פרפראות לחכמה, is a reference to the Mishnah in *Avos* 3:18. There, Chazal liken the relationship between science and Torah to that of tasty foods that accompany the main meal in order to whet one’s appetite and to make the main meal more enjoyable.

It is well known that the *chachmei haTorah* throughout the generations have expressed concerns about the value—and potentially even the danger—of secular studies. It would seem, however, that almost without exception, these misgivings did not extend to the study of the natural sciences. To the contrary! The Gemara,² *Rambam*,³ *Chovos Halevavos*,⁴ *Kuzari*,⁵ Rabbi Yosef Karo,⁶ the Maharal of Prague,⁷ and the Vilna Gaon⁸ (to name but a few) all wrote of the benefits, importance, and sometimes even the religious obligation to study science. Collectively, they identify two distinct reasons why we should seek to understand the natural world. (These reasons are aside from various pragmatic and extrinsic considerations, such

1 To be clear: By science, we mean the natural sciences, such as physics, chemistry, and biology, and not fields of study often referred to as social sciences, such as history, economics, and politics (and certainly not the humanities).

2 *Shabbos* 75a: “שמצוה על האדם לחשב תקופות ומזלות...”

3 *Rambam*, *Hilchos Yesodei HaTorah* 4:12.

4 *Shaar Habechinah* 2.

5 *Kuzari* 2:64.

6 *Kesef Mishnah*, *Hilchos Yesodei HaTorah* 4:13.

7 *Nesivos Olam*, *Nesiv HaTorah* 14.

8 As quoted by Reb Baruch Schick of Shklov in his translation of Euclid’s book on geometry, the Gaon said: “Proportional to what one lacks in his understanding of the sciences (משארי החכמות), he will lack a hundred times in his understanding of Torah, because the Torah and science are interconnected.”

as enabling one to earn a livelihood or raising the esteem of *talmidei chachamim* in the eyes of others.)

The first and most basic reason is that scientific knowledge is often essential for a correct understanding and fulfillment of the Torah itself. The Torah is our guide for how to interact with the world in accordance with the *ratzon Hashem*. Since the physical world comprises nature and is subject to its laws, scientific knowledge is often required to ensure halachah is properly understood and upheld. An endless number of questions in *hilchos Shabbos*, *kashrus*, and *niddah*, for example, cannot be resolved without an understanding of physics, chemistry, or biology. Perhaps the most famous example of Chazal expressing this value is the Amora Rav, who spent eighteen months with herdsmen to study which blemishes on livestock were permanent and which were temporary in order to correctly implement *hilchos bechoros*.⁹ Similarly, the Amora Shmuel declared that he had mastered astronomy to the point that he knew the paths of the heavenly bodies as well as he knew the paths of his hometown Neharde'a,¹⁰ enabling him to rule precisely on halachic matters such as *Kiddush Hachodesh*.

The second reason why every Jew should have a basic understanding of, and familiarity with, the workings of the natural world is because it enhances one's love and reverence for Hashem. Love and reverence are meant to constitute the core of our relationship with Hashem and dictate the way we are to relate to Him at all times. Such a relationship requires our knowing Him to the best of our abilities. Since it is only possible to know Hashem through what He does (as opposed to what He is, which is unknowable),¹¹ we must study His works. Of these works, two are accessible to us: the Torah He revealed to us, and the world He created for us. Since the Torah is a more direct and profound reflection of His will, its study must take priority. The study of nature, however, cannot and should not be ignored as a supplementary and invaluable means to the ultimate goal of loving and revering Hashem. *Rambam* famously wrote:

9 *Sanhedrin* 5b.

10 *Berachos* 58b.

11 See *Chovos Haleavavos*, *Shaar HaYichud* 10; *Shaar HaBechinah*, *Pesichah*.

And what is the path to love and revere [Hashem]? When a person thinks about His works and His great and wonderful creations and sees in them His inestimable, infinite genius, one will immediately love and praise and exalt [Hashem] and be filled with a great desire to know His Great Name. As David [Hamelech] said: “My soul thirsts for G-d, for the living G-d.”¹² And when one thinks of all these matters, he will immediately be taken aback and stricken with awe, realizing that he is a puny creature, lowly and dim, standing with an insignificant and minimal knowledge in the presence of the All-Knowing, as David [Hamelech] said: “When I see Your heavens, the works of Your fingers—what is a human that You should take note of him?”¹³

Similarly, the *Rema* stated: “...They did not forbid the study of the words of the scientists nor of their scientific research; to the contrary, through these, we can know the greatness of Hashem.”¹⁴ More recently, several notable rabbis of the twentieth century were well known for emphasizing the importance of considering the wonders of creation to help instill *emunah*, love, and reverence of Hashem, including the Chazon Ish,¹⁵ Rabbi Shlomo Wolbe,¹⁶ and Rabbi Avigdor Miller.

In this work, we have done our very best to provide the Torah-true community with a resource that facilitates both of these roles that scientific understanding can play within a larger framework of proper *avodas Hashem*. Specifically, we have attempted to explain the scientific topics encountered in the Mishnah to give the reader a better, deeper understanding of the Mishnah itself. At the same time, we have taken the liberty of explaining certain related, more general issues to give the reader a better understanding of the larger scientific principles at work. We expect this broader perspective will provide insight into other areas of Torah-true living as well.

12 *Tehillim* 42:2.

13 *Ibid.* 8:4. *Rambam, Hilchos Yesodei HaTorah* 2:2.

14 *Rema*, responsum 7.

15 See *Emunah U'Bitachon* 1.

16 See *Alei Shor* 2:2:16, *Emunah, Vaad Rishon*.

Along the way, we have also taken the opportunity to explain a few of the innumerable details in creation that demonstrate Hashem’s infinite genius and unending love for us. We do not view this *sefer* as yet another of the many beautiful books that have recently cropped up in the genre of “*sifrei niflaos haBorei*.” The wonders that Hashem created and continues to create are, in truth, so much more profound than the typical fare of amazing plants and animals found in such books. Without science, every feature of our gorgeous universe, from snowflakes to sunsets, seems like yet another marvel in an endless kaleidoscope of unrelated mysteries. Yet, the more one understands the universality of nature’s laws and of its building blocks, the more one sees the unity, elegance, and interconnectedness that underpins all of creation—what we know to be a manifestation of *yichud Hashem*. It is our hope and prayer that our explanations of some of the basic concepts of physics, chemistry, biology, and Earth science will start the reader on the road to actually *understanding* some of Hashem’s genius and *feeling* His loving, active presence in our lives as revealed by the details of the natural world. This, in turn, will enable readers to love and revere Hashem more deeply, just as the *Rambam* and *Rema* prescribed.

It would be disingenuous—and perhaps even irresponsible—were we not to mention the two basic reservations our rabbis have in fact expressed regarding the study of science. The first, and more severe, is the possibility of heretical (anti-Torah) ideas being intertwined within scientific writings. In our times, this is a very real concern. One must be exceedingly careful regarding where one gets his scientific information, which sometimes is presented by authors whose agendas run contrary to Torah values. The second concern is for *bittul Torah*, wasting one’s precious time on scientific studies, when one would better serve Hashem by studying Torah itself. This issue is also very serious and certainly should not be taken lightly—especially since life tends to be shorter than most of us estimate, and the Torah is larger than most of us imagine.

Regarding the concern for heresy, we hope and pray that we have had the *siyata d’Shmaya* to protect us from including anything in these pages that is inconsistent with Torah or its values (*chas v’shalom*). We have shown this *sefer* to our *rebbe’im*

and to other competent *talmidei chachamim* who have reviewed the text in its entirety and have confirmed that this is indeed the case. The issue of *bittul Torah* is more complex and nuanced. Learning this *sefer* certainly constitutes the mitzvah of *talmud Torah*, and one should not read any of it before reciting *Birkas HaTorah*—let alone bring it into the washroom! However, questions of *bittul Torah* must be considered in the context of what one would be learning instead. The reader is encouraged to ask his Rav for guidance if the reading of this *sefer* is coming at the expense of other Torah learning.

The most challenging aspect of writing this *sefer* has revolved around the question of who would be reading it. We expect there will be school-aged boys and girls filled with a healthy curiosity to understand the world around them. We hope to indulge that delightful attitude and have tried to entertain, and at times even to enthrall, such readers. At the same time, we hope that many adults with more substantial vocabularies, educations, and life-experience will peruse these pages in search of answers to questions about a particular Mishnah or a specific scientific phenomenon, or perhaps even read it from cover-to-cover for their general edification. We have tried to put something here for everyone. To that end, we hope that certain readers will persevere through some of the more difficult language and concepts, while others will view some of the more frivolous images and introductory content with a charitable eye.

We conclude this introduction with a personal reflection. This *sefer* is the product of two fathers with strong scientific backgrounds. We love Hashem and we love learning His Torah. We also love to share our insights into the *niflaos haBorei* with our children—especially when they have had questions that were not answered in their yeshivos or Bais Yaakovs. A great deal of our enthusiasm for sharing these insights, which is what ultimately motivated us to write this *sefer*, was engendered within us by our *rebbe*, Harav Hagaon Chaim Zev Malinowitz, *zt”l*.

Rav Malinowitz was a *lamdan* and *dayan* par excellence, who quite literally knew *kol haTorah kulah*, and used his abilities to serve Klal Yisrael in numerous ways, including as the editor of the ArtScroll Schottenstein Talmud. As a young man, he was fascinated by the famed American Jewish physicist Richard Feynman. The

Rav was impressed by how Feynman creatively solved problems and explained complex ideas in simple ways. Rav Malinowitz aspired to do something similar in the realm of Torah and *lomdus*. Rav Malinowitz was especially fond of the following Feynman quotation, which he cited in shiurim on *Chovos Halevavos* and in at least one Shabbos *derashah*:

I have a friend who is an artist and has sometimes taken a view that I don't agree with very well. He'll hold up a flower and say, "look how beautiful it is," and I'll agree. Then he says, "I as an artist can see how beautiful this is, but you as a scientist take this all apart, and it becomes a dull thing," and I think that he's kind of nutty. First of all, the beauty that he sees is available to other people and to me too, I believe. Although I may not be quite as refined aesthetically as he is...I can appreciate the beauty of a flower. At the same time, I see much more about the flower than he sees. I could imagine the cells in there, the complicated actions inside, which also have a beauty. I mean it's not just beauty at this dimension, at one centimeter; there's also beauty at smaller dimensions, the inner structure, also the processes...The science knowledge only adds to the excitement, the mystery, and the awe of a flower. It only adds. I don't understand how it subtracts.

Rav Malinowitz emphasized the importance of seeing the *gadlus haBorei* in every detail of both Hashem's Torah and His creation, and then channeling that inspiration into a deep and abiding *hakaras ha'tov* toward Hashem. He internalized this value from the *sefer* that he considered the chief influence in his life, *Chovos Halevavos*, and he deeply imbued it into us. We pray that this chain of inspiration will continue to you, and that this *sefer* will in some small way strengthen the *emunah*, *ahavah*, *yirah*, and *hakaras ha'tov* that binds Klal Yisrael with our Creator, thereby bringing *zechus* to Rav Malinowitz, *zt"l*, and hastening the coming of the *geulah*, *bi'meheirah b'yameinu*.

HOW TO USE THIS BOOK

This *sefer* was structured as a running commentary on topics encountered in *Maseches Berachos*, so it follows the order of the Mishnayos. There is no need, however, to read it in that order. We anticipate that many will prefer to flip through it, much like one would read a magazine, looking into whichever topics pique one's interest. We encourage you to do so, as there is so much to learn here, and Chazal have taught us that “אין אדם לומד תורה אלא ממקום שלבו חפץ—A person only learns Torah from a place where his heart is interested.”¹⁷

Because there is no particular beginning or end from the perspective of scientific content, many chapters refer to material that is supplemented by content in other chapters. We made explicit mention of such instances when we felt that they were especially important. We have, however, done much more than that. We have prepared a comprehensive glossary, which can be found at the back of this *sefer*, which explains hundreds of technical and scientific terms used throughout the text. Readers are encouraged to make use of the glossary, which contains a world of additional information. It also serves as a more comprehensive cross-referencing tool. Words that can be found in the glossary appear in boldface and in color throughout the text. In chapters that use a given term more than once, it is only in boldface and in color the first time that it appears within that chapter.

Although we encourage you to enjoy this book in any order you choose, we can imagine there will be certain people, such as educators, who would like to use the text as a more formal, scientific resource. The following lists provide possible ways to organize the chapters in terms of scientific topics, and we have provided a suggested sequence for anyone who is looking to use them as part of a more formal curriculum. Many chapters cover more than one subject, so they may appear in lists below more than once.

17 *Avodah Zarah* 19a.

PHYSICS

Atomic structure and electricity	Chapter 30: Lightning and Electricity
Electromagnetic spectrum and black body radiation	Chapter 26: The Color of Fire
Infrared	Chapter 10: Snakes
Light scattering	Chapter 1: Twilight
Light absorption, reflection, and color	Chapter 3: Color Vision
Convex reflection	Chapter 8: Convex Reflection
Sound waves, amplitude, frequency, and the speed of sound	Chapter 31: Thunder and Sound
Sound and vibration	Chapter 4: Whispering
Air pressure	Chapter 11: Wind and Air Pressure

CHEMISTRY

Atoms, molecules, and combustion	Chapter 24: Hydration and Cellular Respiration
Oxidation and chemical bonds	Chapter 25: Sparks and Making Fire
Covalent bonding, ions, and acids	Chapter 17: Vinegar and Acids
Organic molecules and macro-molecules	Chapter 15: Bread and Nutrition
Solubility, ionic bonding, osmosis, and crystal structure	Chapter 22: Salt, Food Preservation, and Crystals
Water phase changes	Chapter 12: Rain, Precipitation, and the Water Cycle
Fermentation	Chapter 14: Wine and Fermentation
Milk	Chapter 19: Milk
Cheese	Chapter 20: Cheese

GENERAL BIOLOGY

Bacteria, cells, and membranes	Chapter 22: Salt, Food Preservation, and Crystals
Hydration, cells, and cellular respiration	Chapter 24: Hydration and Cellular Respiration
Fungi	Chapter 16: Mushrooms and Truffles
Plants	Chapter 5: Flax
Trees, vegetables, and fruits	Chapter 13: Fruits and Vegetables
Insects	Chapter 18: Grasshoppers and Locusts
Snakes	Chapter 10: Snakes
Mammals and milk	Chapter 19: Milk
Fat and energy storage	Chapter 2: Fats

HUMAN BIOLOGY

Digestion and the gastrointestinal tract	Chapter 27: Digestion
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Hydration, cells, and cellular respiration	Chapter 24: Hydration and Cellular Respiration
Bacteria, cells, and membranes	Chapter 22: Salt, Food Preservation, and Crystals
Speech and the vocal apparatus	Chapter 4: Whispering
Sense of sight and the eyes	Chapter 3: Color Vision
Sense of smell and the nose	Chapter 21: Incense and Our Sense of Smell
Sense of taste and the tongue	Chapter 23: Water and Our Sense of Taste
Sense of hearing and the ear	Chapter 31: Thunder and Sound

EARTH SCIENCES

Introduction to astronomy	Chapter 28: Meteors and Comets
The Earth's rotation	Chapter 6: Sun Movement
Seasons	Chapter 7: Halachic Hours
Plate tectonics	Chapter 29: Earthquakes and Plate Tectonics
Forces of erosion and activity on the surface of the Earth	Chapter 32: Mountains, Hills, Seas, and Rivers
The Atmosphere and wind	Chapter 11: Wind and Air Pressure
Precipitation and the water cycle	Chapter 12: Rain, Precipitation, and the Water Cycle
Atmospheric effects on light	Chapter 1: Twilight
Lightning	Chapter 30: Lightning and Electricity
Thunder	Chapter 31: Thunder and Sound