The gastrointestinal research in domestic animals in Poland is briefly discussed in the section. The history starts over seventy years ago with the creation of the Department of Animal Physiology at the Veterinary Faculty of Warsaw University. Professor B. Gutowski, the first head of the Department, and his pupils established the School of Gastrointestinal Physiology; renowned for the achievements in physiology of digestion, gastrointestinal motility, pancreas and liver functions, and comparative physiology of domestic ruminants and wild animals. After the WWII the gastrointestinal research has also been initiated in the newly established faculties of veterinary and animal science of the agricultural universities in Lublin (motility, composition of pepsinogen, biliary and pancreas secretion, vitamin and microelement absorption), Szczecin (lipid absorption, lymph formation), Wroclaw (gastrointestinal and gall bladder motility, bile secretion) as well as in the Institute of Animal Physiology and Nutrition of the Polish Academy of Science (digestion and absorption, development of the gastrointestinal tract in neonates). The research activity was focused on solving the problems faced by animal production in Poland, but it also resulted in a considerable number of physiological findings of an international dimension, and initiated new research areas.

**Key words:** digestive physiology, ruminants, wild animals, gastrointestinal motility, absorption, pancreas juice, bile
INTRODUCTION

Until the first veterinary school was organized in Lyon (1762), in most European countries veterinary subjects were lectured at the medical schools. Thus, the students of medicine received some background in animal anatomy, physiology, surgery, and diseases as well, and afterwards in their medical practice could treat both humans and domestic animals. Veterinary universities appeared in the late 18th century, again in marriage with human medicine - there were common lecturers and laboratories in particular for teaching pre-clinical subjects like, anatomy, physiology, and pharmacology. Therefore, it is difficult to identify the beginnings of research in domestic animals in Poland and the rest of Europe. However, a considerable number of findings cited in the previous chapters of this book could be considered common for both human and veterinary medicine. In Poland, though the first veterinary school was established in the 1880's, the history on animal gastroenterology research begins much later - with the organization of the Department of Animal Physiology at the Veterinary Faculty of Warsaw University in 1930. Dr. Bolesław Gutowski was appointed as an assistant professor and the first head of the department. Two years later he was appointed to full professor of physiology, and during the following thirty years of academic activity, he established an internationally recognized school of animal gastrointestinal tract physiology, which also influenced several other laboratories in Poland. In other institutions the gastrointestinal research started after the WWII. The aim of this chapter is to present a brief overview of the gastrointestinal research in domestic animals in Poland. Due to limited space, the available information has been carefully selected and focused on the physiology studies (no clinical research mentioned) which were recognized world-wide. Unfortunately, a number of interesting studies performed during the second half of the 20th century have been published in Polish and in local journals, thereby limiting the publication of this data abroad. It is perhaps a good time to consider publishing this work in international journals.

DEPARTMENT OF ANIMAL PHYSIOLOGY OF THE VETERINARY FACULTY IN WARSAW

The activity of Professor Bolesław Gutowski - from the brain biodialysates to digestive physiology in ruminants

Bolesław Gutowski (1888* - 1966†) graduated from the Medical Faculty of Warsaw University with a doctor of medicine degree in 1922 (Fig. 1). As a third year medical student, he already started his research at the Department of Physiology headed at that time by Professor F. Czubalski. Soon B. Gutowski had developed an original method of biodialysis, which was a way of obtaining the active compounds from different organs and tissues (1), which became a standard technique in neurophysiology and endocrinology for many years. Using this
method, he was able to demonstrate adrenaline in the ganglion stellatum. The boiled biodialysate from canine brain was active in the peripheral tissues, and could stimulate the \textit{in vitro} contractions of the isolated intestinal segments in rabbits (2). In his habilitation thesis, he proved the presence of certain substances in the brain which increased the blood pressure in dogs (possibly oxytocin and vasopressin demonstrated in the hypothalamus by Bergman 30 years later). Simultaneously with the studies on the biodialysates of the neural tissue, Dr. Gutowski worked intensively on the regulation of secretion of the stomach. In 1925, he published a paper explaining the mechanism of histamine on gastric secretion following the intravenous (bolus vs. continuous infusion) and subcutaneous administration in anaesthetized dogs (3). In this paper, the differences between the responses in the decerebrated dogs and anaesthetized and decerebrated dogs were also demonstrated (Fig. 2). Studies on the chemical stimulation of pancreatic secretion, role of splanchnic nerves on bile secretion, and the first in Poland implantation of the permanent gastric cannula in chicken and the following studies on the regulation of gastric secretion were published in the following years (4). The WWII interrupted the scientific activity for an extended period. Professor B. Gutowski participated in a September campaign in 1939 and spent over 1 year in a sanitation camp in the USSR. He finally came back to Poland in 1947 after 3 years of medical service in the Polish Army in the Middle East, and 2 years of teaching animal physiology for Polish students at the Veterinary Medicine Study set up in the Royal (Dick) Veterinary College, Edinburgh.

Among 17 professors teaching at the Veterinary Faculty in 1939, only 2 professors survived the war. After coming back to Warsaw, Prof. B. Gutowski re-

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{image}
\caption{Professor Bolesław Gutowski, MD, the first head of the Department of Animal Physiology in Warsaw.}
\end{figure}
established the Department of Animal Physiology which was completely destroyed by the war perturbations. The research equipment which he transported from Edinburgh in 8 big wooden boxes (financed by the Polish government on emigration) was the key to begin the experiments as well as student courses in physiology. Incidentally, one of the authors (R.Z.) of this chapter, during his physiology classes some thirty years later, used these tools which are still in good condition. The new academic staff, however, has been unlike the equipment, carefully completed for many years. In mid-fifties, Prof. B. Gutowski initiated a new research on the physiology of digestion in particular in ruminant species, which was continued by his pupils at the Department for nearly a half of the century and spread at that time into other departments at the Faculty and other academic centres. To mention only a few of them for illustration: Dr. L. Feliński moved to Szczecin and organized gut physiology research at the Agricultural University; Dr. T. Krzymowski orchestrated the physiology research at the Agricultural University in Olsztyn and organized the Institute of Animal Reproduction and Food Research Polish Academy of Sciences; Dr. J. Gill organized and headed the laboratory of comparative physiology at the Biology Faculty of the Warsaw University; Dr. Z. Jaczewski organized a research station of wild animals in Popielno; and more recently Drs. S. Garwacki and M. Wiecheteck moved to the Department of Pharmacology and Toxicology; Dr. S.G. Pierzynowski went to the Lund University (Sweden); and Dr. R. Puchała and Dr. P.R. Kiela to the USA.

The Department studies focused on the metabolism of nitrogen and carbohydrate compounds in cattle and sheep, which were fed food rations in

Fig. 2. Left: Preparation of the stomach for obtaining gastric juice in the anaesthetized dog. E - stomach, P - pylorus, d - duodenum, K - cannula, T and t - rubber tubes, l - ligature, A - aspirator. Right: The volume of gastric juice obtained in a normal dog under narcosis (A, B, C) and in a dog decerebrated under narcosis (A₁, B₁, C₁). Effect of histamine given: subcutaneously (A, A₁), by a low intravenous infusion (B, B₁), and by a fast intravenous injection (C, C₁). Adapted from ref. 3.
which a part of protein in the diet was replaced by urea or biuret, and this apparently required an easy approach to the lumen of the gastrointestinal tract compartments. The cannulation of the rumen in a young heifer (5) was the first performed in Poland. In the following years the research concerned the digestive processes in the cow and sheep rumen, ruminal motility and its hormonal and neural regulation by serotonin, acetylcholine and adrenaline, small intestine amino acid absorption, and large intestine fermentation and absorption. The research group of Prof. B. Gutowski also contributed to the studies on the nitrogen cycle described in ruminant species by McDonald in 1948 by demonstrating the circulation of urea between the forestomach, blood and salivary glands, and the contribution of mammary gland in the cow (6). At that time in London’s technique for blood collection from the portal vein in animals had been modified by his pupils (7). It was a significant step forward in an easy and frequent sampling of the portal blood for analyses and was often used in the other laboratories. After his retirement in 1960, Professor B. Gutowski prepared the first Polish language handbook on the animal physiology for veterinary students.

Professor Janusz Gill - comparative physiology of the gastrointestinal tract in domesticated and wild animals

After graduating in 1951, Janusz Gill (*1922) began his association with the Veterinary Faculty in 1946, and in 1948 became an assistant to Prof. B. Gutowski in organizing the Department and teaching. Under the scientific supervision of Prof B. Gutowski and strongly encouraged by dr. J. Żabiński (the director of the city zoological garden in Warsaw, and who was also famous for his fascinating programmes on wild animals in Polish radio), J. Gill initiated a new field in comparative physiology, where the research on the function of the GI tract and its adaptation to various environmental conditions took a relevant place. Moreover, his studies were soon directed on the wild animals living in their natural conditions and in zoological gardens. First experiments concerned the relationships between the animal and environment through the food: studies on the digestion transport in herbivorous and omnivorous mammals, circadian rhythms of digestion (initiated well before American chronobiologists), and on the adaptation in finding the food and eating in canidae (Canis lupis, C. aureus and C. dingo). Among carnivorous animals, a unique regulation of gastric distension has been found in wolfs. In cows, the studies on chewing during eating (8) gave a background for understanding the integration of processes of chewing, swallowing, and secretion of saliva. This paper published in the British Journal of Nutrition was often cited in the international literature for thirty years. In 1958, J. Gill established in the Warsaw Zoo, the first physiology laboratory in the world, and headed it until 1963. In 1968 J. Gill received a chairmanship of the Department of Physiology at the Biology Faculty of Warsaw University, and
headed it until his retirement in 1992. The laboratory in the Warsaw Zoo, in comparison with other physiology laboratories in the country was very well equipped with kymographs, calorimeters, spectrophotometer, balances and ultracentrifuge. The research done in this laboratory contributed to the comparative physiology of the GI tract (digestion transport, gastrointestinal motility, salivary, gastric, pancreatic and biliary secretions and their hormonal regulation) with over 90 unique publications on wild animals physiology involving elk, stag, red deer, lama, antelopes, Indian elephant, hare, wild boar, brown bear, mink, wolf, dingo dog and many other species. A wide range of scientific interests can be illustrated by the studies on the forestomach motility in antelopes on the one hand (9), and on the role of histamine in the regulation of salivary, gastric and pancreatic secretions in wild boar on the other hand (10). In addition to these unique data, studies in the laboratory resulted in experience important for veterinary practice in zoological gardens and national parks such as, transport, handling and anaesthesia of wild animals, etc. The laboratory soon became famous throughout Europe and North America. Among wild animals, the European bison (*Bison bonasus*) was of particular scientific interest. Lasting for forty five years the studies concerned the basic anatomy and capacity of the bison's gastrointestinal tract (11), microbiology of the rumen including the number of protozoa (12), food preferences and digestibility, and the rate of food passage in the gastrointestinal tract (*Fig. 3*), and many other topics. In the book J. Gill published in 1999 (13), he summarized unique observations and research on the physiology of the largest European mammal in its natural conditions (Białowieża National Park) and in the Zoological garden. J. Gill coordinated the

![Fig. 3. The curve of excretion of undigested food particles in 3 European bison females. The excretion is completed within 7 to 10 days. Note the differences between the October and late November experiments made on the female called POCIECHA. Adapted from ref. 13 with permission.](image-url)
W. Barej (*1934-2000†), a pupil and successor of B. Gutowski started his research in 1955, when he was a student of the veterinary faculty, and was soon involved in the research activity on nitrogen and amino acid metabolism in ruminants fed with low-protein diets or protein substitutes (14) (Fig. 4). This research was a combination of basic and applied research, since the shortage of protein feedstuff was an important economic problem in Poland, as it was in other European countries in the fifties and sixties of the previous century. In the seventies, research concentrated on liver function, in particular, in the detoxification of ammonia, which appears in excess when animals are fed with large amounts of nonprotein nitrogen (15, 16). This topic has been further developed by the team of Prof. S. Garwacki and Prof. M. Wiechetek resulting in successful in vitro set up of sheep and rat hepatocytes (17, 18), and very recently in establishing a method of hepatocyte attachment in bioreactors (19). The later studies were performed in a close collaboration with the group of Prof. A. Weryński from the Institute of Biocybernetics and Biomedical Engineering Polish Academy of Sciences. The other original contribution by W. Barej and co-workers was to demonstrate that the metabolic effects of ammonia ion are mediated by adrenaline (20, 21). In the eighties many aspects including gastrointestinal motility, blood flow, secretion, and absorption and their neural and hormonal regulations were investigated. The most often used animal models were conscious sheep and cows, and later neonatal calves, with chronically implanted cannulas, catheters and electrodes. At that time, the research group

Fig. 4. Professor Wieslaw Barej, DVM, pupil and successor of Prof. B. Gutowski. Rector of the Warsaw Agricultural University (1987-1990).
kept intensive collaboration with many European, American, and Japanese laboratories, and nearly all the assistants spent their post-doctoral training in high ranking scientific centers. The results were immediately published in internationally recognized journals and made a serious impact on the digestive physiology of ruminant and simple stomached animal species. The Department of Animal Physiology was top-ranked at the Warsaw Agricultural University, though paradoxically, the conditions for animal experiments were far from perfect. The studies were performed either in the University farms located in the distant countryside or in a small animal room with six boxes for sheep and calves located on the third floor of the University. There was always a long waiting list, including Christmas time and summer holidays, to get space for animal experiments at the Department. On the other hand, the surgery room and laboratories were well equipped with the latest scientific equipment at that time such as the first amino acid analysers, PC controlled HPLC systems, amplifiers and polygraphs. Gastrointestinal motility and pancreas studies could be developed thanks to the electronic devices (A/D converters, flow-meters) and many other small tools, like electrodes and catheters which were usually self-made and the surgical procedures allowed for recordings of biological signals, pressure changes, contractions, pancreatic juice flow, blood and lymph sampling, etc. Dr. Paweł Podgurniak invented dozens of tools for recording gastrointestinal electromyography and motility, arterial and venous catheters, electrodes for recording vagal nerve activity, cooling devices for a temporary interruption of

Fig. 5. The cooling devices used for a temporary and fully reversible block of neural conductivity in conscious sheep and calves. The devices were implanted on the vagal nerves on the both sides of the neck, the polystyrene and silicone-coated cap placed on the devices insulated the surrounding tissues from cold. The vagal nerves were blocked for 30-80 min by an ice cold water flowing through a metal tubing. Vagal block could be repeated many times on the same animal.
neural conductivity in the vagal nerve (Fig. 5), and more recently, a telemetry system and software dedicated for recording small intestinal electromyography in conscious rats (22). Dr. Stefan G. Pierzynowski and co-workers modified or introduced their own methods for collecting pancreatic juice and bile in conscious sheep, cows, and preruminant calves (23, 24). In these methods pure and non-activated pancreatic juice was obtained by implanting silicone tubing directly into the pancreatic duct, moreover, these methods preserved the neural pathways controlling the exocrine pancreas and could be used for chronic studies on the postnatal development of the exocrine pancreas and its neurohormonal regulation. The team also published a chronic method of lymph collection from the jejunal lymphatic trunk in conscious pigs and sheep (25). To study the effect of the infusion of regulatory peptides into the local duodenal circulation bypassing the pancreas, fine silicone catheters were implanted into the right gastroepiploic artery (26, 27). Synchronous recordings of the small intestinal electromyography/motility and flow of pancreatic juice allowed studies on the concerted function of the exocrine pancreas and upper gut and their neurohormonal regulation in conscious calves (28) and piglets (29).

**Studies on the exocrine pancreas function and its neurohormonal regulation via CCK and vagal nerves**

Pierzynowski and Barej (30) have demonstrated important links between the fermentation rate in the sheep rumen, insulin secretion and secretion of pancreatic amylase, thereby characterizing a species-related function of the insulo-acinar axis in sheep. Using an alloxan diabetes sheep model, Pierzynowski and co-workers (31) have found that insulin and vagal nerves are crucial factors for the regulation of exocrine pancreas secretion in adult sheep. Further studies in cattle were performed to describe the development of pancreatic juice secretion (the interdigestive and prandial secretion and the daily pattern of secretion) from the first days of life until adult (23, 32, 33). Demonstration of the low capacity of the exocrine pancreas to secrete the enzymes in neonatal calves (32) and piglets (34) led to a better understanding of weaning-related digestive disorders. Synchronized periodic oscillations of pancreatic secretion in phase with the duodenal migrating motor complex (MMC) were demonstrated in calves from their early postnatal life by R. Zabielski and co-workers. These pancreatic oscillations developed with the maturation of the gastrointestinal tract (28, 35, 36). Moreover, these studies demonstrated for the first time the involvement of endogenous CCK in the development of small intestinal mucosa. Studies in conscious calves and piglets led to developing a new concept of neurohormonal regulation of the exocrine pancreatic secretion (Fig. 6). These findings were first presented during the European Pancreatic Club Meeting in Lund (Sweden) in 1991 (26). It was shown, namely, that some gastrointestinal regulatory peptides (CCK-8, VIP, secretin) affect the pancreas indirectly from the site of their release,
such as in the proximal duodenum. In the case of CCK, besides having a direct receptoral effect on pancreatic acinar cells, an indirect mechanism located in the duodenal mucosa that controls pancreatic juice secretion via a long vago-vagal reflex has been found in preruminant calves (27, 37) and pigs (29). Further studies in preruminant calves demonstrated luminal release of CCK that depend on vagal stimulation, and the presence of functional CCK-A (CCK₁) receptor on afferent nerve terminals in the small intestinal mucosa (36). Consequently, intraduodenal administration of non-absorbable CCK₁ receptor antagonist reduced the secretion of pancreatic juice, and administration of CCK into the lumen of the duodenum stimulated the secretion of pancreatic juice in a dose-related manner (37).

Fig. 6. Schematic presentation of a neurohormonal mechanism involving CCK and vagal nerves that controls the secretion of pancreatic juice proposed following the series of studies on calves and pigs by Zabielski and co-workers.

Studies on the regulation of gastrointestinal motility and secretion by catecholamines and acetylcholine in ruminant species were initiated by Dr. M. Pytasz in the early sixties of the twentieth century. In the earlier years, when the
Department was established in 1944, the main topic was animal hematology. In the following years, the isoforms of pepsinogen in the abomasal juice and mucosa extracts in sheep, cattle, horses, rats and many other domestic animal species, and a breed-related differences as well as the development of pepsinogen and chymosin isoform synthesis in lamb and calf neonates were studied (38, 39). A direct relationship has been discovered between the individual composition of mother milk protein and the initiation of synthesis and the composition of pepsinogen and chymosin isoforms in the offspring. Dr. Barbara Nagórna-Stasiak (40) studied the mechanisms of inhibition of intestinal motility by gastric (pepsin) and pancreatic (trypsin, lipase and amylase) enzymes. In the following years she studied the mechanisms of vitamin C and B absorption, and the role of gastrointestinal secretions and food components (in particular, micro- and trace elements, amino acids) in the poultry. Using chronically cannulated sheep and chicken models Dr. Tadeusz Studziński and his team studied the mechanisms of bile secretion including the profile of bile acids following stimulation with lipids of different compositions of fatty acid length and saturation in sheep and calves. Recently, a feedback inhibition of pancreatic juice secretion by bile salts was found in weaned pigs fitted with permanent bile and pancreas duct catheters (41). New feed additives for animal production appear in the market often with a limited knowledge on their effects on the animal organism and on further consequences on the consumer. The research activity was focused on the role of exogenous enzymes (phytases), phospho-glucopeptides, etc., on the development of the gastrointestinal tract in broiler chickens and bone growth. Their results suggest that nutritional manipulation may enhance a gut-bone axis function and improve the mechanical properties of the bones in poultry (42).

**DEPARTMENT OF ANIMAL PHYSIOLOGY OF THE FACULTY OF VETERINARY MEDICINE IN WROCLAW**

The Faculty of Veterinary Medicine in Wroclaw continues the tradition of the Veterinary Academy of Lvov (1908) because it has been organized after the World War II mostly by Ivovian professors. Before the war, the animal physiology was lectured by professors of the Medical Academy, thus the Department of Animal Physiology appeared in Wroclaw. The first head was Prof. Grzegorz Załucki. The gastrointestinal research concerned the regulation of abomasal secretion in sheep using Pavlov's pouch preparation, bile secretion in sheep and rats, and rumen fermentation *in vivo* and *in vitro*, however, the studies on the GI motility produced the most spectacular results. The motility was studied by measuring pressure changes in the stomach and intestine lumen (balloon method), direct measurement of contractions with implanted transducers and by electromyography. There were also attempts to register gastric (dog) and omasal (sheep) myoelectric activities by surface skin electrodes though unsuccessful. In
the recent years, Prof. K. W. Romański and B. Wozniak-Stolarska succeeded to register the contractile activity of the antrum and bile duct in sheep and rabbits using ultrasonography (43), and revised methods of evaluation of the gallbladder volume and contractile activity measured by ultrasonography. The first international recognition was received by the studies on bile secretion in the rat performed in cooperation with the Medical Academy in Wrocław. In the article published in 1983 in Gut, K.W. Romański and W.J. Bochenek demonstrated for a first time, a direct role of circulating secretin on the regulation of hepatocyte function in terms of bile secretion (44). During his scientific stage in the laboratory of Dr. T.L. Peeters (Leuven, Belgium), Dr. K. W. Romański studied the regulation of small intestinal motility by GI hormones and bile salts in conscious dogs (45). It is the most extensive and detailed study on the regulation of gut motility by bile published in over ten articles. After coming back to Wrocław, he received a 10-channel encephalograph which was helpful for continuing the electromyography studies. Using modified platinum electrodes (46) he studied GI electromyography in sheep. The most original contribution from that time was the description of the gall bladder motility pattern - the minute rhythm (Fig. 7) and MMC, their propagation and synchronicity with the duodenal myoelectric activity (47) and minute rhythm in the sheep ileum (48). The propagation of the gall bladder electromyography signal was described and made possible using three recording electrodes sutured to the different regions of the gall bladder wall. Detailed studies on GI motility in sheep and its neuro-hormonal regulation (in particular that involving CCK) led K.W. Romański to a conclusion on a great similarity in the upper gut and gall bladder motility between the sheep and humans thereby giving a strong background for using sheep as a model for humans (Fig. 8). One of the more recent contributions was an original

![Fig. 7. The electromyogram of a normal conscious non-fasted sheep showing the minute rhythm (arrows) in the small bowel and gallbladder; a 2-min fragment during phase 2b of the migrating motor complex (MMC). 0, time in seconds; c, calibration 25 µV. Adapted from ref 47.](image-url)
observation on the modulation of slow wave activity during the minute rhythm and the role of cholinergic pathways in conscious sheep (49).

DEPARTMENT OF ANIMAL PHYSIOLOGY OF THE AGRICULTURAL UNIVERSITY IN SZCZECIN

Leon Feliński (*1928-1985†) received his veterinary diploma in Warsaw in 1952 and started to work on the physiology of digestion, gastrointestinal motility, absorption and metabolism of lipids and proteins under the supervision of B. Gutowski. In the first years of his activity he established an original method of duodenum cannulation in lambs (50). In the sixties and seventies, he published over twenty original papers on the lipid degradation in the rumen and omasum, lipid absorption in the small intestine, transport with lymph, and metabolism of lipids in the sheep, goat, calf, wild ruminants, and in dog (51, 52). In the seventies, Prof. L. Feliński participated in the UN mission in Vietnam and soon after went as an UNFAO expert to Kamerun and Uganda where he also lectured on animal physiology at the Advanced School of Agriculture University (Uganda), and died there in 1985.

THE INSTITUTE OF ANIMAL PHYSIOLOGY AND NUTRITION OF THE POLISH ACADEMY OF SCIENCES IN JABŁONNA

The Institute was established in 1955 as a research unit of the Polish Academy of Sciences for basic research on the physiology, nutrition and reproduction of
farm animals. In the early sixties the digestibility studies of fibre fractions and various proteins began in cannulated pigs and sheep. The digestibility of fibre fractions was examined in the caecum and colon of growing pigs. For this purpose the experimented animals were fitted with permanent caecum and colon cannulas. During the experiments small silk bags containing the samples were inserted into the intestinal lumen for a fixed period of time and then removed for analyses (53). The digestibility of proteins in the sheep rumen was measured with a newly adopted nylon bag technique (54). These studies revealed that digestion is specific to the source of protein and incubation time. In the seventies, the absorption of protein, peptides and free amino acids was studied using animals prepared with bridge cannulae and isolated loops (55, 56). The applied techniques helped to demonstrate that the absorption of free amino acids predominated in the proximal part of the small intestine, whereas short peptides were absorbed in more distal segments of the intestine. Moreover, threonine and base amino acids were faster absorbed in the upper than in the lower part of the small intestine. Studies on protein and amino acid digestion and absorption, N secretion and protein turnover in cannulated pigs and sheep using $^{14}$C and $^{15}$N radioisotopes were performed in collaboration with colleagues from the DDR (57). Studies have shown that a significant amount of endogenous N secreted in the stomach and proximal duodenum was absorbed there together with the exogenous N coming from the feedstuff. The amount of endogenous N in the intestinal content was significant and depended on the composition of the diet. Studies on the effect of food composition on the amount and enzyme activity in pancreatic juice were performed in conscious pigs using the duodenal pouch method (58). Using this technique, an effect of dietary fibre and anti-nutritional factors was investigated. Dietary fibre significantly increased the daily volume of pancreatic juice. This animal model has also been used to evaluate the kinetics of amino acid incorporation into pancreatic juice proteins.

Recently, in a newly established laboratory of neonatal physiology the development of the small intestine and its regulation by the milk-borne and endogenous hormones was studied in the pig neonates. Large amounts of leptin have been discovered in the sow colostrum, and intragastrically administered leptin was found by Woliński and co-workers to significantly enhance the enterocyte maturation and gut epithelial integrity in a dose-dependent manner (59). The results revealed a novel, yet unknown, biological role of leptin, and showed that the two pools of leptin, exogenous and endogenous, do not overlap each other in the neonatal pig. The role of leptin in controlling pancreatic juice secretion was elucidated in rats (60). The mechanism is complex and involves both neurohormonal CCK-vagal pathways and insulo-acinar axis. In collaboration with colleagues from the Institute of Biochemistry and Biophysics Polish Academy of Sciences, the antibacterial activity factor was isolated in the pig pancreatic juice and biochemically characterized as a pancreatic spasmylytic polypeptide thus describing a novel role of this polypeptide (61). Studies on pigs
of different breeds showed marked differences in the antibacterial activity in pancreatic juice. Following the first application of telemetry implants to record the electrical activity of the stomach and small intestine in freely moving pigs (62), regular studies began on the development and regulation of the gastrointestinal function in pig. At present, the pig model is used to investigate the post-surgical recovery of the gastrointestinal motility in humans in cooperation with Professor K. Bielecki from the Department of General and Gastrointestinal Medical Center for Postgraduate Education Surgery, in Warsaw.

CONCLUDING REMARKS

1. At the present time, the research on the gastrointestinal tract function in wild animals and domestic ruminants is marginal in Poland as well as abroad. In contrast, there is an increasing interest in the studies on pigs in particular during their early postnatal period and around the weaning time to reduce post-weaning gastrointestinal disorders.

2. There is a growing number of data showing the gastrointestinal function in pigs is similar in many aspects to that of humans. In fact, it is much closer than that of rats and mice which are nowadays commonly used in the laboratory practice.

3. In particular cases, preruminant calves and sheep can also be good models, respectively, in the pancreas secretion and upper gut and bile duct motility studies. Perhaps the interdisciplinary integrated teams working together will not be a rare picture in Poland in the near future.

4. Progress in physiology obviously depends on the development of new technologies. The laboratory at the Department of Physiological Sciences (former Dept. of Animal Physiology) at the Faculty of Veterinary Medicine in Warsaw is one of the best equipped for the cytometry studies ever seen, thus giving a new impetus in the research of cell physiology.

5. The results obtained on the molecular and cellular level, however, are incomplete without a careful verification on the level of the entire organ and animal organism. Therefore, whole animal physiology studies, though sometimes considered out of fashion, must not be cast aside, and must be continued on a reasonable scale. It is expected that finding a good balance between the physiology studies on a single cell and on the whole animal level becomes a great challenge for each physiology laboratory.

6. The researchers in Poland excel at experimental surgery - this may be enhanced in the near future. The experimental methods are also supplemented by new technologies (medical-grade implants) and novel techniques for instance, ultrasonography and telemetry electromyography, for chronic
studies in conscious animals markedly improving the animal welfare and limiting the use of animals.

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