

Teaching Science to the Torah-Observant Student

by H. Babich, Ph.D.

Graduation from an educational institution entails the successful completion of a more-or-less prescribed regimen of course work. As students have varied interests, aptitudes, and career goals, each course does not evoke equivalent intellectual stimulation and appeal. An instructional approach available to the teacher to enliven a “required” course (i.e., a course that the student may perceive as irrelevant) is to focus on existing strengths within the students. When teaching in an Orthodox Jewish educational system it can be assumed that the student body has a working knowledge of the basics of Tanach, Talmud, and Halacha. In teaching a secular course in such an institution, the course can better “hit-home” if, when presenting illustrative examples of a particular topic, the instructor presents topics gleaned from the Torah. For students educated and trained in yeshivas or Orthodox Jewish day schools, the incorporation of Torah-derived illustrative examples into science lectures can make the course material more interesting. The more relevant the subject matter is to the class, the better it will be transmitted to and absorbed by that class. The wealth of available Torah material, i.e., especially if one includes Tanach, Talmud, and Halacha, makes it relatively simple to include some relevant point into any area in biology.

The intent of this article is to demonstrate how a lecture in general biology can be modified to include information that would be of interest to an Orthodox Jewish student body. For demonstrative purposes, this manuscript focuses on the digestive system in human beings; however, any other topic in biology could have been substituted, with equal success. The format of this manuscript is to initially present a specific aspect of the digestive process and then mention a related Torah thought or illustrative example. It is not suggested that a secular course, in which a defined amount of material must be covered in a limited amount of class time, include all the Torah thoughts/illustrations presented herein. However, it is

meant to demonstrate that there is sufficient information in Orthodox Jewish religious literature, especially when all of Tanach, Talmud, and Halacha are available for referencing, to enhance any aspect of a given topic in biology.

Digestion is the process whereby ingested food is physically and chemically broken down to molecules of a size small enough to be absorbed by the body. The digestive tract is visualized as a tube that passes through the body. This tube consists of the following components and in the following sequence: mouth → pharynx → esophagus → stomach → small intestine → large intestine. The salivary glands, liver, gall bladder, and pancreas are accessory organs that play a role in digestion.

Digestion begins in the mouth with the physical breakdown of the ingested food by the teeth. An adult has 32 teeth; the morphology of a tooth is related to its specific function. The chisel-shaped front teeth, termed incisors, are involved in cutting and biting. Next is the canine, a long, pointed tooth involved in tearing; in carnivorous animals the canine is termed the fang. Back further are the fairly flattened premolars and then the well-flattened molars, involved in grinding and crushing, respectively.¹ Distinctions in morphologies and functions among teeth were noted in the Talmud. In discussing the characteristics of a “clean” (i.e., kosher for consumption) animal, the Rabbis observed that all ruminants, except the adult camel, lack upper incisor and canine teeth. The “clean animals” are herbivores and have flattened teeth for grinding and crushing vegetation. (Tractate *Chullin* 59a). Human teeth are referred to in several places in the Talmud. The loss of molars and premolars with advancing age (Tractate *Shabbat* 152a), toothaches (Tractate *Shabbat* 111a), gum disorders (Tractate *Avoda Zara* 28a), and oral hygiene (i.e., cleaning teeth with a twig, forerunner of the toothpick (Yerushalmi, *D'mai* 3, 2)) are but a few citations. Several articles reviewing teeth in the Talmud are available.²⁻⁶

Three pairs of salivary glands release saliva into the mouth. Chemically, saliva consists of water in which are dissolved inorganic salts, mucus, blood proteins, urea, lysozyme, and the enzyme, salivary amylase. Saliva also contains the enzyme, lingual lipase, which is secreted by

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glands in the tongue. The functions of saliva are many. It moistens, lubricates and dissolves food for passage down the esophagus; its mucus holds food particles together; salivary amylase initiates the chemical breakdown of starch, a polysaccharide, to maltose, a disaccharide; lingual lipase starts the chemical digestion of dietary triglycerides (fats) into fatty acids and monoglycerides; and lysozyme is a chemical with antibacterial properties.¹

Chazal have noted several of the above-mentioned properties of saliva. For example, the lubricating ability of saliva was noted in *Shemot Rabbah* (24:1). "If a man ate bread as it is, it would go down into his digestive tract and scratch him, but HaShem created a well in the throat which conducts the bread safely down." The digestion of carbohydrates in the mouth may be hinted in *Bamidbar Rabbah* (18:22), which noted that "the water of the mouth is sweet." The therapeutic efficacy of applying spit to cure an eye infection is noted in the Talmud (Tractate *Bava Batra* 126b; Tractate *Shabbat* 108b). The medicinal value of saliva may be related to lysozyme, an antibacterial agent that inhibits cell wall synthesis, thereby promoting osmotic lysis of bacterial cells. Preuss⁷ however, attributed the antibacterial property of saliva to potassium sulfocyanide, which is most abundant in the saliva of a fasting person.

The reasons presented to explain the six hour time interval that the vast majority of Jews wait between eating meat and milk is related to the enzymes in saliva and to the extracellular enzymes produced by the indigenous oral microbiota. According to Rashi, meat leaves a fatty residue in the palate and throat for a period of six hours. Apparently, during this six hour time interval, lipases, derived from glands in the tongue and from bacteria in the mouth, hydrolyze the meat-derived lipids. According to the Rambam, the emphasis is on meat particles that remain lodged between the teeth. Presumably, after a six hour period such meat particles have decomposed to such an extent that they no longer are considered meat. Here, the emphasis is on the microbial decomposition of meat, which may be enhanced by chemical components in saliva.⁸

The tongue, in addition to having nerve receptors for the detection of touch, temperature, and taste, is a muscular organ and is involved in mashing the softer food particles and in guiding the food particles between the upper and lower teeth. Most references to the tongue in the

Tanach and Talmud focus on speech, specifically on speaking slander and talebearing.⁹ For example, in *Tehillim* (120:4) it is stated: "You (the tongue) are like the sharp arrows of the mighty." The tongue is compared to an arrow, as just as an arrow inflicts damage far from its source, so does the tongue spread slander, attacking its victim at a distance (*Bereishit Rabbah* 98:19). The location of the taste buds only on the tongue has an impact on *halacha*. At the *Pesach seder* there is a *mitzvah* to both taste and eat *maror*, but only to eat *matzah*. One cannot fulfill the *mitzvah* of *maror* by ingesting it in a manner that bypasses the tongue and thereby eliminates experiencing its bitter taste. Conversely, one can fulfill the *mitzvah* of eating *matzah* by swallowing it, even without tasting it (Tractate *Pesachim* 115b).

The tongue is important in the swallowing reflex, that is, the process by which the ingested food (now, termed bolus or a ball of liquids and solid food) is propelled down the esophagus at the same time other pathways of exit (nostrils, mouth, and respiratory tract) are closed. The muscular tongue moves the bolus to the pharynx (throat), in which are embedded nerve receptors that respond to pressure. When the bolus contacts these pressure receptors, the muscles of the pharynx contract and force the bolus into the esophagus. As part of this reflex action, the tongue moves up against the hard palate to prevent exit of the bolus through the mouth, the soft palate is raised to prevent the bolus from entering the nasal cavities; and the larynx (or voice box; the beginning of the respiratory tract) is raised so that its opening, the glottis, is now covered by a flap, termed the epiglottis.¹

The swallowing reflex is mentioned several times in the Talmud. The practical health advice of not talking while eating, so that the ingested food does not enter the respiratory tract and cause choking, is noted in Tractate *Ta'anit* (5b). Rabbi Yochanun stated that "one should not talk during a meal lest one's windpipe (trachea) precedes the esophagus" in receiving the ingested food, "thereby leading to danger." Other references to the swallowing reflex are noted with regard to *Pesach*. In Tractate *Pesachim* (108a) the "reclining" requirement during the *Pesach seder* is discussed. As noted in the Talmud, neither lying on one's back nor reclining on the right side constitute "reclining" and, furthermore, both are considered to be health hazards with regards to eating. As stated by

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Rashi, when lying on one's back the neck is stretched backward, causing the epiglottis to fold back and expose the glottis of the larynx, itself which is thrust forward, thereby allowing food to enter the respiratory tract. The Rashbam suggested that eating while reclining on one's right (but, not on one's left) is also hazardous, as it may result in food entering the respiratory tract.¹⁰

Once in the esophagus, rhythmic peristaltic contractions of the smooth muscles of the esophagus gradually move the bolus towards the stomach. To aid in the movement of the bolus, the innermost layer of the esophagus, consisting of epithelial tissue, secretes a slippery mucus. In discussing the laws of a "clean" versus a "trefah" animal, the differential tissue composition of the esophagus was noted in Tractate *Chullin* (43a). "Rabbah said, the esophagus has two coats, the outer red and the inner white." Further on that page, Rav Ashi noted that the esophagus, being a muscular tissue, contracts and expands when the animal eats or bellows.

The muscular wavelike contractions of the esophagus eventually transport the bolus to the stomach. The stomach is a muscular sac that also undergoes wave-like contractions to macerate the food and to mix the food with the secretions of the stomach. Cells lining the stomach secrete the gastric juices, which consist of hydrochloric acid, pepsinogen and mucus. Hydrochloric acid creates an acidic environment in the stomach (about pH 2). This low pH has the following functions: (a) it kills bacteria and other microbes that were ingested with the food; (b) it denatures and softens proteins, especially tough meat fibers; and (c) it activates pepsinogen to pepsin, an enzyme that starts the digestion of proteins. The partially digested material in the stomach is now termed acid chyme.¹

The focus of the stomach is on the digestion of proteins, in particular, meat proteins. The *Kohanim* serving in the Temple often suffered stomach ailments. One reason, presumably, was their steady diet of large quantities of sacrificial meat. Although the *Kohanim* could cook these meats as they preferred, they were often under pressure to consume certain sacrificial meats within specific time frames (i.e., within the same day as the sacrifice) and within restricted locations, such as the Temple courtyard

(*Shekalim* 5:1). Adding to the difficulties of a high meat diet was the prohibition of drinking wine within the Temple environs. Certain wines facilitate the digestion of meats; in Tractate *Berachot* (51a) it is noted that aged wine was beneficial for the intestines. Wine, apparently, stimulates the secretion of the gastric juices, thereby promoting digestion. Because of the digestive disorders experienced by the *Kohanim*, Ben Achiyah, the "resident gastroenterologist," prescribed herbal medicines to alleviate their ailments.¹¹

From the stomach the acid chyme is transported to the intestines, first the small intestine and then the large intestine. The initial portion of the small intestine, the duodenum, receives bile and pancreatic juices. Bile, which functions in the emulsification of fats, is produced in the liver and stored in the gall bladder until needed.

The pancreatic juices contain bicarbonate, which buffers the intestine from the acidity of the chyme, and pancreatic enzymes needed for the chemical digestion of the food. In addition, the cells lining the small intestine produce enzymes for the final chemical digestion of the foods. Once chemically digested to their smallest subunits, the nutrients pass through the cells lining the small intestine and enter into the blood stream. The large intestine functions in the absorption into the blood stream of water and vitamins. The undigestible material remaining in the large intestine is termed feces. This fecal

material is transported and stored in the rectum, the last 10 inches of the large intestine, until elimination from the body.¹

In *Beha'alotecha* it is noted that *B'nei Yisrael* both craved meat and downplayed the *manna*. "But now, our life is parched, there is nothing; we have nothing to anticipate but *manna* (*Bamidbar* 11:6). The Sifrei explained that as the *manna* was a supernatural food from HaShem, it was totally absorbed in the digestive system; fecal material was not produced. To quote from the Sifre, "They said, 'The *manna* is going to burst in our bellies and kill us. Is there a creature born of woman who does not excrete what it eats, while we do not excrete at all?'" It was asked of Rabbi Simeon, If so, how do you explain the verse (*Devarim* 23:14), 'And you shall have a paddle with weapons' for burying excrement? He said to them, "What

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is excreted by them is what the merchants of the nations of the world sell to them, but *manna* was never excreted, as it is said, 'Man ate of the bread of the angels' (*Tehellim* 75:25), bread that is absorbed in the limbs."

Choli me'ayim, or intestinal disorders, and their remedies are mentioned throughout the Talmud (Tractates *Erubin* 41b, 54a; *Shabbat* 11a, 134a; *Sotah* 42b). Furthermore, a reference to rectal cancer may be noted in Tanach. In *Divrei HaYamim* II (21:14-19), Eliyahu conveyed the following threat to King Yehoram. "Behold, HaShem will strike mightily against your people and your children and your wives and all your substance. And you shall have a great sickness - a disease of your bowels, until your bowels fall out from the sickness days upon days." The king was eventually smote with this ailment and "his bowels fell out because of his sickness." Preuss⁷ speculated that this 40-year old king was plagued with rectal cancer, from which pieces broke off from time to time.

Fecal material that is formed in the large intestine consists of undigestible food products (e.g., cellulose) and enteric bacteria. Hygienic practices concerning defecation were noted in the Talmud. Rav Achai said, "If a person holds back his bodily functions," i.e., if he resists his body's strong urge to urinate or defecate, "he thereby transgresses the commandment (*Vayikra* 20:25), 'Do not make yourselves abominable'" (Tractate *Makkot* 16b). Bar Kappara said, "When you are hungry, eat at once; when you are thirsty, drink at once; when your pot is boiling (i.e., when you need to defecate), empty it (i.e., feces) out" (Tractate *Berachot* 62b). Interestingly, this advice is in

accord with concepts of cancer prevention. It is now known that chemical carcinogens are ingested with our foods (e.g., some pesticides) and are produced by metabolic activities of enteric anaerobic bacteria. As such, these chemical carcinogens are part of the fecal material; the shorter their residence time in the intestines, the lesser their potential to interact with intestinal cells and to initiate the formation of tumor.

Thus, it can be seen that there are many Torah-related thoughts/examples that can be incorporated into lectures on the human digestive system. As noted previously, this science/Torah interaction is not limited to discussions on the digestive system. There are a variety of sources in English that are suitable for the science instructor interested in incorporating Torah concepts/illustrative examples into lectures on human physiology.

The books by Rosner^{8, 12} are probably the most informative and that by Finkel⁹ can be used to generate ideas. In addition review articles are available on the following topics: nutrition,^{13, 14} the liver,¹⁵ the spleen,¹⁶ the heart,¹⁷ the kidney,^{18,19} the skeletal,²⁰ reproductive,^{21, 22} and neurological systems,²³ pathology,²⁴ diseases (spiritual - i.e., *tzaraat*;²⁵ genetic - i.e., hemophilia;²⁶ physiological - e.g., gout,²⁷ jaundice,¹⁵ and scurvy²⁸; microbial and viral - e.g., rabies,²⁹ epidemics,³⁰ and communicable diseases;³¹ allergic;³² neurological - e.g., *kordiakos*³³ and epilepsy;³⁴ and psychological³⁵). As noted by Domb,³⁶ the life of a committed Torah Jew does not have to be compartmentalized into its Torah or scientific sections; a harmonious synthesis is feasible. **DH**

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