Mammalian Digestive System

The challenge:

The solution:

Three stages of digestion:

1.
2.
3.

Oral Cavity:

Defined by:

Assisted by:

Results in:

Teeth:

Human dentition

Deciduous teeth

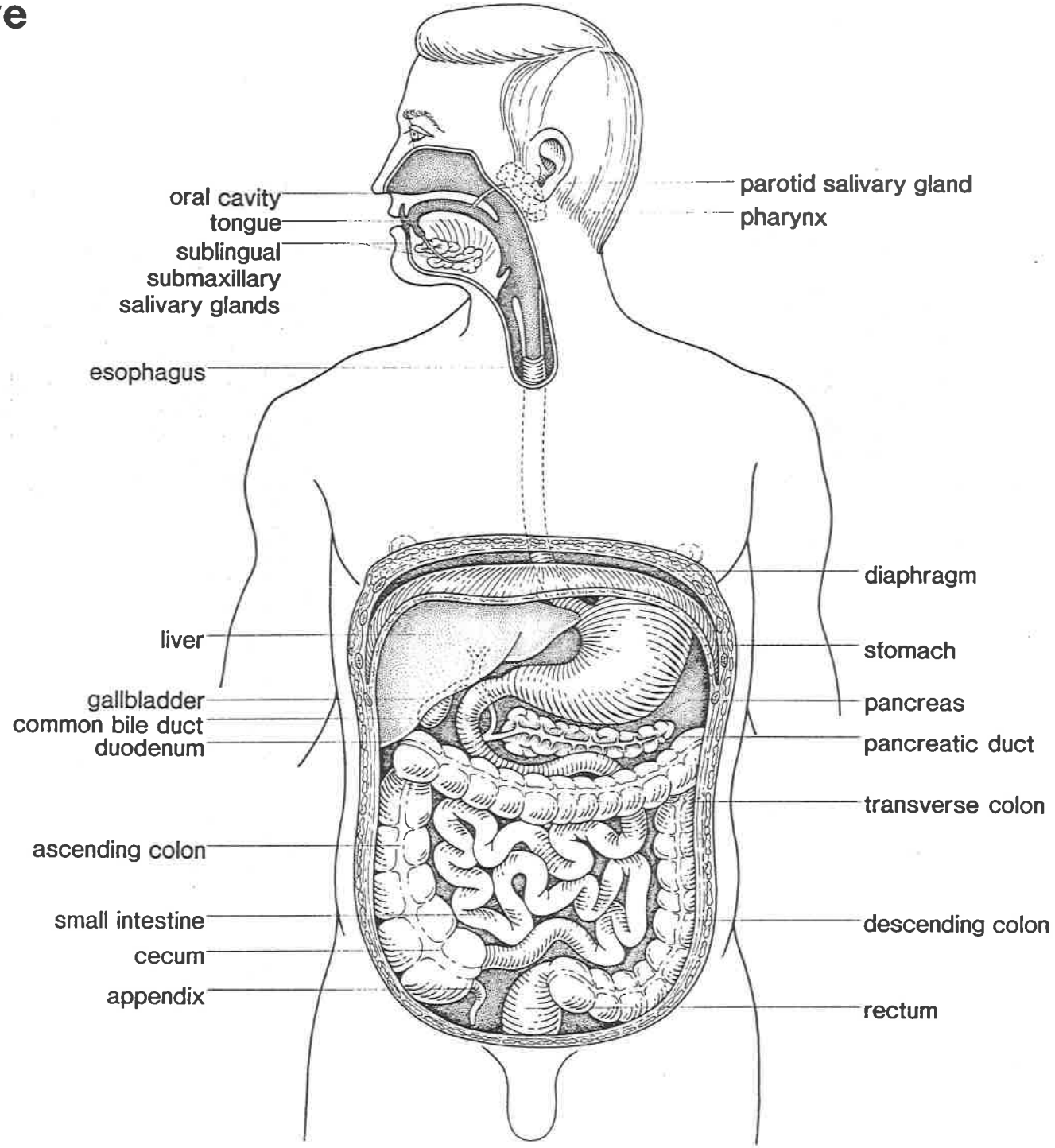
Permanent teeth

Comparative mammalian dentition

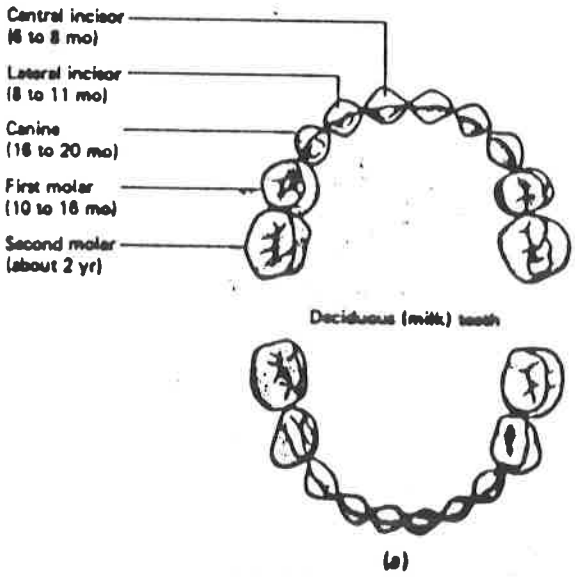
Herbivores:

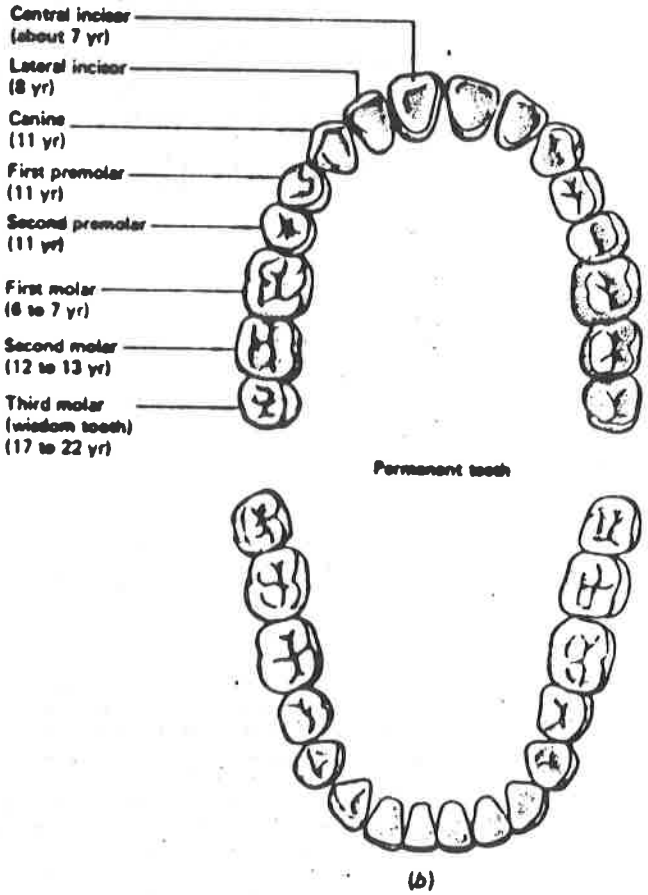
Carnivores

17 Human Digestive System (Fig. 9.1)



Human Teeth


Central incisor
(6 to 8 mo)
Lateral incisor
(8 to 11 mo)
Canine
(16 to 20 mo)
First molar
(10 to 16 mo)
Second molar
(about 2 yr)
Deciduous (milk) teeth
(a)


Central incisor
(about 7 yr)
Lateral incisor
(8 yr)
Canine
(11 yr)
First premolar
(11 yr)
Second premolar
(11 yr)
First molar
(6 to 7 yr)
Second molar
(12 to 13 yr)
Third molar
(wisdom teeth)
(17 to 22 yr)
Permanent teeth
(b)

Teeth of Mammalia

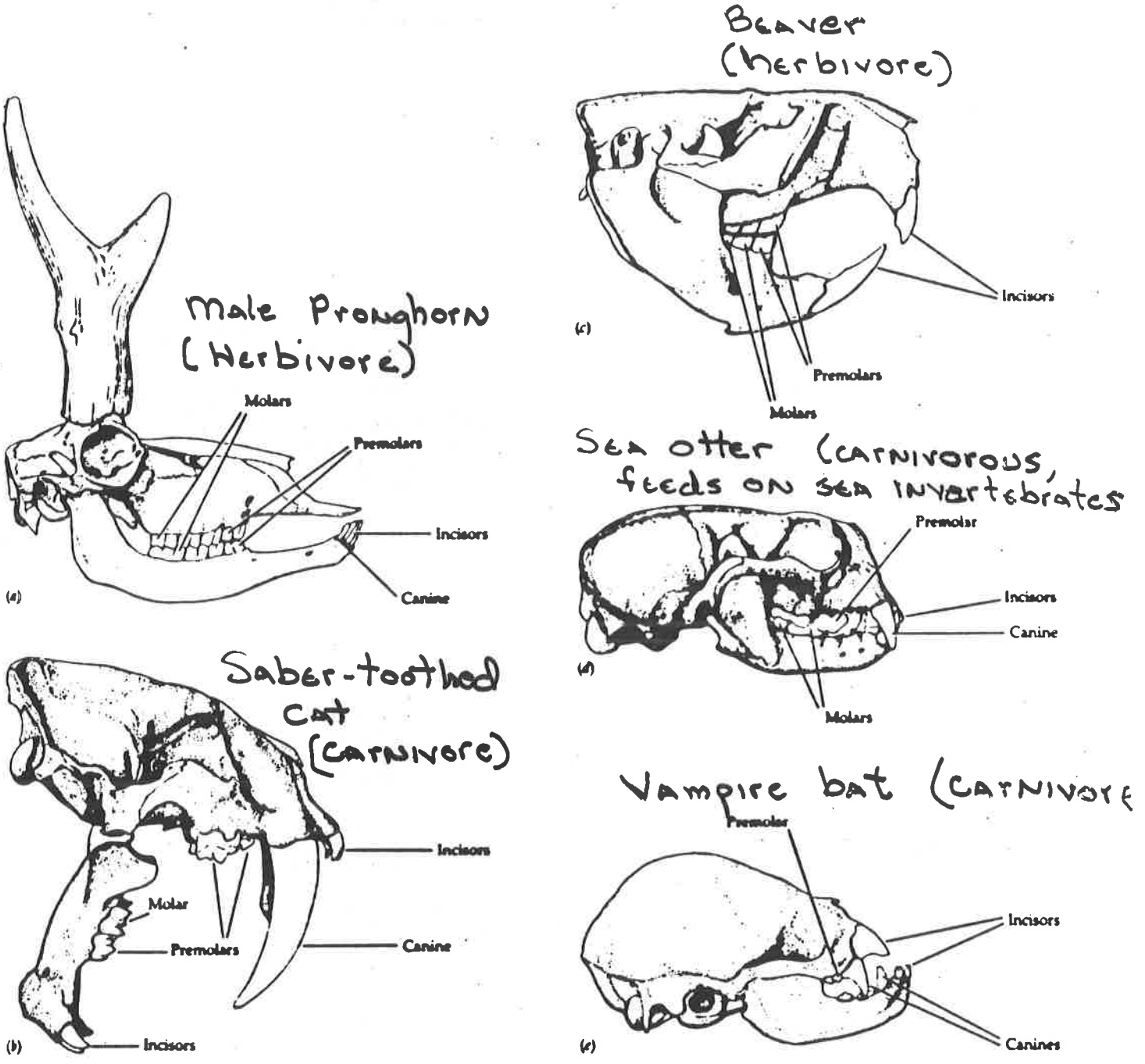


FIGURE 17 MAMMALIAN TEETH

Mammalian Digestive System (cont.)

Tubular gastrointestinal tract has a characteristic layered structure.

Mucosa - Epithelium

Submucosa - Connective tissue

Muscularis - Double layer of smooth muscle

Serosa - Connective tissue

Other features:

- Glands
- Vessels
- Plexi

Esophagus

Entrance

Peristalsis

Connection to stomach

Stomach

Morphology

Sphincters

Functions
- Storage
- Liquefaction
- Physical digestion
- Acidification
- Protein digestion
- Absorption

Mammalian Digestive System (cont.)

Histology of the stomach

Layers

Gastric glands

Mucosa cells - mucus

Chief cells - pepsinogen

Parietal cells - HCl

Secretion rate

Small intestine

Duodenum -

Ileum and jejunum -

Enzymes -

Pancreatic enzymes:

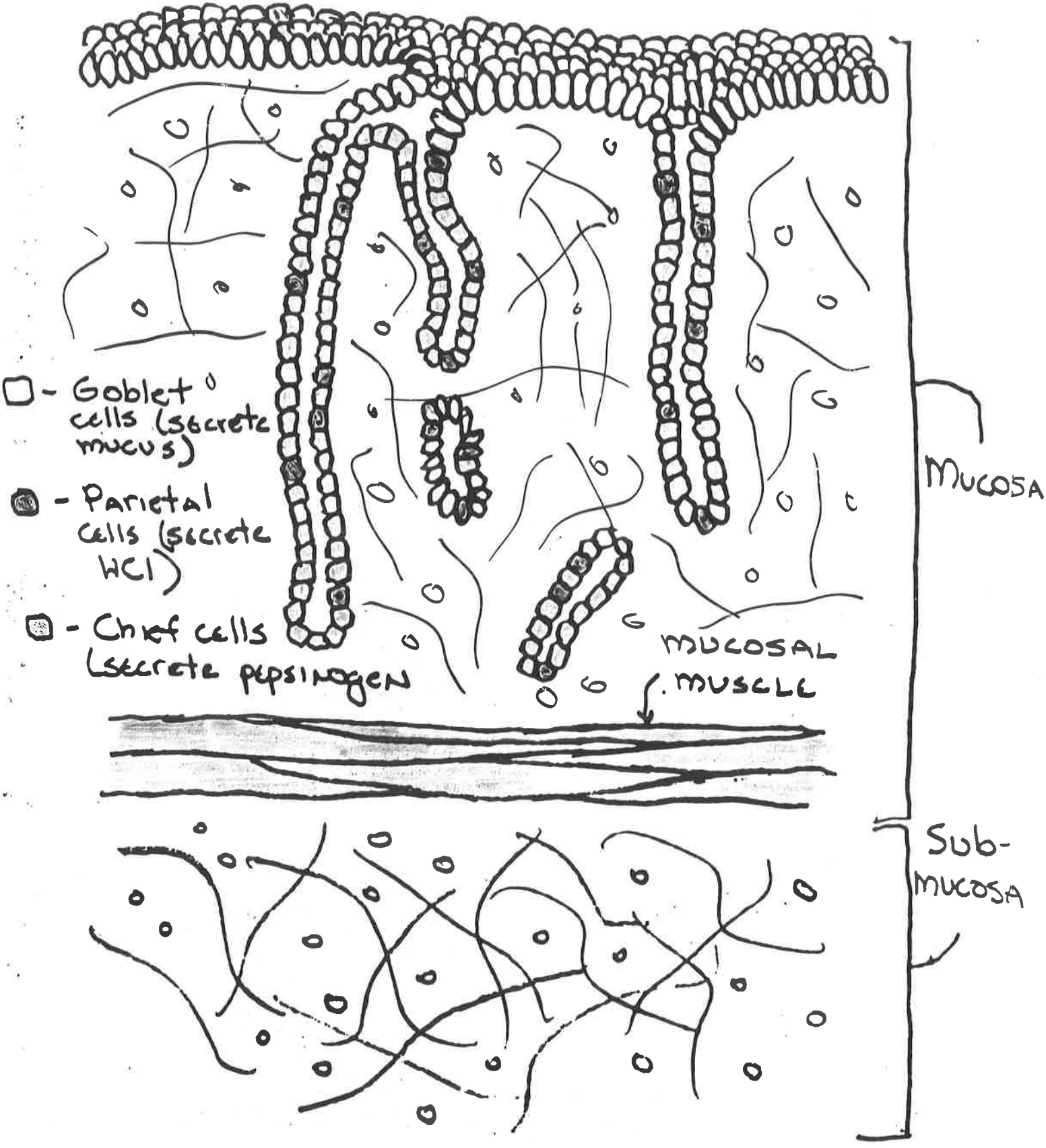
Amylase - Starch
Lipase - Fats
Trypsin - Polypeptides
Chymotripsin - Polypeptides
Decarboxypeptidase - Polypeptides
Deoxyribonuclease - DNA

Intestinal Enzymes:

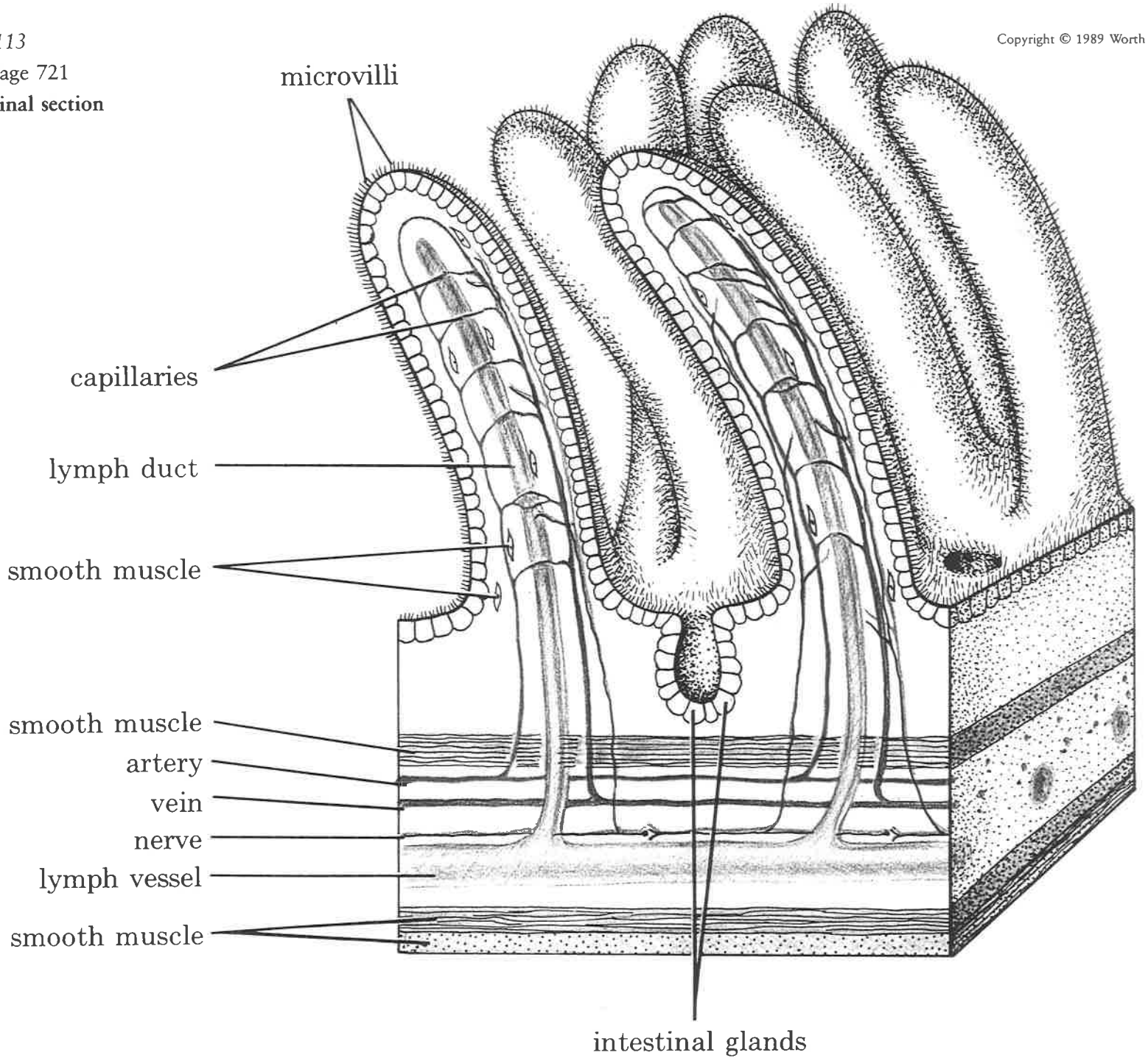
Aminopeptidase - Polypeptides
Dipeptidase - Dipeptides
Maltase - Disaccharides
Lactase - Disaccharides
Sucrase - Disaccharides
Phosphatase - Nucleotide

Inner Surface of the Stomach

(After Curtis Fig 34. P. 676)



Transparency 113
Figure 34–9, page 721
Villi, longitudinal section



Mammalian Digestive System (cont.)

Absorption by the small intestine

Proteins and Carbohydrates

Lipids

Large intestine

Junction with small intestine

Anatomy

Functions

Rectum and anus

Elimination of feces

Gas

Flatus: A Six-Letter Word for Embarrassment

In Champagne, Fermentation Causes Bubbles; In the Intestines—Gas

By Marta Vogel
Special to The Washington Post

Fourteen times a day, on the average, every one of us does something socially unacceptable but physically unavoidable. Don't look now, but that person sitting next to you has a digestive system that expels between 400 and 1,000 milliliters of gas a day, less than a cow's 300 to 600 ml, but still enough for consumers to spend $806 million last year for antacids, including anti-flatulents.

Flatus—composed of carbon dioxide, oxygen, nitrogen, hydrogen and sometimes the flammable methane—used to be blamed on swallowing air while eating and drinking. But the primary cause, though air swallowing still contributes, is now agreed to be the failure of the digestive system to completely process carbohydrates. Particularly difficult are complex polysaccharides, which circumvent the small intestine and arrive in the large intestine, where they are welcomed by resident bacteria.

"When the bacteria digest complex sugars—a process called fermentation—one of the byproducts is carbon dioxide," says Eric Rabkin, co-author with Eugene Silverman of "Passing Gas": "In champagne, fermentation produces bubbles; in the large intestine—flatus."

If your digestive system has trouble with milk—60 to 90 percent of nonwhite adults show symptoms of a lactase deficiency—you may produce what Rabkin and Silverman call "some of the most impressive cases of excessive flatulation." In lactase-deficient people, the complex milk sugars sneak past the small intestine and into the fermentation process of the lower intestine.

Methane producers—about one in three adults—still make methane even when fasting, only at lower levels. Why some people are methane producers and others are not remains a question that little research addresses.

Rabkin and Silverman's review of studies suggests that "people are fixed as methane producers by about the age of 8, and that environment, not heredity, is the principal factor in the development of methane production.

The odiferous component of flatulence is thought to be a product of the lower intestine's attempt to break down fats and proteins.

"Eating large amounts of fat increases the amount of undigested fats in the large intestine and, therefore, the smells that they produce," note Rabkin, professor of English at the University of Michigan, Ann Arbor, and Silverman, assistant professor of pathology at the University of Michigan Medical School, whose manuscript has yet to find a publisher.

Unless they are eating a diet very high in fat or beans, vegetarians normally have more gas volume—but less odiferous—than meat eaters. People who exercise a lot will also seem to have more gas, since exercise speeds up intestinal motility.

According to the Merck Manual of Diagnosis and Therapy, "though complaints are frequent about 'too much gas,' in most normal persons, 1 L [liter] of gas/hour can be infused into the gut with a minimum of symptoms . . ."

For others, such as one patient with "daily flatus frequency as high as 141, including 70 passages in one four-hour period," the result may be "psychosocial distress."

"The physician seldom deals rationally with a patient complaining of excessive flatus," says Dr. Michael D. Levitt, director of research at the Minneapolis Veterans Administration Hospital and unanimously regarded among his peers as the world's authority on this subject.

In 1976, Levitt reported on a 28-year-old man with a five-year history of excessive flatulence who had been to seven physicians. Over one year, he recorded an average of passing flatus 34 times a day and belching 14 times a day. After extensive testing and subsequent "flatugraphic" recording, the patient settled on a low-wheat, no milk diet. Interestingly, reports Levitt, "the addition of Lactobacillus acidophilus culture to milk did not reduce its tendency to induce flatulence," but the "incubation with a commercial source of lactase [e.g. "Lact-Aid"] appreciably reduced the flatulence potential of the milk."

While there is little agreement about which foods cause gas, there is less agreement, though substantial money is invested, on the cure. Anise, fennel, caraway, garlic, peppermint, pineapple and medicinal charcoal have all been suggested, with mixed results, as gas reducers. Commercial antacids such as Di-Gel, Mylanta II and Maalox II contain simethicone—a "foaming agent" that, according to Rabkin and Silverman, may help combine smaller gas bubbles together so that they are "more easily belched away" but will "have no effect on gas in the bowels."

A point of contention revolves around the health ramifications of "relaxation" about such matters versus attempts to try and fool—or at least strategically postpone—these episodes.

"In our culture, there is a tremendous inhibition against allowing yourself to be free to do this," says Rabkin. "If you have to perform the so-called natural functions—move your bowels, have sex—you go off to a private room, but there is no reason to go to a private room to do this. It's not messy. There's no reason to go anywhere."

At least one researcher has hypothesized that the "workload" necessary for retrieval and storage of obviously outward-destined gas may be a major factor in diverticular disease."

Geoffrey Wynne-Jones, in a 1975 article in the British medical journal Lancet suggests that "descending flatus is offered repeatedly for expulsion and is forced to return to the upper rectum and sigmoid. This to-and-fro movement may be expected to produce changes in the wall of the gut at the level most heavily exposed to the movement—the sigmoid colon."

Wynne-Jones notes that diverticular disease is confined to modern urban areas where flatus retention is also practiced, a problem not encountered in earlier times when "the standard of personal, domestic and urban hygiene was lower; transport was often behind the back expression of a mannerless horse; skirts were voluminous and long; and people probably walked more . . . sigmoid diverticular of a social consciousness at the age of 10 to 15 years . . ."

Levitt advocates "letting go," not that he agrees with the diverticular disease hypothesis but that "it's too hard to do anything about it. The only way to reduce it is to monitor the diet, and that's too much work for most people."

But it was Hippocrates who, in "The Flatuosities," stated it most succinctly: "It is best for flatulence to pass without noise and breaking, though it is better for it to pass with noise and breaking than to be intercepted and accumulated internally." ■

Marta Vogel is a Takoma Park, Md., writer.

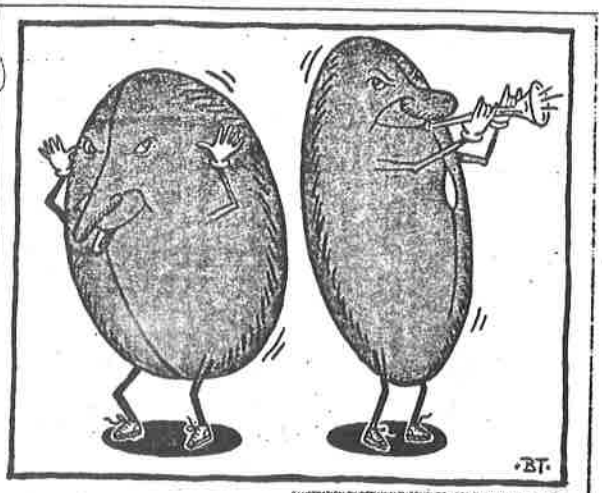


ILLUSTRATION BY BETHANN THORNBURGH FOR THE WASHINGTON POST

The Top Offenders

Onions, cooked cabbage and raw apples were the top three nominations for what people perceived as the most gas-producing foods in a 1942 study by Walter Alvarez. Next were radishes, beans, cucumbers, milk, "rich foods," melons, cauliflower, eggs, chocolate, coffee, lettuce, peanuts, peas, oranges, tomatoes, strawberries, brussel sprouts, broccoli and kohlrabi.

Almost every food has been indicted by individuals for excessive gas production. But few have withstood the rigors of scientific group testing. Levitt says there are many misconceptions about foods that cause gas. He doesn't trust any study where production is not scientifically measured. This is not as difficult as it sounds. After hydrogen and methane are produced in the colon, they are also produced in the lungs, so patients just have to breathe into a measurement device.

"I'm not even sure onions cause gas," says Levitt. "They probably irritate the gut. They give the sensation of something being wrong, of some fullness, which people mistake for gas."

French-fried potatoes and onion rings, fish sticks, donuts and pancakes are pinpointed by David Ehrlich and George Wolf, authors of "The Bowel Book" (Shocken, 1981). Dried fruits are also suspect, especially when combined with starches, such as a mixture of granola.

In a long-term experiment on his own high-flatulent digestive system, Levitt's gas-decoding patient tested over 130 different foods. Low gas producers included tuna, eggs, peanut butter, lettuce, broccoli, orange juice, corn chips and berries.

Other than milk for the lactase deficient, the only food that enjoys a consensus from laymen and scientists alike is beans, which Levitt brands "the very worst," producing two to three times as such gas per gram of carbohydrate.

But some beans are kinder than others. Charles Thomas at the Agricultural Research Center in Beltsville, who has been studying the effects of air pollution on lima beans (not the reverse) since 1972, found that the least gaseous beans are larger types such as Fordhook picked very young—half the size of fresh-frozen beans.

Levitt, who has been testing different varieties of flours, finds that rice flour is completely absorbed and produces no gas. Still, notes Levitt, "Water is probably the safest of all consumables."

— Marta Vogel