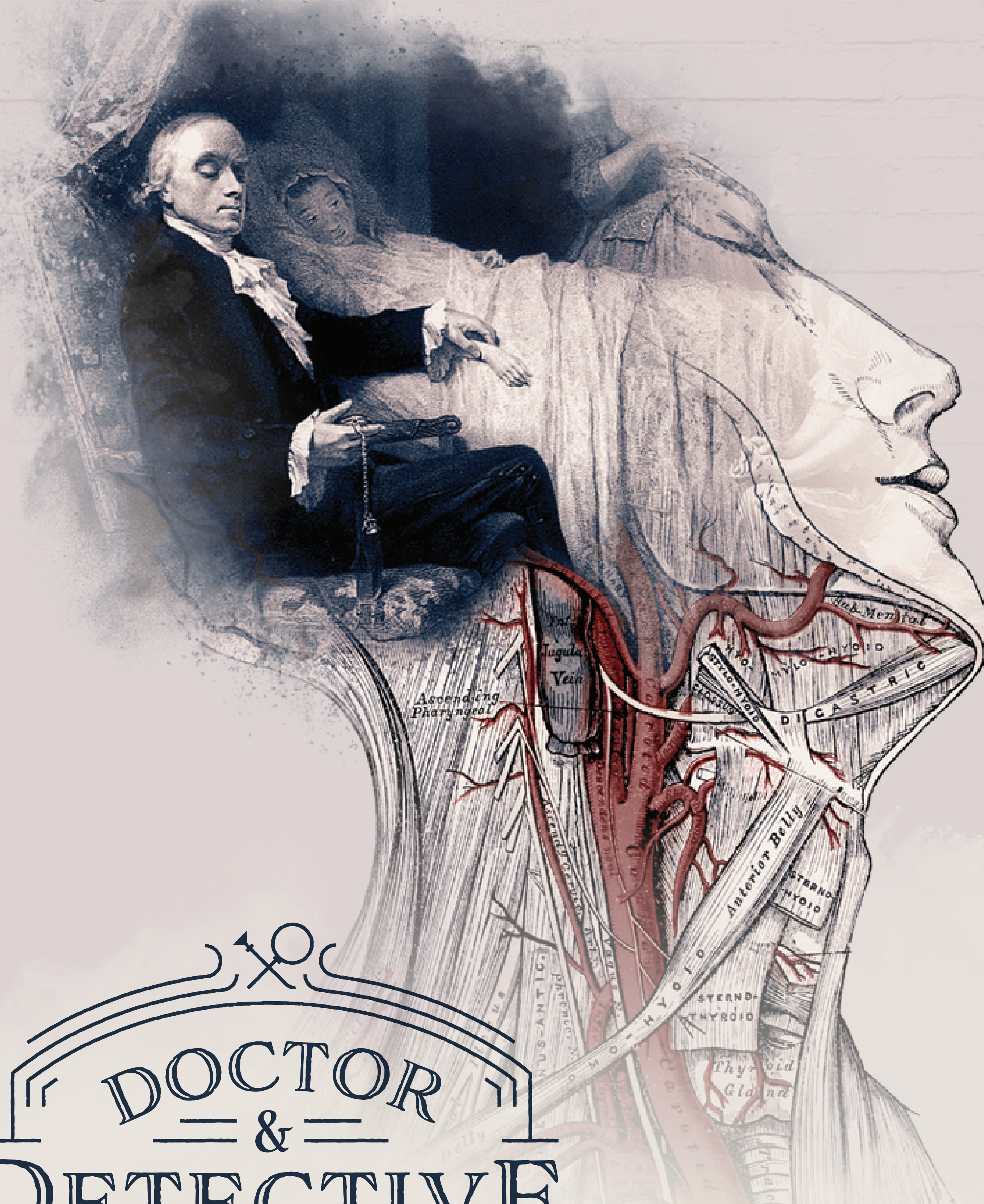


DOCTOR & DETECTIVE

INVESTIGATING THE *History of Diagnostics*

Inspection

Palpation

Auscultation

Contemplation

SNAPSHOTS OF OSLER AT THE BEDSIDE

From snapshots taken by T.W. Clarke

Inspection, palpation, auscultation and percussion have been described as the hallmark features of the medical examination and highlight the physical uses of the senses by the physician. Yet, all of the senses have been utilized at some point in history including taste and smell.

There are a series of photographs of Sir William Osler demonstrating these methods of examination on the wards of Johns Hopkins. The history and physical examination were prior to the 19th century — the only pre-morbid patient interactions that could give a clue to true medical diagnosis of an ill patient. It has been roughly tabulated that essentially ten individuals are responsible for the development of the routine physician/patient interaction that underscores the modern notion of physical examination. These individuals included the following: Hippocrates, Vesalius, Morgagni, Sydenham, Auenbrugger, Corvisart, Laennec, Louis, Mueller and Osler. It is to them that the *"golden thread throughout the history of the world, consecutive and continuous, the work of the best men in successive ages"* has been transmitted to the modern physician as quoted by Sir William Osler.

Hippocrates brought the physician's actions and methods into an art; he separated the profession from the shamans and the mysticisms that had entrapped medical progress from the observation and recording necessary to develop real knowledge of disease and illness. Dissection of human corpses followed by the dawn of the Renaissance in the Middle Ages by the 13th century. Vesalius published his ***Fabrica*** in 1543 and the floodgates were opened to begin the arduous task of questioning the ancients and a modernistic quest for medical knowledge. Thomas Sydenham questioned all medical knowledge and the physician's approach to patients and what is now referred to as "nosology" between 1666 and 1683 and interacted with John Locke and Robert Boyle who were his contemporaries. Morgagni established morbid anatomy and introduced pathology that would eventually link pathologic processes to diseases themselves. He published his magnum opus in 1761. Auenbrugger, in 1760, followed the art of the vintner, by thumping kegs into the practice of medicine and this knowledge became disseminated by Corvisart in 1808. The stethoscope was invented in 1816 by Laennec and this was utilized and improved by the investigations of Pierre Louis who synthesized the findings by following his patients to the morgue between 1800 and 1850. Johannes Müller led the introduction of laboratory investigation into the clinical management of illness from 1830 to 1900. Richard Bright (1789-1858) demonstrated the power of this technique with his experimental ward at Guy's Hospital. He managed to convince the Governors at Guy's Hospital to provide him with a special ward for the investigation of diseases of the kidney in 1843. It was Bright's ward that bridged the gap from laboratory and hospital ward, pointing the way to the future. Finally, the modern diagnostic methods cannot be complete without including Sir William Osler and his introduction of the modern residency program and all of these methods, including the reverence to historical forebears at Johns Hopkins Hospital from 1889-1905.

In this medical sojourn, one could well question about the necessity of urologists in understanding the history and physical examination itself, or what purpose does a stethoscope play in the role of urology at the dawn of the 21st century? Suffice it to say that without clinical examination and development of the ability to find clinical pathology in our patients is giving up the years of training that go into the making of a physician. The physician could, therefore, be arguably nothing more than a technician. We will also specifically address the issue of missing vital bits of information in our day-to-day interactions with our patients. I would like to conclude this introduction by quoting one the giants of surgical authors about diagnosis itself, the late Sherwin Nuland. *"I capitalize it so there will be no mistaking its dominance over every other consideration. The satisfaction of solving The Riddle is its own reward, and the fuel that drives the clinical engines of medicine's most highly trained specialists. It is every doctor's measure of his own abilities; it is the most important ingredient in his professional self-image."* Urologists are specialists in the genito-urinary system, but first and foremost, physicians taking care of patients who are not isolated from the remaining systems of their bodies.

Opposite: Sir William Osler demonstrating inspection, palpation, auscultation, and contemplation.

Images from the History of Medicine (NLM)

Dr. Joseph Bell:

The Inspiration Behind Sir Arthur Conan Doyle's Sherlock Holmes

Sutchin R. Patel, MD

We live in a technological world in which we spend increasing time on our cell phones and computers and less time observing the world around us. These changes also affect how we practice medicine, as imaging and laboratory tests may decrease the time we actually spend with a patient taking a thorough history and physical exam using observation and empirical data to form a reasonable diagnosis.

Thinking about the art of observation and deductive reasoning, we are often reminded of Sir Arthur Conan Doyle's famous literary character, Sherlock Holmes. What many may not realize is that Doyle was a physician, and the character of Sherlock Holmes was based on Dr. Joseph Bell, one of Doyle's professors at the University of Edinburgh.

Sir Arthur Conan Doyle: The Physician

Portrait of Sir Arthur Conan Doyle

Wellcome Library, London.

Sir Arthur Conan Doyle studied medicine from 1876 to 1881 at the University of Edinburgh Medical School where he met Dr. Joseph Bell and served as his clerk at the Edinburgh Royal Infirmary. Dr. Bell wrote about Doyle:

> *Doyle was always making notes. He seemed to want to copy down every word I said. Many times after the patient departed my office, he would ask me to repeat my observations so that he would be certain he had them correctly.*

Doyle opened up his own private practice in 1882. He was a moderately successful practitioner but his yearly income never exceeded £300. A newlywed with time on his hands (his practice had just started), Doyle turned to writing short stories as a source of supplementary income. He created the semi-fictional characters of Sherlock Holmes and Dr. Watson in an 1887 novella titled, *A Study in Scarlet* that was published in *Beeton's Christmas Annual*, a popular magazine.

Doyle wrote to Dr. Bell:

> *It is most certainly to you that I owe Sherlock Holmes… I do not think that his analytical work is in the least an exaggeration of some effects, which I have seen you produce in the outpatient ward. Round the centre of deduction and inference and observation which I have heard you inculcate, I have tried to build up a man…*

Who Was Joseph Bell?

Dr. Joseph Bell (1837-1911) was a Scottish surgeon at the medical school at the University of Edinburgh. He served as the personal surgeon to Queen Victoria when she visited Scotland. His diagnostic intuitions astonished medical students and patients alike; even before patients uttered a word, Bell would describe their symptoms and give details of their past life, rarely making a mistake. He published several medical textbooks including A Manual on the Operations of Surgery in 1886. However, he was most famous as a teacher—his skill in diagnosis was legendary and this talent rested substantially on his acute powers of observation. Sir Arthur Conan Doyle wrote in his autobiography:

> *I thought of my old teacher Joe Bell, of his eagle face, of his curious ways, of his eerie trick of spotting details. If he were a detective he would surely reduce this fascinating but unorganized business to something nearer to an exact science.*

Joseph Bell
Wellcome Library, London.

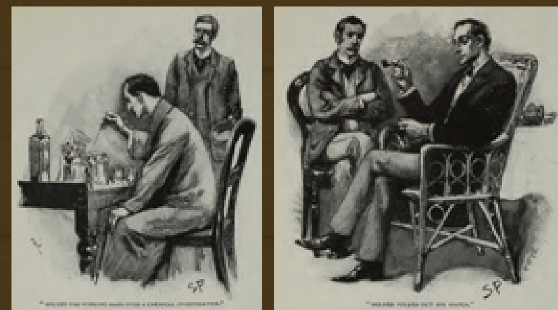
In one classic anecdote: "A total stranger was brought to his [Dr. Bell's] clinic in the outpatient department. While observing him, Bell stated, "Well, my man, you've served in the army." "Aye, sir." "Not long discharged?" "No, sir." "A highland regiment?" "Aye, sir." "Stationed in Barbados?" "Aye, sir." Bell explained to his students, "You see gentlemen, the man was a respectful man, but he did not remove his hat. They do not do so in the army, but he would have learned civilian ways had he been long discharged. He had an air of authority and was obviously a Scot. As to Barbados, his complaint is elephantiasis, which is West Indian and not British."

Doyle would later use this anecdote to serve as the basis for one of Holmes' examples of "the method." Holmes and Watson are seated with Mycroft Holmes (the stout older brother of Sherlock) in the bow window of Mycroft's famous Diogenes Club. The brother and the detective observe two men stopped opposite their window. They run their eyes over the smaller, darker man first:

"An old soldier," I perceive, says Sherlock, "And very recently discharged," says the older brother. "Served in India," I see. "And a non-commissioned officer." "Royal Artillery, I fancy," says Sherlock. "And a widower."

The amazed Watson asks them to explain. "Surely," says Sherlock Holmes, "it is not hard to see that a man with that bearing, expression of authority and sun-baked skin is a soldier, is more than a private, and is not long from India." To which his portly brother adds: "That he has not left the service long is shown by his still wearing his ammunition boots as they are called." Then Sherlock notes: "He has not the cavalry stride, yet he wore his hat on one side, as is shown by the lighter skin on that side of his brow. His weight is against his being a sapper. He is in the artillery." Mycroft completes the analysis: "Then, of course, his complete mourning shows that he has lost someone very dear. The fact that he is doing his own shopping looks as though it were his wife."

Multiple anecdotes of Bell's clinical observations have been reported by his students. As a professor and teacher, he trained his amateur "Watsons" in the habit of observation. In another anecdote, Bell passed around the class a vial filled with amber colored liquid and said, "This, gentleman, contains a most potent drug. It is extremely bitter to the taste. Now I wish to see how many of you have developed the Powers of Observation that God granted you. But sair, ye will say, it can be analyzed chemically. Aye, aye, but I want you to taste it… I don't ask anything of my students which I wouldn't do alone wi' myself. I will taste it before passing it around." He would then dip a finger in the liquid, put his finger in his mouth, suck it and grimace. He watched as each student tasted the harsh concoction, made a face and passed the awful stuff to his neighbor. After everyone had tasted it, Bell began to chuckle, "Gentleman," he would say, "I am deeply grieved to find that not one of you has developed his power of perception, the faculty of observation… for if you had truly obsairved me, you would have seen that, while I placed my index finger in the awful brew, it was the middle finger – aye – which somehow found its way into my mouth."



Sidney Paget is famous for his drawings of Sherlock Holmes.

Arthur Conan Doyle. The Original Illustrated Sherlock Holmes. Castle Books, Edison NJ, © 1976; p. 295. The Memoirs of Sherlock Holmes. XXII. The Adventure of the Greek Interpreter, originally published in the Strand Magazine 1893.

Of note, Dr. John Watson, owes his surname, but not any other obvious characteristics, to a medical colleague of Doyle's, Dr. James Watson. Apparently, there were physical similarities, as well as psychological, between Sherlock Holmes and Bell, as Bell was described as "thin, dark, wiry and had a prominent nose." The famed Scottish novelist, Robert Louis Stevenson (author of *Treasure Island* and *Strange Case of Dr Jekyll and Mr Hyde*) was able to recognize the strong similarity between Joseph Bell and Sherlock Holmes and wrote to Doyle, "My compliments on your very ingenious and very interesting adventures of Sherlock Holmes…can this be my friend Joe Bell?"

Along these lines, Bell wrote an essay titled "Mr. Sherlock Holmes," often published as a forward to Doyle's first Sherlock Holmes case, A Study in Scarlet. In it, he wrote,

> *Syme, one of the greatest teachers of surgical diagnosis that ever lived [wrote] … 'Try to learn the features of a disease or injury as precisely as you know the features, the gait, the tricks of manner of your most intimate friend.' Him even in a crowd, you can recognize at once; it may be a crowd of men dressed alike… and yet, by knowing these trifles well, you make your diagnosis or recognition with ease.*

It is from the fictional cases of Sherlock Holmes and the real clinical cases of surgeon Joseph Bell that we are reminded to spend time observing and talking to our patients. When the clinical facts just don't seem to add up and that voice in the back of our head tells us that something does not seem right, it is our duty then not just to be a doctor but also to be a detective. It is only with the application of both observation and deduction that we can go from being a "Watson" to becoming a true surgical-sleuth like Dr. Joseph Bell.

"You have an extraordinary genius for minutiae."

– John Watson, MD
The Sign of the Four

Doctor As Diagnostician

Sight, sound, smell, taste, pressure, heat, cold, roughness of surfaces and vibration or movement are physical properties that our bodies can sense. The organs of sensation include the eyes, the ears, the nose, tongue and our skins. These five senses allow for slightly more than five inputs because our fingers and skin have so many sensors. It was long ago appreciated that physicians depended upon these senses to develop the examination skills necessary for the diagnosis of disease — though schools of physicians would agree, disagree and ultimately develop some scheme to teach the next generation of physicians.

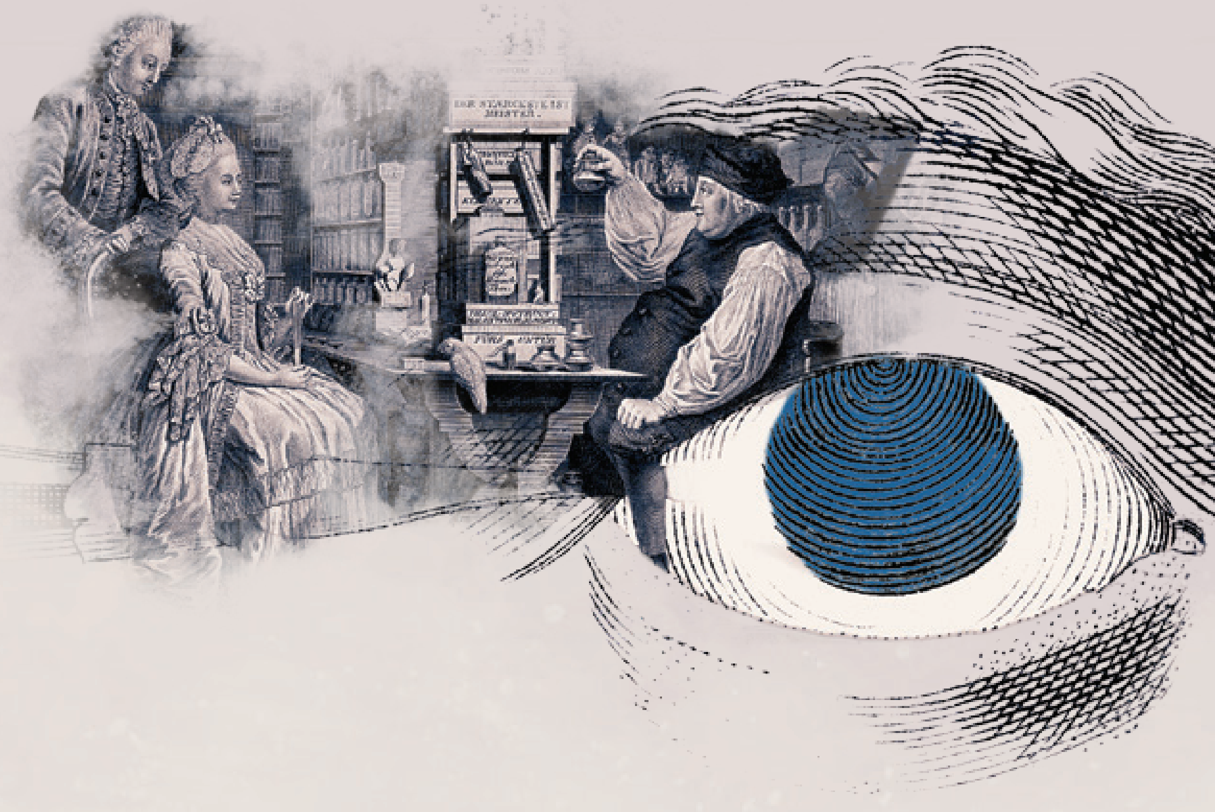
Richard of Fournival was a classicist who collected a rather extensive library of 162 manuscripts by his death c. 1260. He wrote of the senses allegorically in his *Bestiaire d' amours* naming sight as the most noble. But he specifically mentions the many-faceted features of touch — including hot, cold, moist, dry, rough, smooth, and many other things. He depicts the senses in an illumination being yoked by Reason allegorically as horses. The five senses are each a horse with the sense of touch the most complex. In a 1260 illuminated edition of Aristotle's *De sensu et sensato* there is an illuminated "Q" with five male figures representing the senses. How the physical examination developed into its modern iteration clearly evolved after the 18th century following in the wake of the discovery of augmented auscultation by the stethoscope, though surgeons, in particular, were clearly employing advanced notions of palpation in decisions regarding abdominal pain — as demonstrated by suffering and death of the Scottish philosopher David Hume (1711-1776) who died of colon cancer. His private physicians argued regarding the nature of his terminal illness and many physicians were called. While he was induced to try the waters of Bath, he was also introduced to the famous surgeon, John Hunter, and he recorded his impressions: *"John Hunter…coming accidently to Town, and expressing a very friendly Concern about me, Dr Gusthart proposed that I should be inspected by him: He felt very sensibly [i.e. palpably] as he said, a Tumor or Swelling in my Liver."*

The technical prowess of the physician at the turn of the 20th century is so well illustrated by the life and times of William Osler. *"The four points of a medical student's compass are: inspection, palpation, percussion and auscultation."* The physician is like Sherlock Holmes, the great detective we have just learned about — sleuthing throughout the patient encounter to obtain "clues" to the severity of the findings. Once found, the pathophysiology is placed into context of the history obtained from the patient or relatives or friends. The clinical picture allows the physician to order tests (usually laboratory and radiologic). It is increasingly possible for modern clinicians to bypass or not master these sometime archaic sounding methods of bygone eras that are associated with a long litany of eponyms associated with clinical findings such as Homan's sign, or Dietl's crisis, and Trousseau's sign. Students of the past struggled to apply this knowledge to their lexicon and prove that they were worthy of examining patients along with the professors at the bedside.

"Remember, however, that every patient upon whom you wait will examine you critically and form an estimate of you by the way in which you conduct yourself at the bedside. Skill and nicety in manipulation, whether in the simple act of feeling the pulse or in the performance of any minor operation will do more towards establishing confidence in you, than a string of Diplomas, or the reputation of extensive hospital experience."

— William Osler, MD

VISION:
INSPECTION



Uroscopy

Erwin Rugendorff, MD

In the earliest attempts to treat sick people, healers soon suspected urine to be an important marker to a patient's state of health and thus paid close attention to abnormal changes in the appearance of it. The skill of making a diagnosis and prescribing therapy solely on such evidence was named "uroscopy," also spoken of as "water casting."

A physician examining urine brought by a woman.

Wellcome Library, London

Used by serious physicians as one of the available diagnostic tools, uroscopy was based on the doctrine of the four elements and the four humors, a balance of which was deemed essential to health. If the ancients were aware of changes signifying disease, no evidence of this knowledge appears until the early Grecian period, when one finds uroscopy established to diagnose disease. Later, urological scholars of the Middle Ages distinguished twenty different colors of urine; they observed the quantity, clarity, deposits, density of the urine and frequency of micturition. It was the chief diagnostic method available to the physician who supplemented with pulse taking and, at times, study of the face, the appearance of the tongue and excrements.

Fact or Fraud?

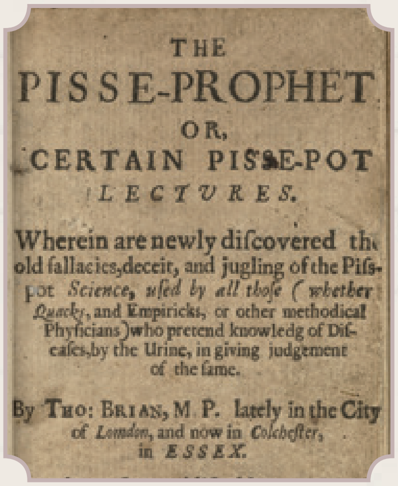
When uroscopy was at its peak, there were so few other diagnostic methods known that inspection of the urine became increasingly popular and spectacular, and more of an art than a science. Physicians, uroscopists, traveling 'water doctors' and charlatans often made a show of the procedure. The urine was collected in a bulbous container, a matula, shaped like the urinary bladder, and made of fine, clear, transparent glass or - even better - crystal glass of Venice. The traveling uroscopist set up a stand in a village. A water-bearer took the matula in its wicker basket to ailing customers and returned it filled. The uroscopist would pompously 'examine' (view and smell) the urine, then

A quack examining a urine flask.

Wellcome Library, London

prescribe and sell medicines. The next day or so, he moved on to a new territory before any results of his diagnosis and therapy became known.

In numerous medieval transcripts pertaining to uroscopy, the physician is warned of possible deceit when dealing with patients and their relatives in terms of urine collection. Perhaps to test the doctor's knowledge and skill, some patients tried to mislead the uroscopist when they sent their urine for examination. One story tells of the patient who replaced his urine with that of his cow; upon examination, the physician is reported to have said, "this patient has eaten too much hay."


THE
PISSE-PROPHET
OR,
CERTAIN PISSE-POT
LECTURES.
Wherein are newly discovered the old fallacies, deceit, and jugling of the Piss-pot Science, used by all those (whether Quacks, and Empiricks, or other methodical Physicians) who pretend knowledg of Diseases, by the Urine, in giving judgement of the same.
By THO: BRIAN, M. P. lately in the City of London, and now in Colchester, in ESSEX.

The pisse-prophet or, certain pisse-pot lectures. Wherein are newly discovered the old fallacies, deceit, and jugling of the piss-pot science, used by all those (whether quacks, and empiricks, or other methodical physicians) who pretend knowledg of diseases, by the urine. In giving judgment of the same.

Title page from 'The Pisse-Prophet', 1655

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THE PISSE-PROPHET

Thomas Brian, a Cambridge-trained physician, practiced for ten years before writing The Pisse-Prophet or Certaine Pisse Pot Lectures in 1637, a social commentary on the practice of medicine at the time. Because the cost of uroscopy was substantially less than visiting a physician, the practice was popular among patients. Brian laments "In God's name what shall I do? I'm supposed to be able to tell diseases from the Water and I have to pretend as much." He had tried in vain to convince the locals that "it were farre better for the Physician to see his Patient once than to view his Urine twenty times."

In plain language, Brian described for the English public how the water-caster pretended to 'read" the urine but actually came to his diagnosis by applying his medical experience to information about the patient cunningly elicited from the water-bearer.

URINALYSIS TODAY

Today, urinalysis is a fundamental test that should be performed in all urologic patients. Although, in many instances, a simple dipstick urinalysis will provide the necessary information, a complete urinalysis includes a physical, chemical and microscopic analysis. The abnormal substances in urine commonly tested for with a dipstick include blood, white blood cells, protein, glucose, ketones, urobilinogen and bilirubin. The physical examination of the urine includes an evaluation of color, turbidity, pH, specific gravity and osmolality.

After completion of the patient's history, physical examination and urinalysis, the urologist should be able to establish at least a differential, if not specific diagnosis that will allow the subsequent diagnostic evaluation and treatment to be carried out in a direct and efficient manner.

Microscopy

Augmentation of inspection

The sense of sight has a long history of augmentation back into the ancient times when magnifying lenses were described perhaps to Pythagoras.

Pliny described burning glasses used by physicians to cauterize. Euclid and Ptolemy described concave mirrors that could magnify objects and Alhazen c. 1038 elaborated on the mathematics using conic sections. Roger Bacon in the 14th century discussed uses of magnification and Salvino d'Amarto degli Armati in Florence and Alessandro de Spina of Pisa both began to prescribe glasses. The revolution of glass production in the Lowlands and particularly in the Netherlands led to the improvement of lenses in the late 16th and early 17th centuries.

Galileo
Wellcome Library, London

Galileo certainly heard of these advancements from his current location in Padua and he may have constructed his first microscope by 1610. In 1614, he was visited in Florence by Giovanni Tarde and he mentions observations with the microscope. Cornelius Drebbel (1572-1633) had also constructed several early microscopes in England by 1619 and Kepler (1611-trying to study snowflakes) also had played with the notion. Most everyone is familiar with Galileo's writing in ***Sidereus Nuncius*** of 1610, *"About ten months ago a rumour reached me of an ocular instrument made by a certain Dutchman by means of which an object could be made to appear distinct and near to an eye that looked through it…"* There is strong evidence that he was referring to Zacharias Jansen from Middleberg, Holland. In 1623, ***Il Saggiatore, The Assayer*** was published and Galileo mentions "a telescope adjusted to see objects very close up." That Galileo also created and popularized a microscope is without question. Johann Faber (1574-1629) was a member of the Accademia dei Lincei and aware of the work of several Italians and he named the apparatus, "microscope" in 1625. Descartes wrote about telescopes and microscopes in 1637 Dioptrique and William Harvey is reported to have acquired a model based upon this design (probably from Isaac Beeckman 1588-1637).

Francisco Fontana in Naples published his ***New Observations of the Things of Heaven and Earth*** in 1646 and his tractate eight was called, *"Of the Microscope, by means of which the most minute and quasi-invisible things are so enlarged that they may be clearly and distinctly seen."* Several of Galileo's apostles had microscopes including Cosimo Medici, Federigo Cesi who called it an "occhialino." Cesi's ***Apiarium*** was published in 1625 and a presentation copy was sent to Galileo. Anthanasius Kircher (1602-1680) also acquired or constructed his own microscope and noticed living organisms in cheese, milk and vinegar describing them in ***Ars magna lucis et umbrae*** in 1646.

The gifted Fr. Kircher was far from finished however, for he had an improved compound microscope and somehow found the time to investigate plague patients. In 1658, he published ***Scrutinium Pestis*** and claimed that he saw "worms" in plague victims. His scope has been evaluated and could magnify to about 32X, not nearly good enough to see *Bacillus pestis*, the causative agent of the Black Death. Finally, Petrus Borellus (1620-1671) was a brilliant physician who also began to experiment with microscopy and in 1653 published over 100 observations and applications clinically with a microscope including removing ingrown eyelashes.

Plague, *Athanasius Kircher*
Wellcome Trust, London

Towards the end of the 16th and the dawn of the 17th century, two great geniuses of the improving ocular lens would make monumental contributions to microscopy — Antoni van Leeuwenhoek (1632-1723) and Robert Hooke (1635-1703). The Hooke and Leeuwenhoek period began with Hooke's 1665 publication of ***Micrographia*** in London.

Portrait of A.V. Leeuwenhoek

Wellcome Library, London

It was a masterpiece and bestseller from the beginning. He discusses construction of the microscope, the theories of light and magnification, detailed 60 observations and had outstanding illustrations from woodcuts (made from his own drawings). Recorded in the minutes of the Royal Society April 23, 1663 is *"Mr. Hooke brought in two microscopical observations, one of leeches in vinegar, the other of a bluish mouldy piece of leather."* Into the microscopic maelstrom waded a draper and part time minor town official, Antoni van Leeuwenhoek from Delft, Holland. He created a single, small (1 mm diameter) ocular that could magnify about 250X, and he wrote 190 letters of his discoveries to the Royal Society following an introduction by his anatomist friend, Regnerus de Graff (microscopic description of ovulation). He had read *Micrographia* and began his first of many offerings on April 28, 1673. His contributions are massive and include the first description of spermatozoa (that fertilization occurs by the sperm entering the egg cell), first accurate description of RBCs as well as the first to identify and measure bacteria.

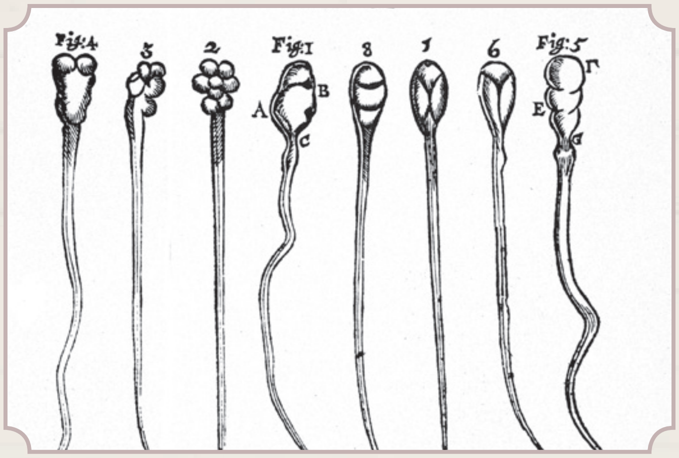
He records this biology altering discovery of an entire Phylum on October 19, 1674, *"Last winter while being sickly and nearly unable to taste, I examined the appearance of my tongue, which was very furred, in a mirror, and judged that my loss of taste was caused by the thick skin on the tongue."* He promptly made a specimen to examine with his microscope noting very small globules. He followed up on these examinations in April 24, 1676 and even better from his letter of October 9, 1676, *"This pepper having lain about 3 weeks in the water, to which I had twice added some Snowwater, the other water being in part exhaled; I looked upon in the 24. of April 1676. and discern'd in it, to my great wonder, an increadible number of very little animals of divers kinds…"* Hooke was promptly moved to confirm these findings which he did on October 5, 1677, and he further quotes some statistics of a single drop of water,

> *"It would follow that in an ordinary drop of this water there would be no less than 4140000 living creatures, which number if doubled will make 8280000 living Creatures seen in the quantity of one drop of water, which quantity I can with truth affirm I have discerned."*

THE INCREADULITY OF MICROBIAL LIFE HAD JUST BEEN ANNOUNCED. Hooke had become a lifelong proponent of Leeuwenhoek's works to the Royal Society. Leewenhoek was not quite finished yet, he

"By the means of Telescopes, there is nothing so far distant but may be represented to our view; and by the help of Microscopes, there is nothing so small as to escape our inquiry; hence there is a new visible World discovered to the understanding. By this means the Heavens are opened and a vast number of new Stars and new Motions, and new Productions appear in them, to which all the ancient Astronomers were utterly strangers. By this the Earth itself, which lyes so neer to us, under our feet, shews quite a new thing to us, and in every little particle of its matter; we now behold almost as great a variety of Creatures, as we were able before to reckon up in the whole Universe itself."

– ROBERT HOOKE, 1665
Micrographia Preface



Spermatozoa of rabbit (figs. 1-4) and dog (figs. 5-8).

From: Observationes de natis e semine genitali animalculis, Philosophical Transactions
By: Leeuwenhoek, Anthony van

Wellcome Library, London

even demonstrated anaerobic bacteria well before Pasteur on June 14, 1680, he created a closed anaerobic tube of water with living animalculses and expected to find nothing, yet *"a kind of living animalcules that were round and bigger than the biggest sort that I have said were in the other water."*

The clinical applications of microscopy especially in medicine would now rapidly accelerate. We have mentioned the use by Petrus Borellus (Pierre Borel) from his 1653 work he noted,

> *"On Whale-shaped Insects in Human Blood-Animals of the shape of whales or dolphins swim in the human blood as in a red ocean…These creatures, it may be supposed (since they themselves lack feet) were formed for the bodily use of the more perfect animals within which they are themselves contained, and that they should consume the depraved elements of the blood."*

In 1657, August Hauptmann first visualized and drew the microscopic organism, *Acarus scabiei*, and was followed by Giovanni Bonomo the following year with further illustrations that the mite caused the disease. This was the first human disease diagnosed by microscopy, the ancient Biblical disease, also known as scabies. Thomas Bartholin (1616-1680) described the microscopic appearance of lymphatic vessels in 1643. Thomas Wharton (1614-1673) describes the glandular system with microscopic observations in 1656. Claude Aubrey (1607-1658/9) described microscopically the canaliculated structure of the testicle in 1658. Marcello Malpighi (1628-1694) discovered capillaries in his microscopic examination of lung tissue (proving that William Harvey was correct on his hypothesis of circulation) and he also discovered the vascular tuft within the kidney that bears his name in 1661. Lorenzo Bellini (1643-1704) at the age of

This type of microscope was invented and used by Anton van Leeuwenhoek (1632-1723). He constructed all his own equipment using lenses he had made himself. At his death, Leeuwenhoek left 247 microscopes and 172 lenses. Only nine microscopes have survived. These can magnify up to 200 times and were of a better quality than professionally made microscopes of the time.

The specimen to be studied is placed on the pin and is brought into focus on the small lens by adjusting the two screws. The glass lens is fixed between two brass plates. The microscope would have been difficult and uncomfortable to use as the eye would have to be placed very close to the lens to make any observations. Lighting the specimen would also have been difficult.

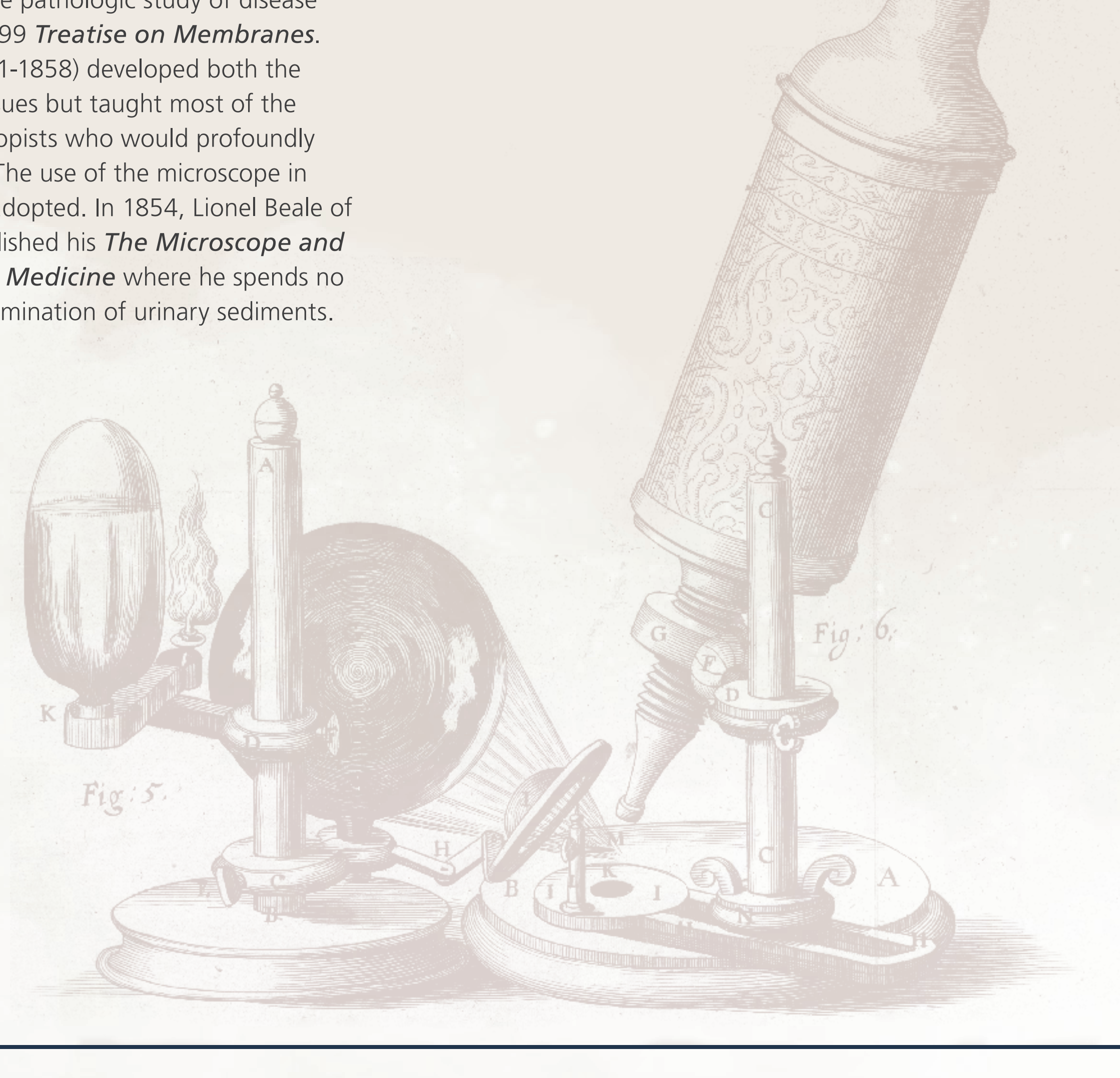
Leeuwenhoek simple microscope (copy), Leyden, 1901-1930

Wellcome Library, London.

19 published his discoveries of the parenchymal substance of the kidney with tubules in 1662. Carlo Fracassati (1630-1672) discovered the taste buds within the tongue in 1665. Malpighi described the sensory receptors of the skin in 1666. Niels Stensen (Niccolo Steno, 1636-1686) describes the striations of muscles and illustrates the microscopic appearance in 1667. Regnier de Graaf (1641-1674) noted the extrusion of follicles from the ovary (Graafian follicles) in 1668. Malpighi followed his microscopic dissections to investigate metamorphosis of the silk worm in 1669 the same year that Jan Swammerdam (1637-1680) published his work on the anatomy of insects. In 1680, Giovanni Alfonso Borelli (1608-1679) published his ***De motu animalium*** and tried to tie the microscopic findings to physiology based entirely on the corpuscular nature of matter. This was followed by the genius of Bellini who published from Bologna his ***De urinis et pulsibus*** where he tried to first propose the actual function of the kidneys based upon microscopic observations in 1683. Joseph Campani of Bologna wrote and illustrated the first treatise of the microscope being used clinically in a case of plague — probably illustrating the work of Kircher previously in 1686.

The stage was now set for Marie François Xavier Bichat (1771-1802) to introduce the pathologic study of disease using microscopes in his 1799 ***Treatise on Membranes***. Johannes Peter Müller (1801-1858) developed both the notions of pathology of tissues but taught most of the next generation of microscopists who would profoundly influence all of pathology. The use of the microscope in urinalysis also quickly was adopted. In 1854, Lionel Beale of King's College London published his ***The Microscope and its Application in Clinical Medicine*** where he spends no small amount upon the examination of urinary sediments.

Golding Bird followed this with a book entirely on urinary microscopic evaluation of sediments and crystals, ***Urinary Deposits: Their Diagnosis, Pathology and Therapeutical Indications*** in 1844. Though spermatozoa had been identified by Leeuwenhoek in 1677 and there arose the infamous controversy regarding the homunculus — Russian nesting dolls within the head of the sperm. In November 1677's letter to Lord Brounker, secretary to the Royal Society, he states, *"I had observed enough material coming from a sick person…but also from a healthy one, immediately after ejaculation. I had seen such a multitude of live animalcules more than a million, having the size of a grain of sand and moving in a space…those animalcules were smaller than the red blood cells. They had a round body, foam in the front, terminated in a point at the back; they were equipped with a tail with five to six times the body length. They progressed in a snake-like motion helped by their tail."* Despite this outstanding head start, the clinical application of Leeuwenhoek's observations would take more centuries to advance. The first real utilization of a detailed spermatozoa count was only reported by Macomber and Sander in the New England Journal of Medicine in 1929, and the first statistical survey of male infertility awaited John MacLoed's work in the 1940s.



Development of the Cystoscope

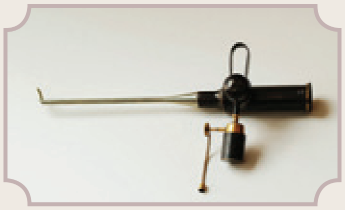
Rainer Engel, MD

Since the earliest days of medicine, physicians and healers have sought ways to look inside the living human body. But it was not until 1807 that Philipp Bozzini (1773-1809), a young German army surgeon, frustrated by the difficulties of locating bullets in his patients, invented the ancestor of the modern endoscope.

Philipp Bozzini's Lichtleiter

The device — the *Lichtleiter (light-carrier)* — was a sharkskin-covered instrument housing a candle within a metal chimney. A mirror on the inside reflected light from the candle through attachments into the urethra, the vagina or the pharynx. One looked through a viewing window past the mirror down the funnel of the attachment. When the instrument was first tested in Vienna, examiners could see stones in a cadaver and were able to identify them as gallbladder stones. However, the instrument was clumsy, difficult to use and grew too hot; in short, it was impractical for clinical use. Bozzini did not live to see the fate of his invention; he died of typhoid fever shortly after demonstrating it.

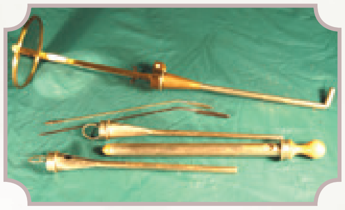
Whatever its impracticality, the *Lichtleiter* was a catalyst for further experimentation and invention. By the mid-1800s, several new instruments had been created. One, a variation on the instrument by Bozzini, was designed by Antoine Desormeaux (1815-1882) in Paris. The instrument was a long metal channel through which a mirror reflected light from a petroleum-fueled lamp. This instrument had one of the same drawbacks as Bozzini's Lichtleiter — it became quite hot while in use.



Desormeaux Endoscope, ca. 1860

Donated by the AUA Western Section

At about the same time, new instrument models were being developed in the United States. The best was an instrument designed in 1860 by Phillip Skinner Wales while he was doing postgraduate study at the University of Pennsylvania. His creation was produced by Horatio Kern, a well-known instrument maker in Philadelphia. Wales' instrument contained a metal shaft with a very acute beak, but it used an ophthalmologic mirror to reflect light down the channel. One peered through the center hole to look into the bladder. It was elegant, light and relatively easy to use.



Wales Urethroscope

Image courtesy of M. Donald Blaufox, MD

The original Lichtleiter, discovered at the College of Surgeons in Chicago by Dr. Irving Bush, was returned to Vienna, Austria in a touching ceremony at the AUA's 2002 Centennial Annual Meeting. The original can now be seen at the Museum of Endoscopy in the Josephinum, Collections of the Medical University of Vienna.

The AUA Didusch Museum was given this facsimile, made in 1989 by the Mercedes Benz Company, by the Josephinum in thanks for facilitating the historic "Return of the Lichtleiter."

THE BIRTH OF TRUE ENDOSCOPY

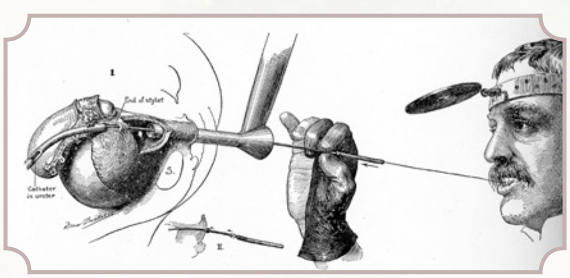
In 1878, true endoscopy was born. In that year, German urologist Maximilian Carl-Friedrich Nitze (1848-1906) presented the first working cystoscope, which he had created in collaboration with the Viennese instrument maker Joseph Leiter. The Nitze/Leiter cystoscope was a landmark discovery in 1879, but it was by no means perfect. The instrument's biggest drawback was the tungsten wire used for lighting, which got very hot and required a complicated water-cooling system. Two large horns near the eyepiece were the in- and out-flow funnels for coolant water. The thinner pegs were electrical contacts for bulb illumination.

Nitze-Leiter Cystoscope

Donated by Irving Bush, MD

The next improvement came around the turn of the century when Dr. Henry Koch and head electrician Charles Preston at ElectroSurgical Instruments in Rochester, New York, created what became known as the *mignon bulb*, a low-amperage light bulb small enough to fit into the tip of a cystoscope. These bulbs enabled the development of cheaper and easier-to-use instruments. The only problem was that light bulbs burn out, often at the most inopportune moments, like in the middle of a procedure.

Some physicians, however, were still using simple instruments not subject to such failures. Howard A. Kelly (1858-1943), the chair of OB/GYN at Johns Hopkins Hospital, for instance, used a small speculum-like tube that was used with the patient in the knee-chest position. Initially, it had neither a light nor a lens system attached to it.



Kelly's cystourethroscope in use as portrayed by the Hopkins medical illustrator, Max Brödel (1870-1941)

William P. Didusch Center for Urologic History

PRODUCING CYSTOSCOPES

Reinhold Wappler

William P. Didusch Center for Urologic History

In 1890, Reinhold Wappler (1870-1933), a young instrument maker, immigrated to New York from Germany. Soon after arriving, he set up his own company to produce an American cystoscope. One of the first instruments developed at the new workshop was the Tilden-Brown composite cystoscope, an elegant set of instruments with a lens to look straight forward, one at a slight angle and another at a right angle. Obturators that were used to insert the instrument blindly were exchanged for the lens system.

Meanwhile in Europe, inventors and clinicians continued to make refinements and improvements in Leiter and Nitze's instruments. One such innovator was the German doctor Leopold Casper, whose catheterizing cystoscope was not easy to use — it employed a complex mirror system between the eyepiece and the shaft, but it had one big advantage: it allowed ureteral catheterization. However, the instrument did not have a deflector to guide the catheter tip into the urethral orifice; that would come later.

By 1900, instruments had been developed to catheterize ureters and irrigate the urethra and the bladder.

The Brown-Buerger cystoscope from 1910 was created by Leo Buerger (1879-1943), a young urologist in New York, who based his design on Tilden Brown's scope. The instrument was then produced by the Wappler Electric Company (later ACMI). The Brown-Buerger cystoscope remained the workhorse of the American urologist for nearly six decades. It was easy to use, enabled catheterization of the ureters and provided an excellent image. Virtually, every urologist owned one of these instruments.

Page from 1952 ACMI catalogue

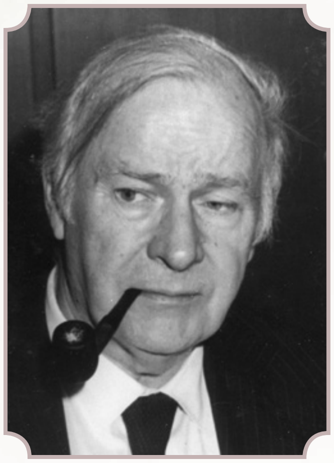
William P. Didusch Center for Urologic History

Into the 1960s, urologists used various battery boxes to light the instruments. The power to illuminate the bulb was produced by a transformer that was either a larger wood-encased apparatus or a small metal-encased device that the urologist wore around his waist. A power cord led to the outlet in the wall.

FIBEROPTICS

The next revolutionary change to cystoscopes was fiberoptics. The ability of light to follow a curved glass rod had been known for many years, but it took several decades for physicists and physicians to discover how to harness this ability for clinical use. Early patents in fiberoptics were issued to researchers in Britain and the United States in the mid-1920s. The first attempt to create a fiberoptic endoscopy system was in Germany in 1930, but it was technically unsatisfactory. Twenty years later, researchers in the United States were more successful, and the gradual emergence of this system as a practical technology began. In 1954, Brian O'Brien obtained a US patent for an endoscope. Six years later, Victor F. Marshall described the first fiber ureteroscope produced by ACMI. Glass fiber bundles, incorporating several thousand individual fibers, were initially used simply to transmit light, but researchers later learned how to make them convey images.

The next big step forward occurred when a urologic surgeon in Liverpool, unhappy with the results of his endophotography, consulted Professor Harold H. Hopkins in London, who developed what became the *Hopkins lens system*, patented in 1959. Initially, industry showed no interest in this new technology; however, a young man just starting a company, Karl Storz, saw promise in the new system and bought the patent. With the Hopkins system, Storz created endoscopic instruments with a tremendously brilliant image and superb illumination. It was not long before every cystoscope maker began to create similar lens systems.



Harold Hopkins, physicist
(1918-1994)

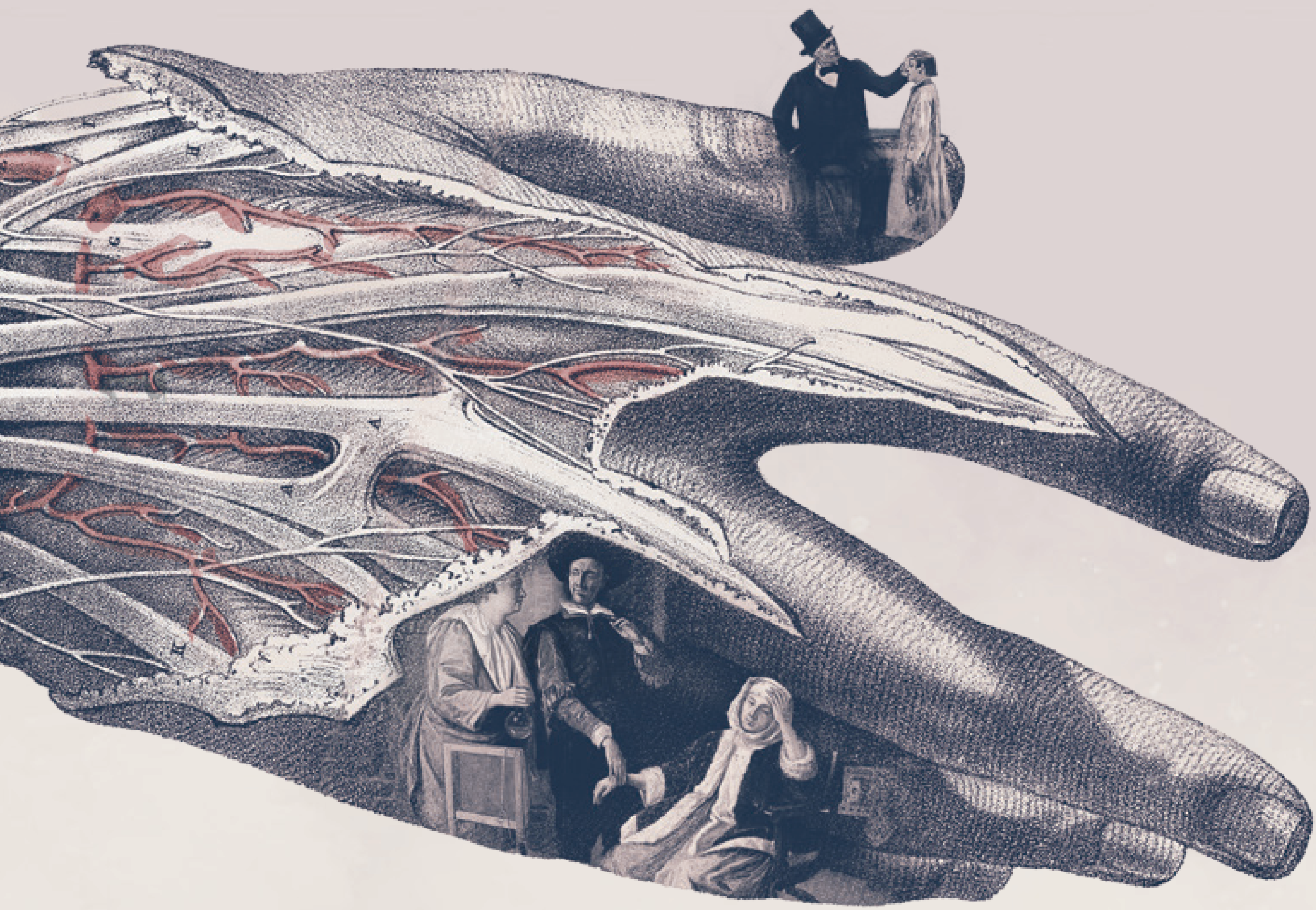
A flexible cystoscope from 2007 can be used for a whole range of procedures from urine collection to small-tissue sampling. We still lack the technology to perform formal resection through a fiberoptic instrument, but seeing how instruments have developed and changed over the past centuries leads us to expect great things for the future.

Max Nitze's vision of his cystoscope is encapsulated in his words from 1888:

"...this writing presents only a framework, the complete construction of which will be accomplished over the course of years through the joint work of numerous researchers.

We are dealing here with a large new field of work which assuredly harbors untold treasures of knowledge..."

TOUCH:
PALPATION



Pulse

THE PULSE IS CERTAINLY THE FIRST VITAL SIGN THAT HAS BEEN DOCUMENTED THROUGHOUT THE CENTURIES. PERHAPS RESPIRATORY RATE FOLLOWED. THE HIPPOCRATIC PHYSICIANS SPENT A GOOD DEAL OF TIME DISCUSSING THE PULSE.

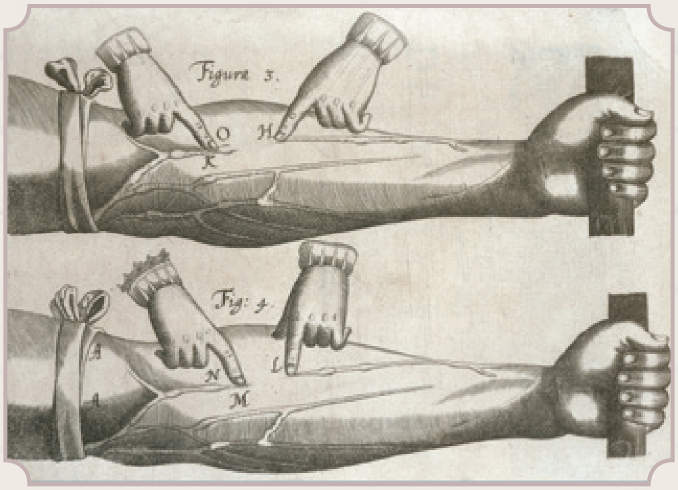
Praxagoras of Cos (c340 BCE), who was the teacher of Herophilus is given the first physician to use the pulse for clinical diagnosis. But the pulse in particular became a research interest of Herophilus in Alexandria. Herophilus likened the pulse to expansion and contraction using the metaphor from music like rhythm. He used the Alexandrian invention of a water clock or clepsydra to keep accurate timing of the pulse. Herophilus gave specific names to pulses, such as the goat-like bounding pulse, pulsus capricans. He is also the person who noted that the pulse's variation is indicative of the general condition of the body. Archigenes (98-117 CE) described the pulses four main characteristics (length, depth, breadth, and speed) and that they all could be characterized by careful palpation. It was next to Galen that pulse would find greater expansion and utility. His work, ***The Pulsibus***, states, *"For many years, I was doubtful about clearly discerning the movement of contraction by touch, and I shelved the question until such time as I could learn enough to fill the gap in my knowledge. After that, the doors of the pulse were open to me."* Galen attributed no less than 27 characteristics for a single beat of the pulse. These include arterial variations in different temperatures or illnesses he calls hot or cold pulses, the pulse of pain, inflammation, lethargy, convulsions, jaundice and even elephantiasis are all different for him. An ancient physician, whom there is little biographical information is Rufus of Ephesus and his ***Treatise on the Pulse***. Also, Avicenna (Abu Ali Ibn Sina, 981-1037 CE) discusses the pulse in Book I of his ***Canon of Medicine***. *"Whoever allows these words to be true and not fabulous will benefit very greatly; despair will not touch him or frighten him in the pursuit of his study, even though he makes no progress for many years."* William Harvey is believed to have used a watch to time the pulses in the animals that he vivisected. Van Helmont in the 17th century used a water clock to document the patient's actual pulse. Cusanis in 1565 probably used a pocket watch to record pulses. Galileo used his own pulse to time his pendulum's frequency, and Kepler used his pulse to the timing of astronomical phenomena in 1600. Santorio Sanctorius (1561-1636) was a professor at Padua and described a pulsilogium to measure a patient's pulse and was the first to record in graphic form clinical pulses. Thèophile de Bordeus (1722-1776) is widely regarded as the founder of the Vitalisic School at Montpellier. He developed a significant classification of pulses that included the following: critical, non-critical, simple critical, compound critical, nasal, tracheal, gastric, renal, uterine, seminal etc. This complex structuring of the pulse had to do with Far East mysticisms that had been incorporated into the dogma of pulses. In ancient India, one passage refers to the physician's interest in the pulse, *"Immediately after pressing the pulse just below the hand joint, firstly, there is a perception of the beating of bayu; secondly, or between bayu and kaph, there is the perception pitta; thirdly or the last, the perception of the beating of slesma or kaph is gained."* (Kanada c.600 BCE)

Egyptian Waterclock, from Oedipus Aegyptiacus: Tomus II Pars ii, p. 340

Division of Rare and Manuscript Collections, Cornell University Library

William Harvey dissecting the body of Thomas Parr.

Oil painting, ca. 1900.
Wellcome Library, London.



Valves in forearm

From: Exercitatio anatomica de motu cordis et sanguinis in animalibus
By: William Harvey

Wellcome Images, London

Sir John Floyer (1649-1734) deserves mentioning for his classic work ***Physician's Pulse Watch***. This is the first regular report on the routine use of timed pulse measurements in the clinical care of patients. *"I have for many years tried pulses by the minute in common watches and pendulum clocks and then used the sea-minute glass such as is employed to test the log."* He expresses the concern for precision measurement so as reduce the error in its application to medicine. Floyer's method was incorporated by the French physician, Louis. Osler summarized his estimation of Floyer's monograph:

> *"The doctrine of the pulse reached such extraordinary development that the whole practice of the art centered around its different characters. There were scores of varieties which in complication and detail put to confusion the complicated system of the old Graeco-Roman writers. The basic idea seems to have been each part and organ had its own tone, so in the human body, if the pulses were in harmony, it meant health; if there was discord, it meant disease. These Chinese views reached Europe in the seventeenth and eighteenth centuries, and there is a very elaborate description of them in Floyer's well-known book. And the idea of harmony in the pulse is met with unto the eighteenth century."*

Bryan Robinson (1680-1754) studied the pulse at various times of the day and in patients of varying heights. Jean Senac (1750-1770) reported his findings in one hundred soldiers that normal range is 60-90 beats per minute. William Falconer (1744-1824) made tables comparing pulse to fever and showed a direct correlation.

Another ancient tale of the value of the pulse comes to us from the great Alexandrian physician, writer about the pulse, Erasistratus of Ceos. He was born on the island of Ceos in c.304 BCE and along with Herophilus, founded the anatomical school of Alexandria. He became the royal physician for Seleucus I Nicator of Syria. That Erasistratus very nearly discovered the circulation of blood itself, is tantalizingly given to us by Galen, *"The vein arises from the part where the arteries, that are distributed to the whole body, have their origin, and penetrates to the sanguineous [or right] ventricle [of the heart]; and the artery [or pulmonary vein] arises from the part where the veins have their origin, and penetrates to the pneumatic [or left] ventricle of the heart."* Virtually none of Erasistratus's works have survived into our hands, so much of his prolific output has been lost. Yet, we know through secondary references that Erasistratus knew that the arteries dilate after the heart contracts, though he still believed that the arteries contained air while veins contained the blood.

So, let's turn our attention to the story of illness of Seleucus I Nicator's son, Antiochus. Seleucus had married the much younger and beautiful Stratonice; Antiochus who was Seleucus's elder son from an earlier marriage had fallen in love with Stratonice and pined away until he literally became ill. The great physician, Erasistratus was called to the scene and could find nothing wrong. However, the shrewd Erasistratus noted that Antiochus's skin to be hotter, his color to be heightened and his pulse quickened whenever Stratonice came near him, while none of these symptoms occurred on any other occasion; and accordingly, he told Seleucus that his son's disease was incurable. The king inquired why and the physician replied that Antiochus suffered from non-gratified love, which the physician declared to be his own wife. The king then tried to coerce

The love of Antiochus for Stratonice

Wellcome Images, London

Erasistratus into giving up his wife for his son, when the crafty physician then admitted that it was the king's own wife, Stratonice that was his son's source of misery. The king, therefore, gave his son his wife and Antiochus' life was saved due to history and physical examination and use of the pulse. Lovesickness has been forever couched in terms of the illness of Antiochus.

"When the erotic appetite provokes a melancholy brooding, fires the passions, burns the humors and wastes the strengths of the body, love 'is not merely behavior resembling sickness, but it is a true disease, virulent, and dangerous.'"
Battista Fregoso

Doctors' & Nurses' Watches

Ronald Rabinowitz, MD

An accurate technique to time the pulse was related to the development of the watch. Following the development of the pendulum clock, table clocks in the early 15th Century had an hour hand. By the late 15th Century, clocks became portable as clock watches. Initially, these pendant watches were worn on chains around the neck, on chatelaines at the waist, or on a brooch. In 1625, pockets began to appear in clothing and by 1675 waist coats with pockets had become popular. The pendant watch was now also a pocket watch. In 1687, the minute hand began to appear on pocket watches. The ability to accurately time the pulse was based on the invention of an independent second hand by Jean Moyse Pouzait in Switzerland in 1776. By 1780, the second hand was now appearing on pocket watches.

Colored painting of a nurse in a red dress checking a patient's pulse while looking at her wrist watch.

Images from the History of Medicine (NLM)

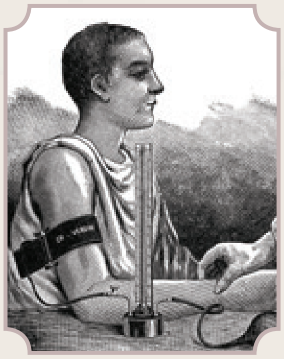
Utilizing this technology, doctors and nurses were now able to time the pulse using pocket or pendant watches with a second hand. Wrist watches in the early 19th Century were pocket watches attached to bracelets and these watch bracelets became popular by the late 19th Century. By the early 20th Century convertible watches had become popular for nurses. These watches had a pendant bow at the 12 o'clock location and an eye at the 6 o'clock location. They could be worn right side up attached to a neck chain, brooch, lapel pin, or silk or cloth strap. They could also be worn around the wrist using the strap for the bracelet portion. For nurses, these pendant watches were most often worn upside down hanging from a brooch with a hidden pull chain or around the neck on a long chain. Doctors measured the pulse using a vest pocket watch attached to a chain from their vest button hole. These pocket and pendant watches had either a subsidiary second hand or a central concentric second hand. In the 1930s, companies began selling split dial wrist watches in which the top dial measured hours and minutes and the lower dial, usually of equal size, measured the seconds. These doctor's wrist watches were referred to as "duo dial" wrist watches.

Physician's watch with separate second hand for timing the pulse, ca. 1925.

14K white gold
In private collection

Blood Pressure

In 1901, a serendipitous encounter of Harvey Cushing and Scipione Riva-Rocci occurred during Cushing's visit to Pavia. They apparently discussed Scipione's work in some detail, for Cushing took detailed drawings of his sphygmomanometer that he would incorporate into his surgical interventions in the coming years.



Riva-Rocci's spygmomanometer in use.

Wellcome Library, London.

In fact, it might well be Cushing who took the little heralded Riva-Rocci's work from esoteric curiosity of lab work into the world-wide clinical arena. It is perhaps at this juncture to pursue the biographical information on Cushing a bit further. He was born in Cleveland on April 8, 1896 into a family of physicians. His father, Henry Kirke (1829-1910) was a general practitioner and his eldest brother Edward also practiced medicine. His great grandfather, David Cushing (1768-1814) practiced in Cheshire, MA and his grandfather Erastus (1802-1910) taught medicine in the Berkshire Medical School. Harvey went to Yale University for undergraduate education, then to Harvard Medical School graduating A.M. and M.D. in 1895 cum laude. He served one year at Massachusetts General Hospital before becoming a resident to Professor Halsted at the John Hopkins Hospital from 1896-1900. From there, he went to Europe after living next door to his real mentor, William Osler at 3 West Franklin Street. It was perhaps the most influential times of young Cushing's life. He was inundated with the historical and bibliomania of Osler as well as the intense research concentration that he developed working with Halsted's principles. He became fixated upon the protection of his patients in every detail. This is what attracted the young up-and-coming neurosurgeon to seek the work of Scipione Riva-Rocci during his visit to Pavia in 1901. Upon Cushing's return from Europe, Halsted had encouraged his young protégé to pursue neurosurgical clinical practice and the development of the Hunterian Laboratory. He continued these tasks until his departure from Johns Hopkins in 1912 to assume the positions of professor of surgery at the Harvard Medical School and surgeon-in-chief to the Peter Bent Brigham Hospital.

Cushing had ample bad memories of being asked as a medical student at Harvard to administer ether anesthesia with calamitous consequences on at least two occasions that he later recollected in letters. He and a fellow second year medical student, named Ernest Amory Codman, developed "ether charts" to monitor anesthesia. The early versions documented the pulse, respirations and temperature during the operation. Early in his career at Johns Hopkins, Cushing was fascinated by Halsted's use of cocaine local anesthesia and probably was the originator of the term 'regional anesthesia.' This was all sparked by his keen awareness of the risks of general anesthesia of the day. In July of 1900, Cushing was working in Berne with Theodore Kocher and was studying the reflex increase in the arterial blood pressure associated with rising intracranial pressure, now known as the Cushing reflex. It is from this background that when he traveled to Pavia that he found the simple, "home-made" device of Scipione Riva-Rocci. He sketched the device in his diary dated May 5, 1901 and upon his return to Johns Hopkins in September he immediately added this measurement to his own anesthesia records during all of his major cases. In September of 1902, he first published his findings on the utility of BP during major surgery. By 1903, Cushing and his friend from Cleveland, George Crile, gave a demonstration of the use of the sphygmomanometer at Harvard Medical School. They recommended the sequential measurement during complex surgical cases to make responses to fluid shifts. This would, in turn, be recorded in charts specifically invented for the localized record which every hospital throughout the world now utilizes.

Harvey Cushing, 1896-1939

Image courtesy Chesney Archives

Thermometry

Friedrich Moll, MD

EVEN HIPPOCRATES KNEW THAT FEVER AND CHILLS INDICATED SOME KIND OF DISEASE IN THE BODY, THOUGH THE PHYSICIAN USED ONLY HIS HAND TO CRUDELY DETECT HEAT OR COLD. THIS REMAINED A SUBJECTIVE SKILL FOR CENTURIES AS THE CONCEPT OF MEASURING TEMPERATURE PRECISELY WAS NOT DEVELOPED UNTIL THE 16TH CENTURY.

In the 1600s, physicians became interested in the conditions under which body temperature changed, so they explored methods of transferring the patient's body heat to a glass tube and recorded the results.

Galileo (1564-1643) constructed a ***thermoscope*** as early as 1592, but it had no scale and could only show whether the temperature was rising or falling.

Galileo Galilei (1564-1642). Oil painting after Justus Sustermans, 1635.

Wellcome Library, London

Galileo (1564-1643) constructed a thermoscope as early as 1592, but it had no scale and could only show whether the temperature was rising or falling.

Santorio Sanctorius (1561-1636), Galileo's friend and inventor of the pusilogium (a pendulum that measured the pulse in inches), was first to put a scale on the thermoscope. His instrument consisted of a glass tube, the bulb of which the patient placed in his mouth. The physician placed the tube's open end into a liquid-filled vessel and, by observing the change in the instrument's reading during ten beats of the pulsilogium, measured the patient's absolute temperature: the first clinical thermometer!

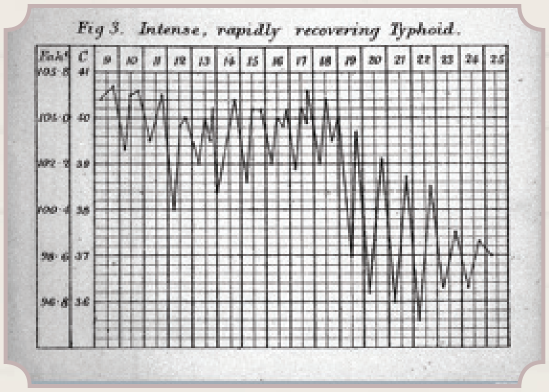
Florentine and Venetian glassblowers in Italy made complex sealed glass containers of various shapes, to be tied onto the body surface. Temperature was assessed by the rising or falling of small beads or seeds within the fluid inside the container.

FAHRENHEIT AND CELSIUS

The three types of thermometers introduced during the 1600s differed in their fluid content, which consisted of air, alcohol or mercury. Many thermometers were coiled or curved until physicians realized that air responds as quickly to pressure as to heat. Early thermometers were inaccurate as scientists poorly understood how liquids expand, and glass-makers could not produce standard thin glass tubes. Gabriel Fahrenheit (1686-1736) was the first to make a thermometer filled with mercury. The more predictable expansion of mercury, combined with better glass-working techniques, led to a much more accurate thermometer. In 1742, Swedish scientist Anders Celsius (1701-1744) developed the centigrade scale that we still use today, with 0 degrees as the freezing point of water and 100 degrees as its boiling point.

Hermann Boerhaave (1668-1738) and his students, Gerard L. B. Van Swieten (1700-1772) and Anton de Haen (1704 -1776), were perhaps the first physicians to use a thermometer at the patients' bedside, though Boerhaave himself had more confidence in uroscopy and patient history. As an instructor at the Vienna Hospital, de Haen incorporated the use of the thermometer into his bedside routine and taught his students that the thermometer was more accurate than the hand to determine fever. He made several observations about thermometry, noting the increase of temperature in the elderly, the differences between the patient's perceived temperature and his actual temperature and changes in temperature as signs of healing.

Nevertheless, the thermometer did not become a part of everyday medical practice until the 19th century. Two German physicians, Friedrich Wilhelm Felix von Bärensprung (1822-1864) and Ludwig Traube (1818-1876), began to use the thermometer to predict the course of and diagnose diseases in their patients in Berlin. They introduced thermometry to one of their young pupils, Carl Reinhold August Wunderlich (1815-1877), who used advanced



Intense, rapidly recovering typhoid

From: On the temperature in disease...
By: Wunderlich, Carl Reinhold August
Published: The New Sydenham Society London, 1871

Wellcome Library, London.

A normal body temperature is 98.4°F (37°C). It is taken from either the mouth or the rectum. This glass thermometer is gradated in degrees Fahrenheit. Rises in body temperature can indicate fever. Doctors began constructing fever charts in the early 1900s. These recorded the temperature patterns of specific illnesses. The thermometer became an important diagnostic tool. This thermometer has its own rosewood carry case.

Wellcome Library, London

thermometry to record the temperature of almost 25,000 patients and amassed volumes of data to determine the relationship of temperature and disease. Wunderlich's 1868 work, ***Das Verbalten der Eigenwarme in Krankheit*** (On the Temperature in Diseases), rapidly became a classic and was translated into English within three years of publication. Wunderlich declared that thermometry was superior to all other diagnostic methods. He believed that the temperature expressed the sum of physiological activity in the body, opening up domains of disease inaccessible to other methods of examination. To make temperature readings easier on the physician, he maintained that accuracy was not paramount and that twice daily readings were sufficient. Wunderlich also established the range of 36.3 to 37.5 °C as normal human body temperature, constructed temperature curves for patients and demonstrated the relationship of elevated temperature and an increased pulse. His work prompted hospitals to record patients' temperatures frequently, and to display those temperature curves on a chart by the patient's bed, enabling the physician to see the development of the patient's temperature at a glance.

By the mid-1860s, physicians in England and the United States were persuaded to measure the temperature of ill patients. Austin Flint (1812-1886), president of the New York Academy of Medicine, wrote:

> *The information obtained by merely placing the hand on the body of the patient is inaccurate and unreliable. If it be desirable to count the pulse and not trust to the judgment to estimate the number of beats per minute, it is far more desirable to ascertain the animal heat by means of a heat measurer. The sensations of the patient with respect to temperature, as everyone knows, are extremely fallacious; he may suffer from a feeling of heat when, to the touch of another, the surface is cold, and vice versa.*

With improved thermometers, physiological signals of respiration (rate), circulation (pulse) and heat (temperature) could be graphed, giving the physician objective data about his patient.

TODAY

The clinical thermometer that was used by Wunderlich in 1868 is never seen in a modern hospital. Now electronic thermosensing devices predominate. Contact thermometry with liquid crystal sensors can be monitored remotely. Infrared medical sensors simply look at the patient to obtain a cutaneous temperature map, all stemming from William Herschel's discovery of infra-red radiation in 1800. Now core body temperatures can be obtained by introduced catheters that telecommunicate to computer equipment at nursing stations.

Recent studies show that 37° C (98.6 F) should be abandoned as the normal temperature; 37.2° C (98.9 F) in early morning and 37.7° C (99.9F) overall should be considered the upper limit of normal oral temperature in healthy adults aged 40 years or younger.

Urologic Palpation

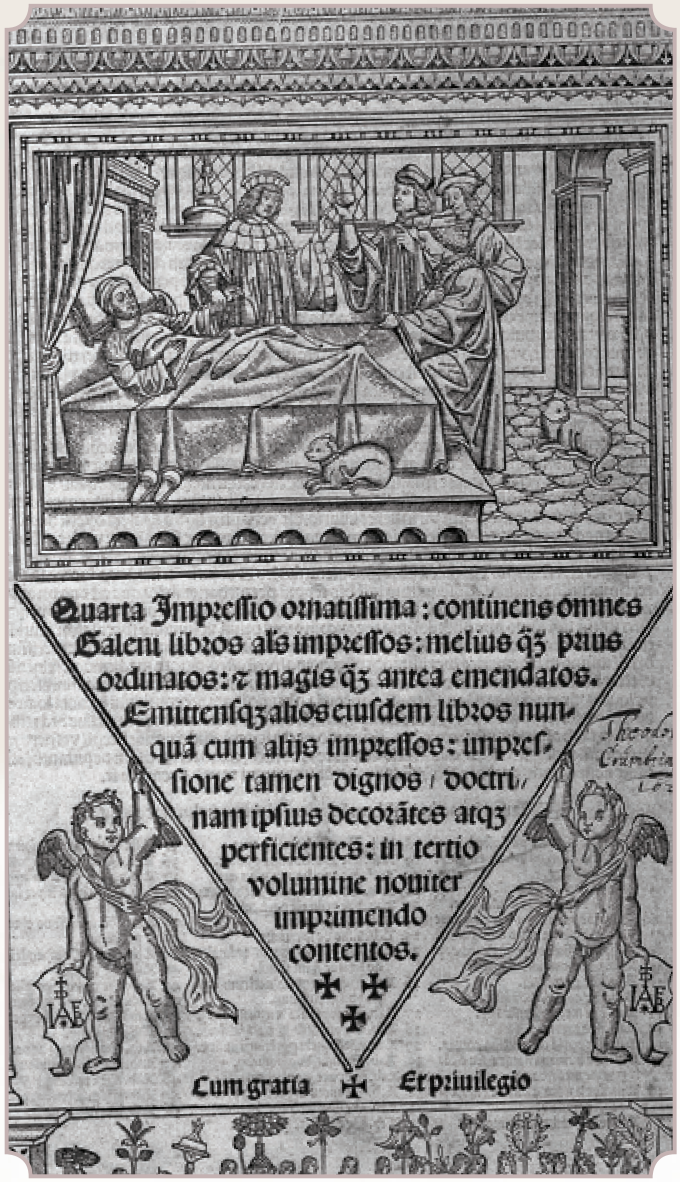
THE SENSE OF TOUCH CLEARLY HAS APPLICATION IN MEDICINE IN GENERAL, AND UROLOGY IN PARTICULAR, THOUGH UROLOGISTS CANNOT CLAIM PRIMACY IN THIS PARTICULAR SENSE ESPECIALLY IN THE WAKE OF THE DEVELOPMENT OF PSA, THOUGH CONTROVERSIAL IN FINDING EARLY STAGE PROSTATE CANCER.

Hippocrates (who probably did write Epidemics I and III) did give priority to the sense of sight for physicians, however, he clearly tells of the sense of touch in palpation of the spleen and liver. Galen remarks that touch is useful to the physician in three ways: taking the pulse (his most important use), taking the temperature and in palpating the body, especially the abdomen. Though the pulse was of most importance to Galen, he wrote a series of 16 books on this topic, he spends some time on the use of touch for temperature — he recommends it is less with the fingers and more with the palm of the hand.

Why did palpation languish so long in the adoption to the physician's history and physical examination? There is no simple answer. Certainly, there was a clear separation of the physician from the surgeon and the latter was where the physical examination had its greatest advancements, especially in the 18th and 19th centuries as anesthesia allowed greater surgical prowess to attack the chest and abdomen. The sense of touch itself was sadly relegated to a secondary role by philosophers and in popular culture.

DIGITAL RECTAL EXAM

The digital rectal examination is not very well documented historically, although it must certainly have been done in examining patients with bladder stones by lithotomists who were performing perineal lithotomy by splitting into part of the prostate. But the clinical correlation having any bearing on the patient with prostate disease is much more speculative. The prostate is a deep pelvic organ, easily examined by insertion of the finger into the rectum, but the first surgical prostate by Jean Nicolas Demarquay in 1852 was accomplished perineally in common with a lithotomy. Theodor Billroth performed a large enucleation of a tumor in 1867 that was cancer and the patient died within 14 months of surgery. John Adams, a surgeon published his 1851 treatise on The Anatomy and Diseases of the Prostate Gland and discusses findings, *"A schirrhous prostate conveys to the finger, passed per anum, a sense of gristly*



Sick-room with a physician taking the patient's pulse and another examining urine.

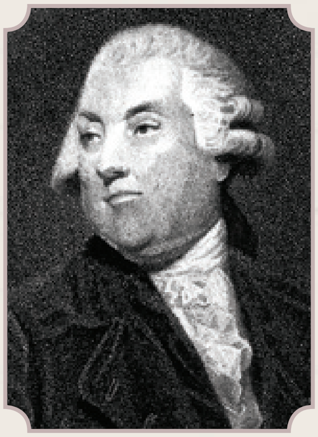
From: Quarto impressio ornatissima: continens omnes
By: Galen

Wellcome Library, London.

hardness, and is usually irregularly nodulated, on lobe being especially affected." William Hunter wrote that the difficulty interpreting a scirrhous mass is significant, *"you examine & feel there is a cancer (ie) you perceive all the parts about the vagina are bloody & unequal & if you touch them it brings blood or you only feel that the uterus is schirrous. As to ye cancerous feel when the Parts are spongy & uneasy I have never been deceived, but as to schirrous I have several times (ie) I have imagined a woman to have a schirus which I thought in ye end would become a cancer, but yet it subsided, so that altho' there has been considerable hardness, yet I have been deceived."* Hugh Hampton Young developed detailed examination records of his digital rectal examinations that allowed for rather long-term follow-up and comparison. Throughout much of the early 20th century this was the only method of examination and detection of prostate cancer.

> *"From a urologist's standpoint, even a routine checkup — to feel for lumps or hardness in a digital rectal examination — is more complicated and takes more skill than many of our patients realize."*
> Patrick Walsh, 2001

TESTICULAR CANCER



Percival Pott, 1714-1788
Wellcome Library, London.

Testicular masses do not represent the difficulty in identifying these rather self-apparent masses in the testicles, which are typically but not always descended in the scrotum. Celsus emphasized a clear distinction between benign scrotal swellings that he called cirsocele, hydrocele and bubonocele. These were distinct from solid more ominous masses called sarcocele. Throughout much of the Middle Ages, these masses did show up, but little was offered. Percivall Pott (1714-1788) mentions tumors of the testicles in his collected works. As with much of Pott's writing, his fluid mind shines through with insights that would not resurface for another century. He begins by stating that testes cancers should be treated as soon as suspected by orchidectomy. *"Sometimes the first appearance is a mere simple enlargement and induration of the body of testicle, void of pain, without inequality of surface, and producing no uneasiness nor inconvenience, except what is occasioned by its mere weight. And some few people are so fortunate to have it remain in this state for a considerable length of time, without visible or material alteration."* Sir Astley Paston Cooper (1768-1841) discussed testicular cancer in his ***Observations on the Structure and Diseases of***

"So much is human genius limited by the limits of human nature, that we just know what our five senses teach."

– Thomas Sydenham
Works

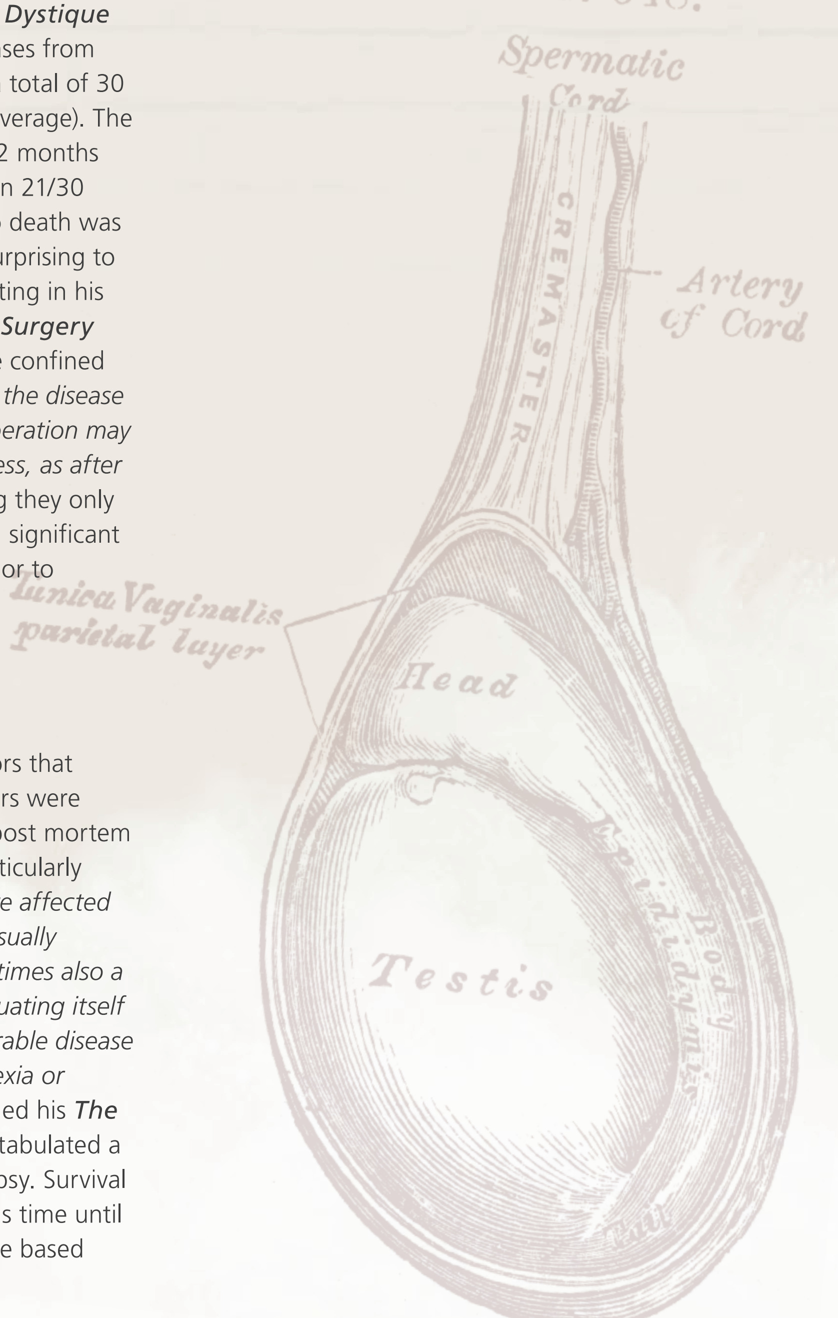
the Testis; With Numerous Plates (1832). He begins his discussion of testicular cancer with the following, *"The testis is often the subject of a malignant disease, which I shall call fungoid, but which has been described by different authors under the terms of pulpy, medullary, soft cancer, and fungus nematodes…The term fungus is most applicable to the disease: because, when it ulcerates, it forms a large fungoid projection; which being full of blood, bleeds freely from the slightest laceration, as well as often spontaneously."* Thus we learn that testicular cancer is not that rare. Remarkably, we have another small follow-up study to Sir Astley's that comes to us from a French surgeon, Dr E. Conche who published a short treatise entitled ***de la Maladie Dystique du Testicule*** in 1865. He tabulates the known cases from the literature which included Cooper's cases for a total of 30 testes cancers, ranging in age from 20-90 (31.9 average). The patients had the testicular masses for a range of 2 months to as long as 5 years, average was 20.3 months. In 21/30 patients we have mortality statistics, the range to death was 2 to 24 months, average was 13.1 months. It is surprising to find that much later, Frederick James Gant, reporting in his textbook of 1886, ***The Science and Practice of Surgery*** notes that even when the cancer is thought to be confined to the testicle alone, noted *"Consequently, when the disease is entirely local- affecting only the testicle- the operation may be performed, and with an equal chance of success, as after the removal of cancer in other parts."* He is saying they only have a 50% chance of surviving — awaiting for a significant mass was associated with significant mortality prior to chemotherapy and radiation.

RENAL AND ADRENAL TUMORS

Abdominal masses that are renal or adrenal tumors that can be palpated are most often fatal. Renal tumors were originally appreciated as causes of death during post mortem autopsy examinations. Daniel Sennert gives a particularly good description, *"And sometimes the kidneys are affected by scirrhous and hard tumours, an event which usually follows an inadequately treated infection…Sometimes also a similar tumour is produced by thick humour insinuating itself into the kidney…Scirrhus of the kidney is an incurable disease because it can strike the patient down with cachexia or dropsy."* Walter Hayle Walshe (1812-1892) published his ***The Nature and Treatment of Cancer*** in 1846 and tabulated a series of 40 kidney cancers all discovered at autopsy. Survival statistics would not improve dramatically from this time until more adequate staging methods became available based upon radiographic images.

Palpation helps the physician undoubtedly in finding masses in patients who present typically late in their cancers, but the history clearly suggests, as it does in breast cancer as well, that palpable masses are not good findings. When small, the masses are more amendable for cure than when they become palpable. This brings up the screening controversies using serological markers such as PSA and screening radiographs such as CT scans. The advantages and disadvantages may yet dissolve in the modern era of biogenetics when the actual cause of the malignancy can be detected and altered.

FIG. 648.



HEARING: AUSCULTATION

Percussion

Percussion was first performed for centuries in the wine and beer industry to get relatively accurate levels as kegs of these fluids were consumed.

Joseph Leopold Auenbrugger

Image from the History of Medicine (NLM)

The story begins with Auenbrugger, picked up by Corvisart and widely publicized by Skoda. In 1761, the little heralded Josef Leopold Auenbrugger published his magnum opus entitled simply, ***Inventum Novum***. The story is widely told that he learned the ancient art of percussion of the kegs in his father's inn. Little is known about this medical man and only one known portrait of him survives in the Vienna Medical Society. We do know that he studied literature and philosophy at the University of Graz. He studied medicine with Van Swieten, a former pupil of Boerhaave. He completed his studies in Vienna writing a treatise on Hippocratic aphorisms. He joined the Spanish Hospital in Vienna from 1752 until 1755. He became an associate physician there for the next ten years until March of 1762 when he resigned. The following year, he published ***Inventum Novum***. This was "New Invention by Means of Percussing the Human Thorax for Detecting Signs of Obscure Disease of the Interior of the Chest." It was a mere 95-page work based upon seven years of effort while he was attending the ill at the Spanish Hospital. He began his treatise as follows:

> *"I here present the reader with a new sign which I have discovered for detecting diseases of the chest. This consists in percussion of the human thorax, whereby, according to the character of the particular sounds thence elicited, an opinion is formed of the internal state of that cavity. In making public my discoveries respecting this matter. I have been actuated neither by an itch for writing, nor a fondness for speculation, but by the desire of submitting to my brethren the fruits of seven years' observation and reflection."*

Auenbrugger recommended that percussion be carried out with the physician's hand gloved with unpolished leather and the patient's chest covered by a tight-fitting shirt. The patient was struck with the fingers extended and held close together. The normal note *"resembles the stifled sound of a drum covered with a thick woolen cloth or other envelope."* He continues to teach us *"If a sonorous region of the chest appears, on percussion, entirely destitute of the natural sounds — that is, if it yields only a sound like that of a fleshy limb when struck — disease exists in that region."* Auenbrugger's efforts were for naught, mostly his work was widely criticized but Maximilian Stoll did begin to use the technique at the Old Vienna School and Josef Eyerel wrote a paper on the method that was read by Jean Nicolas Corvisart who was considered one of the great clinicians of the Napoleonic era. Corvisart was the professor of practical medicine at the Collège de France, and he was in the perfect position to re-introduce the method to the modern era of physicians. The next advance was the invention by Pierre Adolphe Piorry (1794-1879) who invented the pleximeter, derived from the Greek words "to strike" and "to measure." He was a student of Corvisart. A percussion hammer was the next modification by Wintrich.

Jean-Nicolas Corvisart (1755-1821) was one of France's greatest diagnosticians during his lifetime. He was born in Dricourt of the Champagne region before coming to Paris to study medicine. He certainly was a hard worker and inspiring teacher, and became the teacher of Laennec. From 1797 he was Professor of Medicine for the Collège de France. He read and understood the significance of Auenbrugger's work and began to apply percussion to his clinical practice.

Jean-Nicolas, Baron Corvisart. Lithograph by Bornemann after F. P. S. Gérard.

Wellcome Library, London

He would perform autopsies on his patients who died in order to compare the anatomical findings with his clinical observations. In this fashion, he developed a large following amongst young physicians based upon his exciting new research. He was the first to use the term "organic lesion" applied to organs, specifically the heart. He noted muscular hypertrophy, valvular disease, changes in the endocardium and dilation of the ventricles. His fame was such that Napoleon Bonaparte named him as his physician. Corvisart published his 20 years of experience with Auenbrugger's method of percussion using the palmar surfaces of closely approximated and extended fingers to measure the size of the heart or other viscus. Corvisart used the motto *"Resonvere Cavae Cavernae"* or "the hollow cavities resounded" barrowing from Virgil's second book of the Aeneid where Laöcoon throws his spear at the great wooden horse with the resounding resonance. Joseph Skoda was born on December 5, 1805 in Pilsen, Bohemia. He suffered as a child with tuberculosis but was determined to study medicine, following in the footsteps of his elder brother. He studied medicine in Vienna in 1831 with his thesis on De Morborum Divisione at age 25. He was heavily influenced by The Viennese Old School of Leopold Auenbrugger and the work of Covisart, Bayle and Laennec and became one the star professors of medicine by 1846. His first publication, ***"Über die Perkussion"*** *(About Percussion)* attracted little attention. This paper was followed by ***Über den Herzstoss und die durch die Herzbewegungen verursachten Töne und über die Anwendung der Perkussion bei Untersuchung der Organe des Unterleibes*** *(About the Percussion of the Heart and the Sounds Originated by Heart Movements, and Its Application to the Investigation of Organs of the Abdomen)* in 1837. Though originally his work was not widely received, it did establish his reputation and this coupled with his continued academic output brought him increasing fame. *"That the lungs partially deprived of air, should yield a tympanitic, and, when the quality of air in them is increased, a non-tympanitic sound, appears opposed to the laws of physics. The fact however is certain, and is corroborated both by experiments on the dead body, and also by this constant phenonemon, viz.: that when the lower portion of a lung is entirely compressed by any pleuritic effusion, and its upper portion reduced in volume, the percussion-sound at the upper part of the thorax is distinctly tympanitic."* Skoda was part of the cadre of great physicians leading to the New Vienna School.

Percussion involves tapping the patient's chest to listen to the different tones. It was an early technique used to diagnose illness. The ivory pleximeter has its own scale. It was placed on the chest to receive the tap of the percussor. The scale may have measured distances on the chest to gain a more accurate diagnosis. This let the physician determine what part of the chest was making what sound. Percussion as a diagnostic tool was widespread in the 1800s.

The technique was invented by Leopold Auenbrugger (1722-1809) in 1761. It was not widely practised until his Latin work was translated into French in 1808 by Jean Nicholas Corvisart (1755-1821).

Wellcome Library, London

Stethoscope

René T.H. Laennec (1781-1826) lived and died during the tumultuous years of nearly constant war and horror of the French Revolution and Napoleanic Wars. He was a brilliant student, publishing widely during his early training but could not get an academic appointment, so he turned towards clinical practice. His extensive experience in pathologic autopsy led him towards the scientific side of investigation.

Exactly how Laennec discovered mediate auscultation depends upon whose source you use, there are some conflicting reports even in Laennec's own words. His friend de Kergaradec wrote, *"The author told me himself, the great discovery which has immortalized his name was due to chance…One day walking in the court of the Louvre, he saw some children, who, with their ears glued to the two ends of some long pieces of wood which transmitted the sound of the little blows of the pins, struck at the opposite end… He conceived instantly the thought of applying this to the study of diseases of the heart. On the morrow, at his clinic at the Necker Hospital, he took a sheet of paper, rolled it up, tied it with a string, making a central canal which he then placed on a diseased heart. This was the first stethoscope."* He had a large, lucrative private practice. He had used direct auscultation in the past when he had worked with Bayle and Corvisart. Laennec would recall *"As inconvenient for the physician as for the patient, distaste alone renders it almost impracticable in the hospital; it cannot even be proposed to most women and in most of them the volume of the breast is a physical obstacle to its use."* These eureka moments were supposed to have occurred in 1816. For the next three years at the Necker, Laennec devoted an intense amount of time trying different stethoscopes that he made out of various woods that he hand tooled at home. *"Laennec heard with his stethoscope sounds never before heard or described and for which no terms existed in medical literature. He was the creator of a large number of words now currently employed in physical diagnosis, such as rales, bronchophony, pectoriloquy and egophony."* (Major, 1954)

At Necker Hospital, Paris, France, in 1816, Dr. Theophile Laennec devised hollow wooden cylinders for listening to sounds in patients' chests. These early stethoscopes helped physicians to better understand diseases of the lungs.

Images from the History of Medicine (NLM) Laennec and the stethoscope

Painted by Robert A. Thom.

"I am far from denying the utility of studying anatomical species of disease. I have scarcely worked on anything else, and this book itself is entirely devoted to the subject. It is the only basis of positive knowledge in medicine, I believe, and one should never lose sight of it in etiological research for fear of chasing chimeras or creating phantoms to combat...But I also believe that it is dangerous to study local conditions exclusively and to the extent that their difference from the causes on which they depend is lost from view...The necessary shortcomings of a limited outlook is often to take the effect for the cause, or to fall into the even greater error of considering them as identical."

R.T.H. Laennec, *Traité* 1819

Laennec's works sold over 34,000 copies and he received immediate regional attention as well as from afar. Most observers recognized the work as the landmark that it would become. However, the practical application, the evolution of the instrument itself, as well as the philology of his terms would all continue to evolve. His work, of course, had its rivals; none more vocal than Broussais, a contemporary and actual supporter of auscultation. He would write in his own work following Laennec's death, *"In spite of his faults, the name of Laennec will remain in science and be honorable for his homeland. What he has done will be used to advantage, and his mistakes, which people will grow tired of criticizing, will fall into oblivion."* (***Examen*** 1834, 334-5.) The first major positive review was written within a month of the book's publication by L. L. Rostan who commented that "in spite of defects the work was that of an attentive, laborious, and patient observer." Jean-Alexandre Le Jumeau de Kergaradec (1788-1877) wrote a five paper appraisal of Laennec's work and confirmed many of the findings by application at the Hôtel Dieu hospital. He went further by applying the stethoscope to the gravid uterus. He described the fetal heart beat and the "placental soufflé" or murmur over the vessels of the placenta. Matthew Baillie wrote a letter to Laennec in November 1819 thanking him for his work, and John Forbes came out with the first English abridged translation of the work he entitled, ***A Treatise on Diseases of the Chest*** which was Laennec's own subtitle. All 500 copies were sold! Forbes would later apologize to Laennec for his "liberties" in editing so much of the prose from his English translation which trimmed Laennec's tome from 900 pages to less than 500 pages.

"Laennec did more than discover auscultation, much more. It was he who first sought and found the confirmation of the clinical diagnosis at the autopsy table and united pathological anatomy and clinical medicine by an inseparable bond. Morgagni had raised the question, what changes are produced by the disease? Laennec went further and asked by what symptoms or signs are these changes to be recognized during life? In answering this question Laennec created local diagnosis."

Laennec's stethoscope
Wellcome Library, London.

Pratt's laudatory verbiage aside, Laennec was not the first to herald the new urgency for autopsy correlation to clinical signs and symptoms but perhaps Boerhaave and Morgagni could lay claim to this assertion. There is a profound tendency in medical history for hagiographic accolades for discoverers and fondly fitting the actual contributions into a sublime story of medical progress. Laennec tinkered with his stethoscope design for the remainder of his short life. He finally settled upon one that was 45 cm in length, 4 cm in diameter, with a plug that fitted into it when listening to the heart. It was made portable by making the tube into two interconnecting pieces.

The first non-rigid stethoscope was designed and built by Nicholas Cummins, an Edinburgh physician in 1829. The first monaural completely flexible instruments were made of rubber in the 1830s. The fully flexible binaural stethoscopes were made by the 1890s. The diaphragm was finally added into the design about 1900. Austin Flint, Sr., MD (1812-1886) has been considered by many to be the American Laënnec. Charles Denison is also one of the early American converts, and on October 22, 1892, he wrote the following article: "The essentials of a good stethoscope." He opens with *"I have been promising myself for some time to write in protest against the frauds of instrument-makers in the manufacture of the stethoscope which bears my name. My instrument was not patented, as it should have been, for the purpose of needed regulations to the quality of work and reasonableness of price. Therefore it is essential for an instrument-dealer to order a lot made by an irresponsible manufacturer, and sell them to unsuspecting medical men, as the real article, at an unreasonable profit. This has been done in two instances in New York, and one in Chicago, to my knowledge. In consequence, my attention has been called to the most awkward and imperfect imitations, under* *the name 'The Denison Stethoscope,' and I have been chagrined to see joints uneven and loose, tubes impervious or partly occluded and especially the flexible portion made with inflexible rubber tubing, with no regard whatever to my directions."*

One postscript to the Laennec saga seems appropriate. Another Corvisart protégé who finished about the same time as Laennec discovered his stethoscope (1816) was Pierre Adolphe Piorry (1794-1879). He apparently worshiped Laennec and longed to follow his idol's footsteps. He discovered the idea of the pleximeter. This is from the Greek word "to strike" and using a small plate percussing with a finger one could improve on the quality of the percussion examination. He typically used an ivory plate that was 5 cm in diameter. Piorry liked to use his fingers to strike his ivory plate. Later, Wintrich introduced the percussion hammer that would be usurped by embryonic neurologists as a reflex hammer. Piorry was able to reliably measure the size of the heart, the liver and an enlarged spleen using his well-practiced hands.

There were several improvements to Laënnec's stethoscope over the years, including one by Pierre Adolphe Piorry (inventor of the pleximeter) in 1828. The Piorry stethoscope evolved to have a thinner stem without an extension piece and was about half the size of Laënnec's. It was trumpet shaped, made of wood, and had a removable wood plug, ivory earpiece and chest piece. The ivory chest piece also served as a pleximeter. Most stethoscopes made after 1830 were modeled after the Piorry design.

Wellcome Library, London.

"A wonderful instrument called the Stethoscope, invented a few decades ago, for the purpose of ascertaining the different stages of pulmonary affections, is now in complete vogue at Paris. It is merely a hollow wooden tube, about a foot in length (a common flute, with holes stopped and the top open, would do, perhaps just as well). One end is applied to the breast of the patient. The other to the ear of the physician, and according to the different sounds, harsh, hollow, soft loud etc., he judges of the state of the disease."

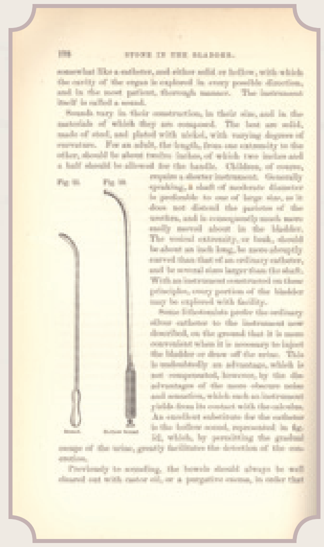
– London Times
1824

Sounding for Stones

Before the advent of Wilhelm Conrad Röntgen, stone disease was diagnosed by careful history and physical examination.

Confirmation was possible only with bladder and urethral stones, however. This confirmation also has an interesting history; it was typically performed by itinerant lithotomists and later by skilled surgeons. The technique to identify a stone was called "sounding" and the name essentially is self-explanatory. The specialist would pass a typically metal instrument transurethrally in a male or female suspected of stone disease and listen intently for the contact with a concretion that could create the metallic "clink" associated with a stone (there were occasional porcelain sounds, glass too makes vibrant tone but would add danger to the procedure). A more skilled practitioner was capable of gathering information on the size and number of stones in the bladder. According to Gross, *"Sounds vary in their construction, in their size, and in the materials of which they are composed. The best are solid, made of steel, and plated with nickel, with varying degrees of curvature. For an adult, the length, from one extremity to the other, should be about twelve inches, of which two inches and a half should be allowed for the handle." Samuel D. Gross's "Practical Treatise on the Diseases, Injuries, and Malformations of the Urinary Bladder, the Prostate Gland, and the Urethra"* in 1851 also presents a surgeon's view of sounding for bladder calculi. Samuel D. Gross is the surgeon that was immortalized by Thomas Eakin's "The Gross Clinic" painting of 1875. Gross was a pioneering experimental surgeon who rose in fame at the frontier school the Louisville Medical Institute. He practiced surgery there for sixteen years before he was lured back to Philadelphia as the professor of surgery at Jefferson Medical College.

Joseph Covillard from Lyons quoted a patient who could feel the calculi shake in his bladder; nine stones were subsequently removed. The great Vesalian anatomist from Padua, and teacher of



A Practical Treatise on the Diseases and Injuries of the Urinary Bladder, Samuel D. Gross

William P. Didusch Center for Urologic History

"The restricted and ordinary meaning of sounding is, the introduction of an instrument through the urethra into the bladder, to obtain evidence, by the touch or hearing, of a calculus being present."

— John Green Crosse
1835

William Harvey, Fabricius ab Aquapendente also noted that when calculi are numerous, as well as considerable in size, they have been felt by the patient to move against each other. *"..stepitum in motu aegrotantes persentiunt."* Gross discussed the symptoms as well, but goes on to state, *"When the symptoms above described are all present, or even when several of them are absent, there is a strong probability that the patient is laboring under stone of the bladder, and this probability is converted to certainty, when the surgeon is able to feel and hear the foreign body."*

Imagine, if you can, being a male patient in the Middle Ages: there are no narcotics, no anesthesia is even possible, only intoxication and, if you are extremely lucky, then the practitioner who is called to see you washes his hands and instruments. The pain of a bladder stone is immense and desperation is the only pathway that would deliver you to the hands of a lithotomists. Prior to proceeding with the torture of surgery, you must first endure the passing of a metal rod through your penis in order to probe and make sure that a stone is present. Though itinerant lithotomists were probably not all idiots, we do glean from some classical sources that they might not have been too far removed from that lowly status. Let's recall the statements from the eminent physician/writer Sir Thomas Browne on surgeons. In 1679 he wrote, "The ignorance of chirurgeons as to the chirurgical operations creates so many mountebanks and stage quack-salvers."

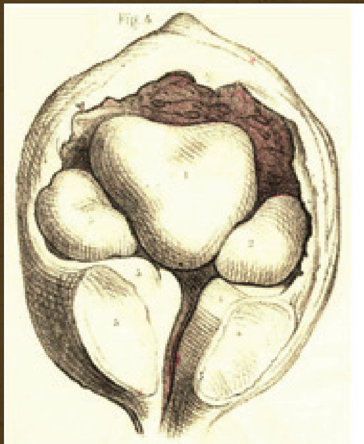


Plate 64,--Figure 4.

FIG. 4, Plate 64. — The prostatic canal is contracted by the lateral lobes, 4, 5; resting upon these, appear three calculi, 1, 2, 3, which nearly fill the bladder. This organ is thickened and fasciculated. In cases of this kind, and that last mentioned, the presence of stone is readily ascertainable by the sound.

From: Surgical Anatomy
Author: Joseph Maclise

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Tommaso Alghisi (1669-1713) was a lithotomist who discussed the art of using the sound. Lithotomists had already explored for centuries different types of implements for passing into the bladders of humans to insure that a stone was present. Alghisi was born on October 12, 1669 to a master of surgery at the S. Maria Nuovo and probably apprenticed there, famed already as the place where da Vinci studied anatomy. He became a surgeon qualifying to the "barber-surgeons" on April 25, 1692. He was substantially influenced by the local scholars of Florence, particularly Francesco Redi, and perhaps met Steno. By 1699, he was appointed as a professor of surgery at S. Maria Nuovo and his father died in 1702 leaving him in charge of surgery. In 1708, the University of Padua conferred the degree of doctor of medicine upon him. Alghisi created one of the first well-illustrated books on lithotomy using woodcuts of Cosmus Mogalli. There are sixteen engraved plates in this treatise, with exquisite drawings of handling of the sound. Alghisi was the pupil of the famous Bellini, and he is given credit for using an indwelling catheter to drain the urine away from the wound following the lithotomy. He used the Grand Appareil, became famous and attracted the attention of Pope Clement XI to whom he dedicated his book. Thin, flexible myrtle leaf sounds were used by some, while large metal instruments were favored by others. A porcelain probe was described by Auguste Nélaton to identify a lead ball in soldiers in 1862.

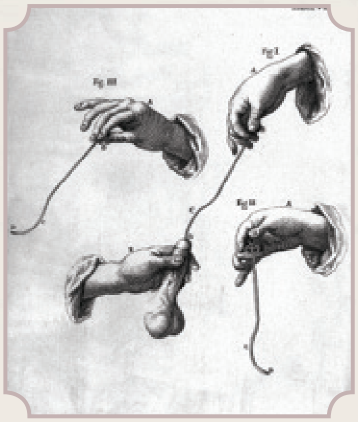


Illustration from *Litotomia; ovvero, del cavar la pietra*

By: Alghisi, Tommaso

Wellcome Library, London.

SMELL &
TASTE

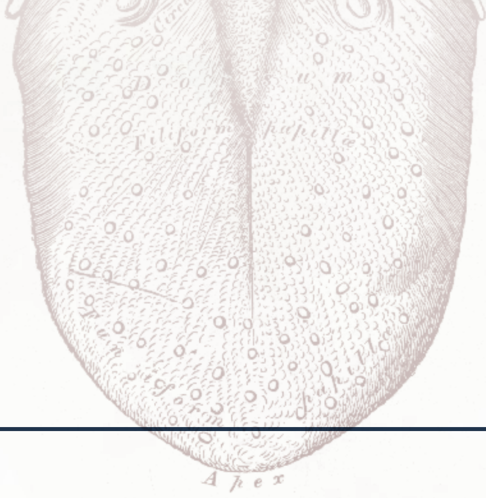
The Diabetic Taste Test and the Scent of a Disease:

Smell and Taste in Medical Diagnosis

Sutchin R. Patel, MD

Ancient medical practitioners used all five senses (vision, touch, hearing, smell and taste) in their observations. While some believe that our dependence on technology has sharpened our diagnostic ability, others feel that it has dulled our senses. Of the five senses, smell and taste seem to be the two senses that we use the least when examining a patient today. This would thus lead us to ask: Is there a role for either of these senses in medicine today?

Around 6 BCE, the Hindu physician, Sushruta described a disease (diabetes) called "honey urine." The description of the disease was named for the taste of the patient's urine as well as the observation that ants were attracted to the urine because of its characteristically sweet taste. Thomas Willis noted that *diabetes mellitus* (*mellitus* = Latin for "sweet like honey," the term was coined by British Surgeon General, John Rollo in 1798) produced urine that was "wonderfully sweet, like sugar or honey." During the practice of uroscopy, the color, consistency as well as the taste and smell of urine samples were carefully examined in a matula and compared to a chart that matched the different urinary characteristics to specific ailments. However, in 1637, Thomas Brian attacked the exaggerated claims for uroscopy, ridiculing those who practiced it as "pisse prophets." In 1772, Dr. Matthew Dobson from the Liverpool Infirmary established that the sweetness in urine came from sugar and by the 19th century, much to the relief of current practicing physicians, chemical analysis replaced tasting urine as a means for determining glucose levels in urine.



The Greek and Chinese used scent as early as 2000 BCE to diagnose infectious diseases, such as tuberculosis. We can use our sense of smell as a diagnostic tool in medicine. Some infections and malignancies can lead to changes in metabolism leading to the production of different metabolic compounds thus leading to a different odor. From the scent of *fetor hepaticus* in patients with liver failure to the fruity smell of ketones in the breath of patients with diabetic ketoacidosis to the smell of *c. difficile* diarrhea, these are a few of the conditions that can be diagnosed with our sense of smell.

Animal noses have been well known to detect scents and odors outside the diagnostic capabilities of the human olfactory system. In the late 1980s, a dog handler became suspicious of a mole on her leg after her dog kept sniffing at the lesion on her leg and eventually tried to bite it off! The dermatologist consulted diagnosed the lesion as melanoma. Several studies have addressed animal scent detection as a diagnostic technique. Already apparatus for sampling skin and breath vapors have been devised and gas chromatography analysis enables detection of organic compounds at concentrations below those detected by the human nose. Despite emerging technologies to analyze patient scents, many of which are fairly expensive, the use of our nose is free and can aid in our diagnostic capabilities.

Medical History

Our historical understanding of what medicine expected from doctor and patient interactions comes from a single solitary source – Hippocrates.

Prior to his writings, the interaction of doctor and patient is mere hyperbole. We know a fair amount about medicine and surgery from such ancient sources as Egyptian hieroglyphics and Mesopotamian clay tablets, but how doctors and patients interacted is not detailed. It is from Hippocrates that the bedrock notions of these interactions are first iterated. That the Greeks did take much of their medical practice from the Egyptians is not questioned and that even prior to Hippocrates, before the 4th century CE there is good evidence that Greek medicine was flourishing. Homer in the Iliad, which dates approximately to 1200 BCE, noted over 141 wounds and used approximately 150 anatomic terms. The Hippocratic writings were collected in Alexandria well after the Master of Cos was deceased. A high level of medicine is depicted from this rather broad collection of works. He also is the first to stress that medicine is a profession and, as such, there are obligations to the patient involved in every interaction. The exact framework for questioning the patient though was clearly lacking in these texts as was accurate descriptions of physical examination. The ancient Greek lack of true anatomical knowledge is clearly linked to their lack of knowledge about the pathological consequences of disease. This would take many centuries to acquire. Their appreciation of vital signs was thus limited to easily obtained signs — pulse, respiratory rate and palpable fever. The first known document regarding the interrogation of a patient's illness is by Rufus of Ephesus in about 100 CE entitled, ***On the Interrogation of the Patient.*** *"The physician will be instructed and wiser about the patient if he interrogates the patient."* Rufus probably lived during the time of Trajan and probably was a Hippocratic follower, though he certainly voiced some differences. It is believed that he trained in Alexandria for he is widely read, having commented upon the works of Zeuxis and Dioscorides. He also wrote a treatise on the pulse to which we will return. The importance of the patient's history is nowhere better expressed than in Rufus's own words:

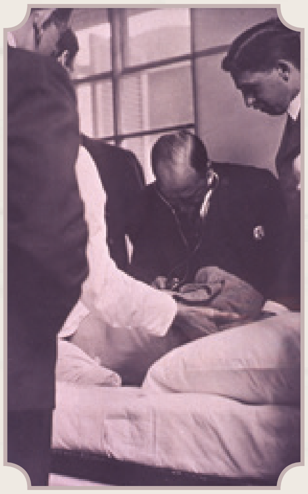
> *"It is important to ask questions of patient because with the help of these questions one will know more exactly some of the things that concern the disease and one will treat the disease better. One should start by interrogating the patient himself. One will learn just how sane or troubled the patient is and the degree of strength or weakness of the patient. One will obtain a certain notion of the disease process and of the body site affected. One can conclude that the spirit and mind are in good shape if the patient responds in a suitable manner with a faithful memory."*

Andreas Vesalius is rightly heralded as the father of modern anatomy. It is to his magnum opus, *De Humanis Corporis Fabrica* of 1543, that can be called the sentinel moment in medical history where investigation of anatomy, and then onto morbid anatomy, can be pinpointed. Without this knowledge of anatomy and then disease, it was impossible to begin to relate realistically to patients and their illnesses. The only major advances were up till this time in surgery, where history and physical examination were absolutely necessary to deal with abscesses, fractures and tumors. But even Vesalius lacked knowledge of physiology and certainly committed errors of omission. In his aftermath, however, an awakening and ever inquisitive group of followers would begin the task of discovery, such as William Harvey in experimental physiology, Thomas Sydenham who formalized questioning illness with practical nosology, and Morgagni who's 1761 *De Sedibus* used Vesalius's foundations to begin to questions the body in disease. Now with the beginnings of the understanding about the causes and clinical courses of some diseases, the physician could begin to interact with the patients' historical commentary and examine the patients' bodies with some degree of sophistication.

The next major advances came with the introduction of augmented sensory aides to physicians. Auenbrugger described percussion in 1761, Corvisart popularized this process and linked findings with morbid anatomy of the post mortum examination. Laennec developed a primitive stethoscope by 1816 and Louis developed a huge following of students that took this application to a nearly modern level of sophistication. His legion of students literally populated the Western Civilized world. Mueller added these methods to his institutions in Germany and coupled with Leibig added clinical chemistry. Sir William Osler, a restless

Sir William Osler seated at bedside, in consultation with a patient.

Images from the History of Medicine (NLM)



Sir William Osler demonstrating palpation and auscultation.

Images from the History of Medicine (NLM)

perennial student himself, took all of these, including their historical legacy, and brought the whole package to Johns Hopkins Medical Center in Baltimore and the patient's bedside. Now regimented histories and physicals, their historical significance and the legacies of the founding fathers, coupled with morbid anatomy and the most recent scientific findings were all together available to medical students and residents. The modern complete doctor and patient interaction was thus developed. John Gillis so nicely summed up a textbook review from 1850 onwards and explained *"For the ordinary doctor the taking of a medical patient history is and has been one of the fundamental procedures."* He noted the historical lineage that placed this portion of a ritualized examination process into context. *"The patient history became incorporated into the physician's examination as another set of observations and signs, thus producing two histories: a superficial, chaotic story presented by the patient, and a deep, "true" history revealed by the skill of the physician."* We can still almost feel the dichotomy of the physician's role and the patient's. Both are clearly separated thought the goals of both are the same, to restore health. So to quote Gillis once again, *"When a person is sick and medical treatment is sought, a clinical encounter is initiated and a physician will take a medical history either directly from the person or from a third party (parent, relative, friend, or witness). The physician will combine this history with a physical examination to form the clinical assessment. For the ordinary doctor, this is and has been one of the routine and fundamental medical procedures."*

The decline and fall of clinical bedside history and physical examination has been a curious 20th century phenomenon. Following the 19th centuries massive efforts to correlate the findings of morbid post mortem findings with clinical examination findings, we see a rather fall in the physician standards instead of continued rise. *"Ushered in by such remarkable progress, one might have expected that the twentieth century would bring the golden age of clinical medicine. The development of new diagnostic technologies could add to the power of the physical examination."* Sadly, this did not occur. There are many theories as to why the skills of history and physical examination have actually waned in modern medical practice but they include the following: modern technology makes physical findings easier, the technologies themselves provide greater accuracy, the technological findings are less subjective, the great teacher of the bedside physical examination are lacking, there simply is not enough time in medical schools to train superb diagnosticians, and many others. It has now been well documented that *"history — taking and prescribing have been described as the main functions of medical practitioners at the end of the eighteenth century: the important thing then was what the patient thought about it: the important thing became later what the doctor found."* Stanley Reiser now believes that the physician-patient interaction has progressed through three distinct phases: taking patient history, believing the physical exam findings, now to believing the technology (labs and CT scans). Yet the admonitions of our predecessors cannot be denied: *"Physical signs cannot be exclusively relied upon for the formation of a diagnosis: the symptoms and history of the case must be also taken into consideration. It is generally difficult for the young student to guide the patient's account in such a way as to derive the necessary information from the details. Most persons ramble in describing their symptoms, and many insist on giving their own or other person's opinions as to the nature of their disease, instead of confirming themselves to the narration of facts."*

VITAL SIGNS:

The ultimate use of physical examination data today are enshrined in the vital signs, which are also recognized as four in number — pulse, blood pressure, respiration and temperature. They are a recording of the facts of a patient's physiology, the response to pain or illness is manifested in these signs. Osler tells us, *"Observations are made with accuracy and care, no pains are spared, nothing is thought a trouble in the investigation of a problem. The facts are looked at in connection with similar ones, their relation to others is studied, and the experience of the recorder is compared with that of others who have worked upon the question."* The vital signs are just that — signs — that help the physician along the pathway to appropriate therapy but cannot be taken out of context with the illness and physical findings.

The history examination is currently being altered extensively by new electronic medical record systems. Though the history of electronic medical records is beyond the scope of this dissertation, the methods in which the patient's interaction with care workers is most definitely being affected by this technology. Patients can now talk directly to the computer and input their own symptoms either by keyboard or by talking to the computer systems. The physical examination is also being affected by our continued technologic prowess. In the 20th and 21st centuries, the advances in the art of physical examination have rapidly proliferated. Let's turn to auscultation of the lung for disease. Though the radiologic evaluation of the chest has come front and center, there is still a demand to auscultate. We have already used Raymond Murphy's paper ***In Defense of the Stethoscope*** to suggest there are valid reasons to augment the sense of hearing for pulmonary findings. What was left out during this discussion is the advanced technologies, such as computer augmented sound recognition that Murphy was actually investigating. Murphy, in fact, was promoting space-age technologies to overcome part of the uncertainty of the stethoscopic auscultation. He specifically utilized single-channel and multi-channel computer analysis of acoustic stethoscopes to investigate various pulmonary diseases. Along a similar line, cardiac auscultation also has been going the high-tech route. Electronic digital stethoscopes from five manufacturers were reported on by Tavel showing the visual interpretation of wave sounds were improving dramatically and might be amendable to computerized interpretation.

Pulse recording has gone the way of computerized digitalization for some time now. In 1852, the German physicist, August Beer, proved that light transmitted through fluid varies in relationship to the concentration of the fluid. Karl Matthes, in 1939, made an electronic device that showed oxyhemoglobin saturation could be measured using this principle with a device applied to the ear lobe. Glenn Millikan and J.R. Squire further studied the oxygenation in pilots during WWII. Takuo Aoyagi, a Japanese electrical engineer next designed a functional pulse oximeter. Now, these devices are routinely deployed not only in our ICUs but on many medical and surgical floors as well.

Thermometry, likewise, evolved with significant advances. The clinical thermometer that was utilized by Wunderlich in 1868 is never seen in a modern hospital. Now electronic thermosensing devices predominate. Contact thermometry with liquid crystal sensors can be monitored remotely. Infrared medical sensors are being explored that can simply look at the patient and obtain a cutaneous termperature map, all from William Herschel's discovery of infra-red radiation in 1800. Now core body temperatures can be obtained by catheters that telecommunicate to computer equipment at nursing stations.

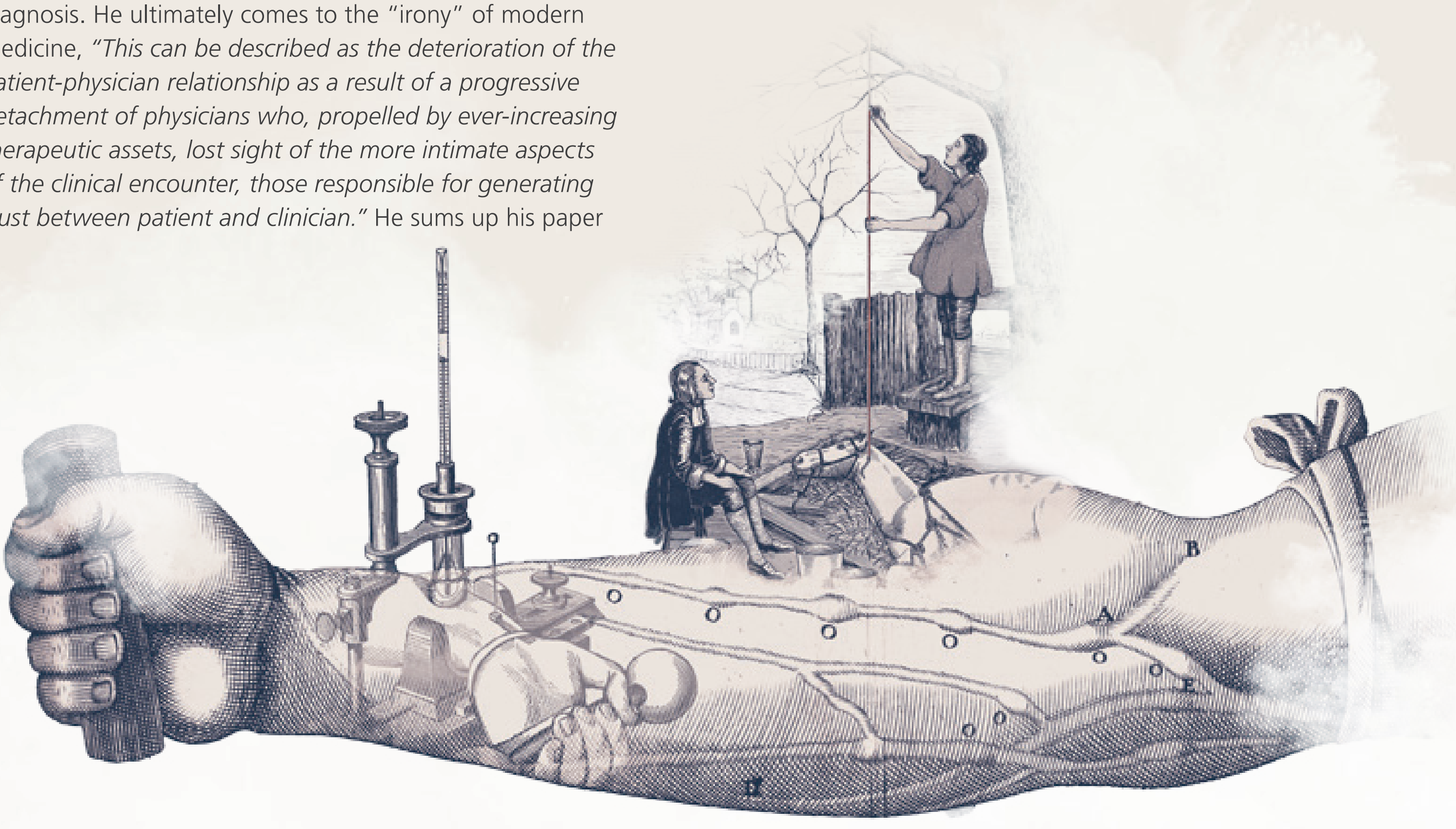
The pulse oximeter revolutionized operating room monitoring of the patient's well-being. Before the pulse oximeter, the actual oxygen perfusion into the patient's bloodstream was unknown. We could see the patient's chest rise and fall but whether the oxygen was actually getting to where it was needed was just assumed. This machine measures the percentage of hemoglobin in the red blood cells that are saturated with oxygen at any given moment with very good accuracy and it is done non-invasively with a small finger sensor.

Donated by Howard Katz, DDS

Despite all of the technologic advances, humans still become ill and suffer as individuals. We have quoted from recent bits of work by medical author and clinical researcher Abraham Verghese who is Professor and Senior Associate Chair for the Theory and Practice of Medicine, Department of Internal Medicine at Stanford University School of Medicine. In another paper of his entitled ***A History of Physical Examination Texts and the Conception of Bedside Diagnosis,*** we can obtain further insight. He looked at textbooks relevant to physical examination in the English language from the late 19th to the middle and late 20th centuries. He noted a tendency for the books the earlier works to focus on the concept of *"physical diagnosis."* Later, the books generalized and discussed predominately findings of the examination. He ends with the textbook that I was taught bedside diagnosis, ***Bedside Diagnostic Examination: A Comprehensive Pocket Textbook*** by DeGowin and DeGowin from the University of Iowa. He noted that DeGowin specifically created his textbook to intensely focus on the act of observing, touching and listening to the body.

In an interesting paper from Yale University, Peixoto reports on studies where patients continue to like to be examined even in this era of complex technologies. He references data that astute clinicians are able to provide the correct diagnosis in general medical practices in 80% of the cases. He then goes into the history of the decline and fall of bedside diagnosis. He ultimately comes to the "irony" of modern medicine, *"This can be described as the deterioration of the patient-physician relationship as a result of a progressive detachment of physicians who, propelled by ever-increasing therapeutic assets, lost sight of the more intimate aspects of the clinical encounter, those responsible for generating trust between patient and clinician."* He sums up his paper by stating, *"The point is that progressive abandonment of the physical examination is a mistake. Bedside diagnosis can be an effective supplement to the present diagnostic armamentarium and particularly worthwhile in an era of cost-containment and progressive loss of the patient-physician relationship."* He goes on for three more pages with his recommendations for improvement of the skills that we all have been losing. These social dimensions of medical care have yet to be replaced by our technology, though I do not doubt that this too might be achievable in the near future. It is the loss of professional decorum, that so mattered to William Osler in that bygone era that he called noblesse oblige. This is summarized rather nicely by the son of a urologist, now a surgeon in Boston, Atul Gwande:

> *"It is unsettling how little it takes to defeat success in medicine. You come as a professional equipped with expertise and technology. You do not imagine that a mere matter of etiquette could foil you. But the social dimension turns out to be as essential as the scientific matter of how casual you should be, how formal, how reticent, how forthright. Also how apologetic, how self confident, how money minded. In this work against sickness, we begin not with genetic or cellular interactions but with human ones."*



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