MALPIGHI AS ANATOMIST[1]

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IN these crowded days it is easy to overlook or forget what one owes to the past. The present is vocal and urging; the past silent and patient. Besides, life is so many-sided that no one can realize fully his entire indebtedness to the past, although the higher a civilization, the greater this golden heritage always is.

It is fortunate that we are willing to pause in a hurried day in order to pay our respects to a searcher who labored with great enthusiasm to almost the very end of his life in order to enlighten man regarding his own body. The name of Malpighi can never become a household word, but the debt that every one owes him nevertheless is great. There are no greater triumphs than those over ignorance and helplessness, over barbarism and brutishness. Hence it will be a sad day for civilization when the Malpighis are forgotten.

Although we are observing the tercentenary of his birth, Malpighi does not belong to the ancients. He was a modern anatomist, not only in his methods but also in his attitude and outlook.

As anatomist, Malpighi was not an observer of the dead alone. He was an experimentalist who worked much with *living* creatures of different kinds. He used both vertebrates and invertebrates as well as plants, and felt that there was a kinship among all living creatures, so that one could learn regarding the higher from an examination of the lower forms.

During all the time that he was professor of medicine he earnestly tried to reveal and understand the architecture of beings of all kinds, and to this end he used the microscope, chemicals, pigments such as ink, and the processes of maceration, boiling, injection, ligation, dissection and vivisection. How modern he was can best be illustrated by the fact that an enterprising medical student who copied from Malpighi's works over two hundred years afterward is recorded as actually having received a prize for his contribution to science.

It seems regrettable that Malpighi's anatomical studies had to be done largely during vacations and spare hours, for his interests did not lie in the single lane of the anatomy of his day. Worms, insects, fishes, amphibians and mammals of many kinds claimed his attention. He made contributions to embryology and to both gross and microscopic mammalian and human anatomy, and was in a large measure a founder of embryology and of the microscopic anatomy of organs. Indeed, Sir Michael Foster in his "History of Physiology" states that where Malpighi left embryology, it remained till the beginning of the nineteenth century.

It is true that Malpighi was in a sense a preformationist, for he had concluded that the chick is present in the incubated egg. This erroneous conclusion rested upon the observation that when hen eggs which had lain in a warm climate for some time were opened, it was found that development of the new individual had already begun, as indeed it has by the time a fertilized egg is laid. Moreover, since we now know that not all the cytoplasm of an ovum has the same potentialities, it is clear that present-day ideas of development might in some measure still be regarded as embodying a preformation hypothesis, although our ideas contain none of the early implications, and could we but go back farther in oogenesis with our experimental efforts, we would no doubt reach a stage in development in which the segregation of developmental potentialities probably had not yet occurred.

When Malpighi saw something new he was not content until others also had seen it, and some of his great discoveries are recorded in letters to his friends. That he took keen delight in his work is shown by his declaration that "in performing these researches so many marvels of nature were spread before my eyes that I experienced an internal pleasure that my pen could not describe." This devotion to practical studies caused him to be ridiculed, and he, like his great predecessor Harvey, was taunted by being asked how dissecting plants and watching the eggs of silkworms and hens hatch could possibly help cure the diseases of man. It is a strange commentary on modern life that there are those among us who still ask this same outworn question.

Since the labors of great men of the past often seem magnified by our forgetfulness of other workers in their field of activity and their time, it is well to recall briefly some of Malpighi's approximate contemporaries in anatomy. Among these were Bartholin, Bellini, Brunner, Cowper, du Hamel, de Graaf, Gall, Glisson, Highmore, Meibom, Nuck, Peyer, Riolan, Rivinus, Ruysch, Schneider, Steno, Swammerdam, Sylvius, Tulp, Wharton, Willis, Wirsung, etc. These names are known to all physicians, and most of them still are associated with parts of the human body, but Malpighi was greater than any of these. We still associate his name not with one but

[1] Remarks at the banquet of the Italy-American Society of San Francisco at the time of the tercentenary of Malpighi.

with a number of structures in human, comparative and plant anatomy.

Anatomy was beginning to flourish. The lymphatics had recently been discovered by Aselli; rickets was about to appear in the mortality tables of England, and quinine had just been introduced into Spain. The microscope had become known in Italy four years before Malpighi's birth, and Harvey's great work appeared the same year.

Malpighi was born a few years before Leeuwenhoek, and Thomas Sydenham, Thomas Willis and Robert Boyle were born a few years before him. Kepler had died a few years before the birth of Malpighi, and the temper of Italy was as troublesome, probably more so, than that of the England of Harvey. It will be recalled that Harvey wrote in "De Motu Cordis":

> But what remains to be said upon the quantity and source of the blood which thus passes, is so novel and unheard of a character, that I not only fear injury to myself from the enmity of the few, but I tremble lest I have mankind at large for enemies, so much doth want and custom that become as another nature and doctrine when sown, and that hath struck deep root, and respect for antiquity, influence all men; Still, the die is cast, and my trust is in my love of truth, and the candor that inheres in cultivated minds.

The Italy of Malpighi's day was rather less tolerant, for its learning was at a low ebb. There was very little in the life of seventeenth century Italy to encourage, but very much to discourage a pioneer. There were beacons of learning, however, and early in his career Malpighi joined the Accademia del Cimento of Florence, an organization for the experimental study of the physical sciences, and it is to his credit that he did not hesitate to go afield and experiment in the biological sciences as well.

When Malpighi was graduated from Bologna in 1653, as doctor of medicine and of philosophy, he was fortunate in being invited to join a small group, an anatomical club (Coro Anatomico) under the leadership of his later brother-in-law, Massari, who had been recommended to him as a preceptor in medicine. This zealous group of nine dissected human bodies and experimented on animals in Massari's own home, and this experience could not have been without influence upon Malpighi's career. However, he was a born anatomist, for he experimented and practiced dissections assiduously most of his life, though through a strange irony of fate he never held a professorship in anatomy, but professorships of medicine instead. Although he served in this capacity at Bologna, Messina and Pisa, and also was greatly honored by being called to be the private physician by Pope Innocent XII, enduring renown as a physician nevertheless does not seem to have been his. This is no reflection upon Malpighi, for his chief devotion was given to other things, although his contemporary fame as a physician is amply attested by his being called to fill professorships of medicine at several universities, sometimes at truly princely salaries.

Malpighi early realized the weakness of relying upon authority in anything concerning the works of nature, and thus antagonized those who blindly followed the errors of the great men of the past. Indeed, it was his interrogation of ancient authorities that caused him to lose favor and also preferment at his alma mater, where it seems he could rightly have expected to stay after his graduation in medicine. Although he tells us that he sometimes had recourse to the "eye of reason" when the microscopes, some of which he made himself, failed him, he was impatient with the views of Hippocrates and Galen on matters of structure and function. In his work on the kidney, Malpighi wrote:

> The fact that the human mind has pondered this and similar ideas about the kidneys throughout the ages stimulated me to further investigation . . . and be sure of this one thing, that I never reached my idea of the structure of the kidney by the aid of books but by the long, patient and varied use of the microscope. . . . Indeed, some people even introduce personal opinion against the indicated course of the urine in the papillary passages. . . . Do not stop to ask whether these ideas are new or old, but more properly whether they harmonize with nature.

Although Bowman's capsule was not discovered until 1842, and Henle's loop not until 1862, that is, approximately two hundred years later, Malpighi nevertheless firmly believed that the renal glomeruli are directly connected with the ureters. Although he could not prove this by means of injections of the ureters, arteries or veins, he held that both "reason and analogy" show that the glomeruli and ureters are united. He compressed the renal papillae and saw urine escape from the collecting tubules, and also ligated the ureter and vessels upon living animals and examined these after death, in order to demonstrate the relationship which he believed must exist between them.

Malpighi's contributions to anatomy were many and permanent, as the terms Malpighian corpuscle, layer and tubule attest. His description of the anatomy of the silkworm, of the human skin, of the liver, uterus, lungs, the kidneys, the spleen and the glands marked advances in many important respects. Indeed, in regard to some of these organs little was added to Malpighi's conception until long thereafter. This was true especially regarding the liver and kidney, and the incubating egg and silkworm.

Malpighi was both keen and ingenious and studied living things not only after but also before birth. His observations on the incubating hen egg form foundation stones in modern embryology. Although he thought that parts of the mature body were preformed in the egg he made a number of discoveries and accompanied the twenty-two quarto pages of description with eighty-four very good original drawings. Since this work in embryology was done before the days of thermometers and incubators, Malpighi also may have had to impress roosters for the service of hatching the eggs after the ingenious manner described by his great countryman, "L'Omo Universale," da Vinci.

Before Malpighi's day the ideas regarding the spleen and the pancreas were decidedly fanciful. The latter was looked upon merely as a cushion to help support the stomach, and regarding the spleen it was held that so-called black bile from the liver reached the stomach by way of the spleen either through the veins or by means of a special duct passing from the spleen to the stomach. Malpighi, who had ligated the vessels of the spleen in the living, scouted these ideas, and rightly maintained that the spleen has no duct, and that no material passes from it to the stomach. He thus corrected the false old notions upon which the current phrases "too much spleen" and "suffering from the spleen" are based.

It is not without interest to recall in this connection that a text-book of anatomy written by a self-styled anatomist, for one of the largest schools of manipulation in this country—a school whose graduates were authorized by the people of our state to diagnose and treat human ills—I say it is not without interest to recall that in this text-book of anatomy it is stated that: "Chiropractors have long maintained that the spleen furnishes a secretion that is used in the process of digestion" and that the spleen "has certain relations to digestion not yet understood." Indeed, the author of this text-book of anatomy is credited with having found during our time a duct leading from the spleen to the stomach, which was named after her. It is regrettable to think that some present-day Americans are willing, when ill, to be treated upon the basis of pre-Malpighian anatomy and physiology, and blindly wave aside the knowledge gained through the arduous and fruitful labors of great men of the past such as Malpighi.

Malpighi also discovered the sebaceous glands of the skin, and showed that the papillae of the tongue are not there to keep it moist. He showed that they are associated with nerves; believed that they had to do with sensation, and drew a similar conclusion regarding the papillae of the skin.

Every one familiar with the anatomy of the skin must have been perplexed by the fact that Malpighi spoke of the deeper portion of the epidermis as rete mucosum, for both these words seem thoroughly inappropriate. In all modern dissecting rooms the sloughing superficial layer of the skin includes the entire thickness of the epidermis, which, as is well known, is so thin in most areas that one must marvel how Malpighi could possibly have distinguished a deeper from a superficial layer. Hence it does not surprise one that Bichat denied that Malpighi had seen such a deeper layer in the epidermis, for as is common knowledge, the epidermis is separated as a single layer in connection with blisters, maceration and so forth.

It seems that Malpighi included in his work on the skin a study of bovine tongues, in which when boiled or macerated, or treated with an alkali, he could detach the superficial from the deeper portion of the mucosa, which under the circumstances had become clearer, somewhat swollen and more translucent than the superficial portion of the mucosa. Moreover, since only the interpapillary portions of the deeper portion often remained after detachment of the more superficial, the former contained perforations in the places of the papillae, when it was detached, thus giving him the impression that it was a meshwork or rete. Having observed these things in the thick mucous membranes of the tongues of bovines, Malpighi by analogy seem to have transferred the conception so gained to the human skin, for the idea that skin extends up into the nostrils and mouth had then but recently been advanced.

Malpighi rightly attributed skin color to pigment located in the epidermis, although this question remained a matter of dispute for almost two hundred years later. In 1823, Beclard, predecessor of Bichat, for example, still wrote: "The anatomical texture and composition of the skin are delicate points of anatomy that have greatly exercised the patience of observers and upon which they are far from agreeing."

Malpighi showed further that the trachea ends in small air sacs in the lungs, an observation which cleared the way for a truer conception of the rôle of breathing. Since Malpighi had shown that silkworms die in spasms "in the time it takes to say a *pater noster*," if the tracheae or breathing tubules on their bodies are coated with oil, it is indeed a little puzzling why he did not himself find a closer solution for the process of respiration. However, in doing these experiments on silk worms Malpighi was circumspect and emphasized that the nature of the oil is immaterial and that the worms die even if their bodies are coated with honey.

It is particularly significant for us of to-day that

many of Malpighi's discoveries were made by the aid of experiments on living creatures and that they could not have been made in any other way. It was impossible to see the natural motion of the blood except in living beings, and it was while observing the lungs and other organs of frogs, hedgehogs and turtles, under magnification, that Malpighi discovered the existence of tubular connections between the arteries and veins which we now know as capillaries. Regarding this discovery Malpighi wrote, "I see with my own eyes a certain great thing. . . . All this you will see exceedingly well if you examine the turgid lung of a frog with a microscope of a single lens against a horizontal sun." It was in such simple words as these that Malpighi recorded the crucial discovery which was needed to bring final proof of Harvey's conception of the circulation of the blood. One can not help but surmise that Harvey would have discovered the capillaries and so completed the entire story of the circulation himself, had it occurred to him to have recourse to the microscope available at the time. However, Harvey, a relatively aged man at that time, doubted the discovery of the lymphatics and could not be expected to turn to a new method of investigation in the evening of his life.

Malpighi found that nerve fibers run from the spinal marrow to the brain, and by dissecting the boiled hearts of cattle showed that the muscle of the ventricles is arranged spirally, a discovery which was not completed till two hundred and forty-four years later, in 1900, by a young Canadian anatomist, John Bruce McCallum, working at Johns Hopkins. It is true that Malpighi did not recognize the true nature of the brain of the silkworm, and mistook the red cells of the blood for "fat globules which looked like a rosary of red coral," that he thought the spinal nerves were hollow tubes and believed the gray matter of the brain which is scattered among the white to be glandular in structure, but he nevertheless was a very acute observer, and unusually gifted in reading the great book of nature. His descriptions and drawings alone are proof of this and he carefully explained his methods.

In the light of his day, it should not seem strange that Malpighi thought that the nerves were hollow, for the existence of a "succus nervicus" was then generally accepted, and when the doctors of that time used the phrase "caput purgiis" they meant it literally, for nasal secretion—rheum—was thought to represent impurities discharged from the brain, and spinal marrow—hence such expressions as "mourning of the chine." Moreover, the ducts of several glands had recently been discovered, and these were known to be hollow, and since Malpighi thought that the entire body including the brain was glandular, the conclusion that nerves were hollow and carry nourishment seems natural enough. Malpighi further thought that the finest particles of nutriment could pass directly to the nerves from the papillae of the tongue, for he reasoned that were it not so, "Wine taken into the mouth could not restore vigor presently."

The microscope then was a new tool, and it is no wonder that Malpighi was over impressed with what it revealed. The same thing happened to Leeuwenhoek, who demonstrated testes in maggots which he found in cheese, and to Swammerdam, who demonstrated all parts of the butterfly in the body of a caterpillar. It is interesting that the conception of glandular structure for the entire body was shared also by Wharton, the discoverer of the duct of the submaxillary gland, and by the great Dutch physician Boerhaave.

In order to reveal Malpighi's breadth of scientific interest, it is only necessary to read the following list of topics selected from the many that engaged his attention:

On a pregnant mouse.

Concerning the experience of extracting salt from minerals, fossils, etc., with common water.

The structure of the aorta of bovines.

The covering of stumps of sawed-off branches with bark.

On the spoiling of ground grains by honey dew.

The old trunks of laurels.

On various parts of elephants.

The sprouting of laurel seeds.

On ears of corn spoiled by moisture and honey dew.

A hair-like fistula in the human body.

The spermatic vessels of the dormouse.

An oak gall.

The hatching of the butterfly from the pupa.

The structure of the nests of wasps.

The omentum of the mole, the medulla of the silkworm and the uterine fetus of the hedgehog.

The eye of the night owl.

The motion of the heart of the locust.

On calculi in the guinea-pig.

The vesicles and spermatic parts of castrated horses.

The white fungus of wood.

The eggs of ground snails.

The pods of castor beans.

The noctiluca.

On the tench, the locust, the butterfly and on the oesophagus and eyes of cattle and the eyes of fishes, frogs and turtles.

On bull calves, snakes and "lucertolo."

On the pregnant and non-pregnant uteri of cattle.

On the worm and cricket.

The bones of fishes and the gall bladder and gall of bovines.

On the fat of the mole.

On human skin.

The pigeon pullet in the egg.

The feces of horses and the horns of cattle.

Observations on flies, snails, guinea hens and the guinea hen pullet in the egg.

Note on tubal pregnancy.

Note on the muscles of torpedo.

The gelatin found in the cranium of "piante."

On the structure of hair, feathers and snails, bones, teeth and gout.

Observations on the ear.

The seeds of lichens, mosses and ferns.

On tides.

On the optic nerve of the swordfish and a series of other vertebrates.

Malpighi was not only an anatomist, but also a zoologist, a botanist and physiologist as well as a practicing physician. He also took interest in physics and chemistry, and was known as a chemical physician. With his wide interests went tireless industry and an indomitable spirit which was not quenched by the loss of his instruments, home and manuscripts by fire at the age of 56 but endured to the end of his active life.

It is possible that what Haeser termed his confused style and often hardly comprehensible Latin may have been a factor in the lack of a broader recognition of his many achievements in his own day and ever since then.

It stands to the undying credit of England that the Royal Society of London invited Malpighi to correspond with them, and elected him to membership. Almost all his papers written after he went to Bologna were published by that society, as Harvey's immortal work had been published in Frankfort.

Although the stirring things which happened in Malpighi's days may have spurred him on, I think that we must grant that his fruitful labors were the product of his genius and not of his day. The microscope, injections and other advances in technique were equally available to others, but no one used them to such good advantage as Malpighi. He stood at a new era, and spoke with a new voice. He was not a child of his time and his was a magic hand which illumined all it touched. His methods were objective and experimental, thoroughly modern and scientific in every way. He was an experimental, physiologic anatomist.

I have endeavored to recall very briefly some of Malpighi's services to mankind. My tribute is of necessity incomplete and inadequate, but fortunately his accomplishments speak eloquently for him. It is to these that one must turn in order to realize more fully what he did for all of us. We may not all be his friends, but all of us are his debtors.

SCIENTIFIC EVENTS

UNVEILING OF TABLET TO SIR WILLIAM AND SIR JOSEPH HOOKER

ON Sunday, August 17, in connection with the meeting of the International Congress of Botanists, a tablet was unveiled at the parish church of St. Mary's, Halesworth, East Anglia, England, in memory of the famous botanist and first director of the Royal Botanic Gardens, Kew, and his equally famous son, the second director of Kew, Sir Joseph Hooker.

The tablet was unveiled by Lieutenant-Colonel Sir David Prain, a former director of Kew, and the dedication was by the bishop of St. Edmundsbury and Ipswich, who also gave an address from the text, Psalms 104, verse 24. The bishop stressed the importance of open-mindedness on the part of ecclesiastics toward the findings of science and the equal importance of a similar attitude on the part of scientists toward religious thought and work. The Scripture lesson was read by Lord Ullswater, former speaker of the House of Commons and chairman of the tablet committee. The arrangements were carried out by Professor Oliver.

The tablet was designed by Mr. A. H. Gerard, of the department of sculpture, Slade School, University College, London. The design of the lower border of the tablet is an overlapping of the corollas of certain rock garden flowers to symbolize plants growing close to the ground. The side-border design is of conventionalized flowers of a species of heath, magnified forty times, symbolizing plants that grow up into the air. At the center of the top border is represented the sun, without which plant life would not be possible, and on this border are also five conventionalized birds, symbolizing the dissemination of seeds. The design is carved in incised relief, a method used by the Egyptians some 3,000 years ago.

Medallions of the tablet will be cast by Wedgwood to supply orders received.

Sir William Hooker lived in Halesworth when a young man, and was unsuccessful in his attempt to conduct a brewery adjacent to the family home where Sir Joseph was born. When the latter was about four years of age his father abandoned business and adopted botany as a career. In this profession it was early predicted of him that he was "likely to become a person of some importance."

Among those who attended the ceremony of unveil-