Big Data
Gaining new insights

Fire Starters
How a laboratory is getting in the minds of rowdies

Breathless
Thriller about a natural reflex

No Way Out
Long-term sedation: Trapped in your own body
Fire, water, earth, air – man cannot live without the four elements. Yet he must protect himself against their dangers. Dräger’s ‘Technology For Life’ has been helping people deal with the elements for 125 years.

“To ward off these four elements, most especially when they rage wild and tumultuous, without allowing the threatened human life to be torn away by their power and energy, and to rein those elements back in again – that has always been, from the very earliest beginnings, the mission of Dräger.”

Senior Pastor Wilhelm Mildenstein, St. Mary’s Church Lübeck, on January 16, 1928, at the funeral of Bernhard Dräger

This refers not only to our home planet, but – in the narrower sense – the earth’s crust. From the tilled soil to the TauTona Mine in South Africa, where gold is extracted from a depth of 3,900 meters, to the SG-3 research borehole on the Kola Peninsula in Russia, which descends to a depth of 12,262 meters. More than 20 million people across the world earn their daily living as miners. Their work is essential yet dangerous. Risks can be minimized by upgrading pits using the latest technology, and by equipping and training mine rescue teams.
A surface area of around 1,000 square meters is concentrated in one gram of activated charcoal, which absorbs materials from the air – more starting on page 48.

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People Going Places

Helga Tschugg, Senior Nurse, Innsbruck University Hospital, Austria

“The skiing season has been under way since the end of October – unfortunately we’ve already had two people seriously injured: a young Russian snowboarder who is now paraplegic following a bad accident, and a man who was knocked down while unloading his car. All vacations are cancelled for us at Christmas, because the place is full of people from all over the world. Every year there are 45 million overnight stays in Tirol. In the past there used to be breaks in the season, because the ski resorts didn’t open until December.

What do I wish for in terms of my job? It’s difficult to say. When people overestimate themselves, they have to live with the consequences. We once had a student, a paragliding enthusiast, a real pro. She plunged 50 meters in free fall to the ground and died three days later. That was tragic, but she was aware of the risk. I also can recall a young motorcyclist who was hit by another motorcyclist traveling in the opposite direction. He didn’t survive either. You then start thinking about how unfair life can be when you are in the wrong place at the wrong time. Currently lying in one of our eleven beds is a woman who is also paraplegic after falling from a great height in the mountains. The drop was not as high as the world-weary woman had hoped. How is it possible to deal with all that? Ninety percent of our patients continue to live on. A Tirolese was involved in a logging accident 16 years ago. He is now in a wheelchair, plays the trombone, and goes monoskiing. Sometimes I ask him to come and talk with the patients. He gives people a real boost, including the entire team. But you have to learn to leave everything behind here at the hospital; put it away in a drawer before going home. When I was a little girl I wanted to be a baby nurse. I have now been working in intensive care for 30 years and I’m still happy. I like empathizing with others. People used to have more family support, but these days many lead an isolated life.”
Andreas Friedl, Engineer and Watch Officer, Innsbruck Fire Department, Austria

“I have been with the fire department for 22 years and have seen quite a few things, from cats stuck in trees to forest fires. One burned for ten days in 2008. The flames leapt 40 meters into the air from the forest. It gets extremely dry below the Martinswand rock face in summer and there was also a warm dry wind blowing. Even though helicopters were dropping water, we had to go in and break up the steep forest floor, because root fires can still smolder deep underground. The forest protects the city. Innsbruck is the only large European city with residential areas susceptible to avalanches – by the end of October we already had 1.80 meters of fresh snow on the mountains!

Recently there was a fire in an underground parking lot; 400 batteries exploded. We were stretched to our limits physically. Besides having Dräger breathing apparatus (type: PSS 5000), we also had twin packs with us while searching for people in extreme smoke. Two bottles give you double the air supply. Our biggest challenge? Probably the Brenner Base Tunnel. Once the project is complete in a few years, three tubes will run underground through the 64-kilometer-long shaft. There can be up to 1,000 passengers in one train. You really don’t want to think about the scenario if something happened there. My worst job was 15 years ago when an 18-year-old sewer worker was stuck head first in the shaft. We got him out quickly, but there was water in the shaft. What a miserable end it must have been – it played on my mind for a long time. Other times we also have to rescue dogs from the Inn. People stand on the bridge and clap. I’ve never seen that when we rescue people, but that’s how our society is. As a firefighter you can really indulge your little Helper Syndrome.”
Keywords

Each keyword reveals a new aspect of an article and shows it from a different perspective. Every theme, after all, has many facets. The explanations and definitions of these keywords are drawn from lexicons, dictionaries, and encyclopedias – and they include forays into other fields so that we can view them from different perspectives.

OTHER WORLDS

No longer master of your own house

During wonderful moments it seems as though we are in harmony with ourselves and our surroundings. Yet conflicting feelings often surface in the course of everyday life: the stomach wants chocolate, but the mind, controlled by reason, vetoes the idea. Sigmund Freud’s psychoanalysis brought order to this chaos in 1917 by describing the unconscious mind – including the wound that the ego is not master of its own house.

Coma patients most likely feel the same way: more starting on page 8

ROOMS OF WONDER

Walk-in centers of the Enlightenment

It is not only the Internet that educates. Museums offer exhibitions arranged by theme, put things in an illuminating context, and they create a tactile experience. They originated from baroque art collections known as “rooms of wonder”. The Enlightenment transformed museums from establishments where people merely come to marvel at the exhibits into places that educate.

They also showcase medical technology: more starting on page 44
NOT QUITE NORMAL

Society’s rednecks

They disrupt, play with fire, look for trouble: rowdies. This word was originally used to describe ill-mannered rednecks who did all they could to rub people up the wrong way. But “rowdiness” is also the stigmatizing term for something that is merely uncomfortable. In the case of fire devils it is clear what kind of rowdies are at work and these are the ones from which the rail companies need to protect themselves: more starting on page 18

DIGITALIZATION

The entire world in 0 and 1

Parts of the world have got used to the decimal system. After all, both hands add up to ten fingers. However, the Greek and Chinese, for instance, used a base five counting system; the Mayas counted in steps of twenty. Sumerians and Babylonians, on the other hand, were not guided by humans, but by the position of the stars – their base 60 counting system was especially suited to astronomical calculations. The universal genius Gottfried Wilhelm Leibniz did away with all of this in radical style in 1697: he developed the dual or binary system consisting of only the values 0 and 1. It was considered enough to describe the world and could be universally translated: into yes and no, God and devil, male and female, but also into day and night. There is no third possibility – logically. Electricity is either on or off. Claude E. Shannon’s groundbreaking communication theory links the dual system and early computer technology, laying the foundations for what we now see in a completely new way as “big data”: more starting on page 38

PERCEPTION

Follow your nose

The 30 million olfactory cells in the human nose can sense incredibly well a diluted substance such as methyl mercaptan in garlic. Dogs can do much more. Yet with many hazardous substances it is no longer possible to rely on noses made of flesh and blood. In such cases, only analyses can help and provide the necessary safety: more starting on page 48

GERMS

Attacks on the body

When someone feels unwell or becomes sick, germs are often the cause – microorganisms which follow their own evolutionary program of reproduction within the body. At the expense of the host who has to foot the bill, the size of which is generally a weakness of varying degrees, because the body mobilizes all its forces to fend off the invaders. Their discovery in the first place is linked with the names Louis Pasteur and Robert Koch. We have known what we are up against ever since. Yet it can still be difficult, like in the case of sepsis: more starting on page 32
FOCUS
LONG-TERM SEDATION

Between Two Worlds

Glaring lights, loud beeping machines, unguarded conversations – intensive care units can save patients’ lives and also push them to the edge of despair. Artificially placed in an altered STATE OF CONSCIOUSNESS they fight their own battle parallel to the recovery of their body. How to make this process easier for them?

ILLUSTRATIONS: ALINE ABREU

People are dwarfed by the sensations that can await them in a coma: What is reality, what is delusion?
Fear filled the house of Dorothea Knappe one Monday. It was midday when the headaches started to pound her temples like arrowheads, pulled the floor out from underneath her, and robbed her of 13 days’ consciousness and four weeks’ reality. When she opened her eyes again and observed the nurse (who at that moment was calling out to a colleague that there was no longer any point in continuing treatment, before checking the medication) she thought that he was pumping poison into her veins. She then closed her eyes again. Eighty percent of all intensive care patients become delirious, 44 percent still suffer from post-traumatic stress disorder weeks and years later, and one third develop depression. Behind it all is an altered state of consciousness in which patients find themselves when they have been placed in a medically induced sleep.

**Breathing as independently as possible**

What people commonly refer to as an “artificial coma” is actually not a coma at all, but a kind of long-term sedation. “The diabetic coma, the uremic coma, or the coma that follows a traumatic brain injury is a manifestation of an impairment of the central nervous system (CNS),” explains Michael Bauer, Professor of Anesthetics at Jena University Hospital. “In a coma the function of the CNS is impaired, while under analgesic sedation it is reversibly suppressed.” Analgesic sedation means inhibiting pain (analgesia) while simultaneously calming the patient (sedation) with medication. Patients are generally invasively ventilated via a tube or their breathing is supported by means of non-invasive ventilation. Unlike the approach used up until the middle of the last century, clinicians now try to maintain the patient’s respiratory independence to the greatest extent possible. Modern ICU ventilators help them to do this. The depth of anesthesia is then as light as possible and as deep as necessary. The same applies to the sedation and ventilation.

The depth of anesthesia is checked at regular intervals by measuring the

*Name changed*
FOCUS
LONG-TERM SEDATION

“Patients are sedated just enough to help them endure everything happening around them”

brain waves using processed EEG (electroencephalogram) or sedation scores, such as the Richmond Agitation–Sedation Scale (RASS), which relies on observation and clinical assessment of the patient. In ICUs this assessment is recommended every eight hours in line with the current guidelines of the Scientific Medical Societies. On top of this are so-called sedation windows, during which the patients are effectively woken up for a brief period of time or brought back to a lighter sedated state so that they can be neurologically assessed.

“If a patient has a stroke while under analgesic sedation, this can be totally masked and overlooked,” explains the Jena-based specialist Michael Bauer. The lightest possible sedation means a state of consciousness which, although altered, is not completely suppressed. “This approach accelerates the healing process, makes it easier to wake the patient later on, and shortens the stay in the ICU,” confirms André Gottschalk, Head Physician of the Clinic for Anesthesiology, Intensive Care, and Acute Pain at the Diakoniekrankenhaus Friederikenstift in Hannover. “Patients are sedated just enough to help them endure everything happening around them. They should be as conscious as possible and be able to communicate – by hand squeezing or blinking.”

No orientation or sense of time
It took four weeks before Dorothea could trust her relatives and nurses. The 64-year-old was delirious after waking up. She had no orientation or

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Who is observing who here? A coma causes an altered state of consciousness – an alarming level of attention is devoted to tiny, seemingly trivial details.
It is reassuring when the rhythm of day and night is maintained

> sense of time, caused by an irregular day-night rhythm and a feeling of helplessness. It was another Monday when she started therapy in the rehab center and began to understand what had happened to her. A completely alien environment and unusual noises or smells interfere with the clouded perception under medication—and allow the imagination to run wild. If people are careless with the way in which they manage the patients’ sense of time, for instance by leaving lights on at night and having devices blaring out, those affected can be thrown into a state of confusion. “We do all we can to ensure that nighttime remains nighttime. We dim the lights, turn down devices, and sometimes close the doors to the rooms,” says André Gottschalk. During the day it is important to create familiar situations for patients as often as possible, such as through regular and frequent visits.

Shot, poisoned, and tortured under sedation

Clemens Hagen’s fiancée Kimberly Hoppe didn’t leave his side. He almost bled to death internally following a ruptured abdominal aortic aneurysm and could only be saved with a large number of transfusions and two weeks under analgesic sedation. He appeared to be sleeping while she remained by his bedside. “During this phase I did anything but sleep,” says the journalist talking about his time between two worlds. “And it was in no way peaceful: I had to run for my life and was shot, poisoned, and tortured. Kimberly cheated
The body temperature is lowered to between 32 and 35°C (normal approx. 37°C).

Doctors take control of the body’s basic functions. Patients are fed via a feeding tube or intravenously.

Unlike a naturally occurring coma, the artificial coma can be ended by doctors at any time.

Risks and side effects of an artificial coma tend to be low according to experts.

Long-term sedation is used after serious accidents or life-threatening illnesses.

This slows down the metabolism and reduces oxygen consumption, giving the body more reserves.

Brain activity in a coma patient (1), when fully conscious (2).
The 52-year-old dealt with his life-threatening situation in the most terrible nightmares. “It was all so realistic, like a 3D movie with me as the main protagonist. The only difference is that movies and normal nightmares quickly come to an end. You wake up, go to the kitchen, drink a glass of water, and everything is fine again. I had no ‘off’ button; I couldn’t stand up. It was torture for the psyche!” Three months and countless talks later, he was at least able to forget it all to a certain extent. He worked through his experiences by writing a book with his fiancée (see p. 16). Unaware of the big favor she would be doing her boyfriend, she began to write a diary on the first day and kept it going as she sat by his sickbed – a practice that is becoming ever more popular. The ICU diary can improve patients’ orientation later on and be an immense help when working through post-traumatic stress disorders and other psychiatric conditions. The idea comes from Scandinavia. Health professionals and relatives keep a diary for the patient, talk directly to them, comment on events, and explain what is going on around them: which machines are being switched on and off around them, who is coming to visit, what progress has been made. When the patients regain consciousness – in whatever state that may be – the books are handed to them. The problem for patients who have been under sedation, according to Nursing Researcher Peter Nydahl, stems from the unconscious
When fears and subconscious experiences dominate your life

experiences that disturb their later behavior after waking up. ICU diaries counteract this loss of control.

Work based on contact

Peter Ammann also knows a great deal about people who, out of fear, can no longer go into fast food restaurants, because the beeping at the counter reminds them of the ICU. The psychologist specializes in the field of process-oriented coma work and he also teaches health professionals and counselors how to deal with people in altered states of consciousness. It is important for him that everybody involved understands one thing: “We are not composed solely of physiology. Physical processes are closely connected to the consciousness; both influence each other.”

Delirium

Those who fight for their lives and win the battle are not necessarily cured once they leave the ICU. According to the latest findings, the delirium which generally subsides after a few days or weeks is blamed for later cognitive disorders. Forty percent of patients who took part in a follow-up study conducted by Vanderbilt University Medical Center still suffered from cognitive impairments three months later. Among 34 percent of these patients there was even evidence of the disorder one year later. No less than 26 percent exhibited deficits comparable with a mild form of Alzheimer’s disease. Since the duration of the delirium appears to play a role, but cannot yet be influenced, physicians mostly recommend preventive measures. Lack of daylight, no visitors, and isolation are considered the biggest risk factors associated with the development of delirium.
Treating coma patients carefully is just as important as acknowledging their experiences

> Not only is the careful handling of patients who are helpless in bed extremely important, but also the ability to appreciate the inner experiences of people in a coma. “Most contact with coma patients has a specific purpose, because it is aimed at getting them to act and react,” says Ammann. This is where the processing work heads in another direction. “I get closer to the patients’ state of consciousness and meet them at the point where they stop. The entire work is based on contact.” All parties must be prepared to get involved in this. “Naturally it takes up a great deal of time when I engage in intensive experiences, but it is also about my attitude toward the patient: How do I enter the room? Do I consider the fact that they are lying there, or do I just ignore it, because I think that they won’t be aware of anything anyway?” Ammann is often called on to help patients who are stuck in a situation where the process of weaning them off the ventilator isn’t working. “The weaning process is a big step and I have to view the patients against this background. Are there perhaps non-medical reasons why they are not becoming active again by themselves?”

Switch on, switch off – all ICUs now know that this principle does not work for patients under analgesic sedation. The right way to deal with this knowledge is to engage in a process in which many hospitals already find themselves. Delirium management, ICU diaries, holistic counselors and relatives playing an active role by the sickbed, noise reduction, and last but not least, respect for the patient who is assumed to be sleeping. These are all steps that can show a coma patient, on the threshold of life and death, the correct direction. Dorothea Knappe can now face her negative experiences. She recently paid a visit to the ICU where she spent six weeks and she was able to say to her fears: hello and goodbye – you can count me out in future.

Isabell Spilker

EEG monitoring

According to medical guidelines, EEG-supported monitoring of patients under analgesic sedation represents an important option during deep sedation and is also recommended for identifying whether sedation is too light or too deep in patients with neuromuscular block. It should be called on for support in cases where the RASS (Richmond Agitation–Sedation Scale) value is -3 or less, i.e. when there is no response to a voice. The Infinity Delta monitor can display the monitoring activities of all areas of intensive care in one unit. In this case it is linked to an EEG pod which records the brain waves in real time and permits continuous online analysis. Dräger monitors feature modern alarm management and can make the day–night rhythm easier for patients (by means of volume and brightness controls as well as alarms that can be adapted to various situations).

Literature:
Peter Ammann:
Reaching out to People in Comatose States: Contact and Communication,
Books on Demand, January 2012

Links:
Peter Ammann
www.peterammann.de
Peter Nydahl
www.nydahl.de
Hospital architecture: a healing effect

Pale light, bare walls, unpleasant sounds – it doesn’t have to be like this: on some of the wards at the Charité Hospital in Berlin, for instance, patients with certain clinical pictures convalesce in rooms specially arranged by architects and media designers. That’s because the healing process can soon be inhibited in rooms that are cool, sterile, and full of medical devices. A high degree of privacy, technical devices that blend into the background, and attenuated alarm sounds virtually turn the rooms into cozy living spaces. The “Parametrische (T)Raumgestaltung” (“Parametric Dream Room Design”) project funded by the German Federal Ministry for Economic Affairs and Energy is conducting research into the effect the room has on convalescence when it is not only cozy and homelike, but also able to create daylight conditions by means of technical features (such as an LED-controlled ceiling).

These diaries provide meaning

PETER NYDAHL is a nursing researcher at the University Medical Center Schleswig-Holstein in Kiel and has imported the idea of ICU diaries from Sweden to Germany. It is his hope that they can soon be kept for all patients who have been ventilated for more than three days. Also for this reason he presents seminars and gives talks on the subject.

Mr. Nydahl, how many hospitals in Germany are using the ICU diaries?
We conducted a survey of various hospitals last spring. Of the 140 units surveyed, 44 are using them and a further nine are planning to introduce them.

Are there any reasons not to use them?
Some hospitals only keep patients in the ICU for a short period of time – for instance, after simple operations. It’s not worth doing it there. In other cases it is actually due to a lack of staff. There is currently not one single unit on which all the health professionals are participating.

To what extent can the diaries really help ICU patients?
When you ask patients what they remember, they mostly answer: “Nothing!” It gets more interesting when you ask them about their dreams. The risk of delusional memories (those whose origins they are no longer aware of) rise depending on the kind of sedation and the degree of inflammation. This especially applies to patients who are on long-term ventilation. I can recall a young motorcyclist who was lying in a RotoRest bed for a week following thoracic trauma. He was deeply sedated, had no memory of the time, but recounted how he had dreamt of going to sea and lying in a bunk from which he was always in danger of falling out.

How could a diary have helped him here?
Diaries help in keeping with the principles of salutogenesis, as once defined by the medical sociologist Aaron Antonovsky. According to these principles, we can recover if we understand something about our condition and are better able to handle it and learn how to cope with it.

Does the health professional’s relationship with the patient change when they try to gain a better insight of their feelings through the diary?
Younger colleagues in particular have difficulties with this. I look at it professionally. Of course you write emphatically and think about how the situation might feel from the patient’s perspective and then formulate it objectively. You sometimes also read the entries from the relatives, who are also asked to play their part and write things down. From the patient’s perspective these entries are the most important. Patients and relatives go through the process in completely different ways. The relatives sit on the bed writing while the patients are having confused dreams. The diary can play a key role when they get together again afterwards.
On Fire

The train is one of the safest forms of transport. This is another reason why the experts at DB SYSTEMTECHNIK GMBH regularly get to grips with the materials which will later be used in the trains – at their in-house fire laboratory.

The thick pall of smoke gets blacker in front of the fire until the toxic curtain completely obscures the flames. Zero visibility conditions now prevail in the test room. People would be disoriented here. The atmosphere is poisonous in the smoke box anyway, as shown by the measured values on the computer screen, which displays the results of the connected spectrometer. The table lists various carbon, nitrogen, and sulfur oxides, plus methane, hydrogen cyanide, and hydrogen bromide. “These values are effectively the fingerprint of a combustion process,” says Andreas Böttger. On this particular morning in the fire laboratory at DB Systemtechnik GmbH the fire protection engineer is testing fluorescent tube covers for their potential use in rail vehicles. For this purpose, he is cutting samples to a defined length and arranging them in a special container. The fire protection experts go about their work in a similar manner for all other tests in order to get reproducible measurement results such as fire behavior, smoke toxicity, and smoke optical density. In the smoke density chamber the samples, which measure just a few centimeters, are heated by a conical heating coil until they are on fire. A gas stream is taken from the testing chamber for measuring purposes. It is filtered from the proportional soot particles and fed to the spectrometer, which determines the concentration of the noxious gases.

Almost 1,000 tests a year

The fire laboratory has been based in the district of Kirchmöser in Brandenburg for almost 15 years. This year the provider of engineering services for Deutsche Bahn expanded the laboratory at a cost of around 400,000 euros in order to be able to conduct tests that comply with the new European standard DIN EN 45545-2:2013 (fire protection on railway vehicles – requirements for fire behavior of materials and components). For this purpose, it has been accredited by Germany’s National Accreditation Body in accordance with DIN EN ISO/IEC 17025 (testing and calibration laboratories).

The engineers conduct almost 1,000 fire tests every year: from the thick composite material used for the flooring of regional trains to the numerous plastics found in the interior of modern passenger trains. “We test and certify virtually all the components that are later used in rail vehicles,” confirms Dr. Kathrin Mädler. The engineer is head of the Materials and Joining Technology Department with around thirty employees. The historical
brick building in Kirchmöser, just under an hour away from Berlin by train, is situated in an idyllic location among forests and lakes. The community of 4,000 people nonetheless has an explosive history. The facilities were built at the beginning of the 20th century as a dynamite factory and later became a development center for the German State Railway. Besides being home to DB Systemtechnik and Deutsche Bahn’s environmental services, numerous private rail companies in the neighborhood also attest to this chapter of history.

In addition to the fire tests conducted at the in-house laboratory, the engineers also produce and assess fire protection concepts for the trains – for instance, for new designs such as the ICx train, which is set to replace the Deutsche Bahn Intercity trains in future. But even with extensive renovations, the so-called redesign, the professionals of Kirchmöser are required. Among other projects, they oversaw the technical revamp of the ICE 1, ICE 2, and ICE T trains from a fire protection perspective.

The European standard for fire protection in rail vehicles, which came into force in March 2013, reflects the progress made in relation to the technology and operation of long-distance routes in recent decades with the construction of the new high-speed network, the planning of ever longer tunnels, and the commissioning of high-speed trains. The DIN EN 45545-2:2013 standard has also led to an improvement in the mutual acceptance of fire tests by the licensing offices in various countries. “Against the backdrop of the
The end of steam traction: in 1977 the then federal railroad weaned its locomotives off smoke

Increase in rail traffic, the introduction of the standard across several national borders was important, says Dr. Christian Bohne. The engineer is head of the material technology division for vehicles. Furthermore, there are now comprehensive and scientifically grounded regulations which guarantee a standardized level of safety in Europe when it comes to fire protection in all rail vehicles.

The continued efforts in relation to fire protection on the railway go back much further. After all, while today’s protection against the risk of fire on trains predominantly concerns the consequences of vandalism and technical errors, fire actually traveled on the railroad for a long time and even powered the trains. It wasn’t until 1977 that the then federal railroad weaned its locomotives off smoke – the end of steam traction, which followed in the GDR in 1988. This was applied to passengers 30 years later, when a complete smoking ban was introduced in September 2007.

Central gas supply

The test with the fluorescent tubes is now complete. Fire Protection Engineer Böttger is already testing the end caps of the shatter-resistant fluorescent tubes, which are made from a clear thermoplastic. “This is where our small flammability chamber makes its grand appearance!” It works with a propane gas flame the size of a lighter – in addition to spray cans and sharp objects, this is one of the classic tools of vandalism on and in the trains. The tests in the small ignition chamber provide information on the flammability of materials. For this purpose measurements are taken to see how the flame develops vertically on the test object, whether there are any flaming droplets, and when the flame goes out. The burner is fed via a gas supply system from Dräger; the gas comes from pressure cylinders stored in a secure outdoor shelter. Besides propane gas, the system also supplies the laboratory with methane and nitrogen (as a zero gas) as well as a test gas made up of carbon monoxide, carbon dioxide, and nitrogen.

The role of the fire shaft located in the neighboring room is to supply the material samples with a propane gas flame for three minutes. The energy that is released here is equivalent to that of a burning pile of newspapers. The International Union of Railways has precisely defined this ignition source known as the “paper cushion”. During these and other tests it gets very hot inside the test apparatus – temperatures of up to 500 degrees Celsius are reached when measuring the sideways spread of the flame. In doing so, a test piece is clamped diagonally to a surface burner, which exposes the surface of the test material to up to 50 kilowatts of thermal energy per square meter.

This is also the reason why the laboratory is air-conditioned. Before the tests, the samples are stored in an air-conditioned chamber which is set to 23 degrees Celsius and 50 percent air humidity. All materials have to be stored in these conditions for at least 48 hours to guarantee the reproducibility of the results.

“Composite materials, such as floor panels with a wooden core and bonded lay-
ers, are even stored for 14 days so that the temperature and core moisture level conform to normal standards,” says Andreas Böttger.

No matter whether the samples go up in flames in the smoke chamber or the fire protection experts expose sections of flooring to extreme temperatures and analyze the heat release of the material by means of oxygen consumption calorimetry, all materials have to demonstrate whether they meet the required standards. The determining factor in the approval of a material is the danger rating of the rail vehicle. All trains and carriages are given a certain rating representing a product of operating scenario and design – from class 1 (not designed for tunnels or elevations) to class 4 (for tunnel sections and elevations without side evacuation possibilities). In terms of the designs, a distinction is made between N (standard vehicles), A (automatically operated trains), D (double-decker vehicles), and S (sleeping cars). The higher the danger rating, the bigger the demands made on the tested materials.

Sometimes the experts become fire investigators – as in the case of the reconstruction of a fire in the toilet of a train traveling from the Netherlands to Germany. The cause of this small fire was a lighter flame. However, the driving force here wasn’t vandalism, but a smuggler searching for the cannabis package he had hidden behind a wall panel. Such events can also lead to improved safety measures: the findings are incorporated in new designs. Peter Thomas
From Zero to 21 Percent

We usually breathe automatically – it is only when this reflex is restricted that we become aware of our BREATHING. And yet the physiological facts of this vital function were only discovered late.
As the man in the blue neoprene suit resurfaced, 22 minutes had passed; 22 minutes with just one single breath. On May 3, 2012, in an ice-cold water tank at a diving school in London, Stig Avall Severinsen, yoga teacher, physician, and apnea diver, had just broken a world record – an achievement that was only possible thanks to years of training, thousand-year-old tricks in the art of respiration, and preparatory breathing with pure oxygen. After all, if there is one thing for which mankind is not made, it is living without oxygen; without the constant rhythm of inhalation and exhalation.

It seems strange when we come across creatures that don’t need oxygen. Once the world belonged to them: the anaerobes; the breathless. Although these creatures still exist – at the edges of hot springs and under the earth – they suppressed the principle of breathing 2.4 billion years ago. Back then, protozoa, algae, and plants discovered photosynthesis, split carbon dioxide, and oxygenated the atmosphere – from zero to 21 percent by volume. Oxygen became a highly efficient combustion material for animal life and made mankind possible.

Yet what exactly is breathing? “What a question that is!” would have been the reply of the ancient philosophers: it is life itself! In Indo-Germanic languages (such as German) the close association of the term has been maintained. The Sanskrit word atman, a key term in Indian philosophy, denotes the eternal substance of the human being. Its German relation (Atem) describes
Circulatory systems provide life – also within the human body – but they were only scientifically described relatively late.

> what we now understand as breathing in and out.

**With curiosity and microscope**

And its rarer special form *Odem* is the traditional meaning of the “breath of life”. The English word “breath” is something of a linguistic innovation, superseding the Old English word “þm” (*æthm*). *Qi*, the all-pervading life force of Chinese Daoism, also means “breath”. People have always known about its fundamental force, but it wasn’t until the modern age of science that its functional details were revealed. With curiosity, a microscope, and mechanical pump, ways of replacing and supporting the breath of life were sought. One learned through research that aerobic metabolism produces 15 times more energy than anaerobic metabolism. Without “oxidative metabolism”, a brain weighing 1.3 kilograms (with its 100 billion nerve cells and their 100 trillion dendrites) couldn’t even be formed, let alone maintained. This explains why first responders battle for every second in the event of respiratory arrest.

Nowadays, a distinction is made between two different kinds of respiration. “Internal respiration” is the combustion of nutrients in the individual cells, while “external respiration” is the kind we are aware of – the breaths of air flowing in and out of the chest which change depending on the amount of exertion, for instance during sports. Each cell of the body and the specialized gas exchange membranes of the lungs connect the cardiovascular system together. The heart and lungs are more or less like the body’s logistics providers. They must provide: at anytime, without interruption, to anywhere.

**Carrying the atmosphere around!**

It took a long time before respiration was understood in this way – and even longer before the technological foundations were laid which made it seem a matter of course that people survive in places to which they are not equal by nature: in smoke and gas clouds, under water, in space. It is amazing that it is now possible to almost perfectly replace the mechanical element of breathing temporarily.

Hold your breath: it is sufficient for apnea divers to stay under water for several minutes – they do not need heavy compressed air tanks or cumbersome buoyancy compensators.
In the late 17th century it was the British physician William Harvey who was the first to correctly describe the systemic circulation which carries oxygen to every cell. Before that, the Greek physician Galen, whose medical opinion was long respected above all others, had officially stated that the lungs supplied the body with spiritual powers and otherwise functioned as cooling bellows.

The fact that this actually involved specific gases was discovered in several stages by scientists in the 17th and 18th centuries: Vincenzo Viviani and Evangelista Torricelli provided evidence of atmospheric air pressure in 1643 using pumps. The English aristocrat Robert Boyle used the air pump to suck glass cylinders empty. Candles went out; test animals died. In 1676 Richard Lower demonstrated that blood in pulmonary circulation contained something vitally important.

It wasn’t until the 19th century that the picture of respiration was successfully completed, partly thanks to Charles Darwin’s theory of evolution put forward in 1859 and partly due to the rapid growth of physiology as a science in the second half of the century. After hundreds of thousands of hours spent experimenting, pulmonary respiration and circulatory management were finally understood so clearly that it was possible to fulfill the one wish expressed by Alexander von Humboldt back in 1799: those wishing to explore deep tunnels, save people from fires, and dive into oceans should take their own air to breathe. Around the turn of the 20th...
Respiration supplies the body with energy – an achievement that leaves you breathless

> century, all the strands that had been evolving in separate areas suddenly came together to form the now extensive knowledge about human bodily functions. The technique of compressing gases and the subsequent pressure reduction; chemical processes for producing oxygen, which can be used to make self-rescuers for miners; mechanical systems for rhythmic ventilation, which permits effective resuscitation; all technologies on which Johann Heinrich Dräger and his successors based their surprising innovations.

What appears simple today, compressing 1,800 liters of air in a bottle and being able to take precisely metered breath, is in reality the fruit of a thirst for knowledge and accumulation of experience dating back hundreds of years, as is the art of filtering pure breathing air and the ventilatory support adapted to the self-regulating body, such as that used during intensive care treatment.

This technological perfection in no way detracts from the miracle of respiration. People are still amazed when they encounter a record diver like Stig Åvall Severinsen and see how he guides the flow of life to the region around his lungs. This would even be the case if they could watch with the aid of a machine: the Dräger PulmoVista 500, designed to optimize the ventilation of patients, would be able to precisely visualize the way in which he guides his breath. It would be an encounter between various products of human mastery.

Silke Umbach

* needed by apnea diver
Stig Åvall Severinsen on May 3, 2012: a world record!
A PERSON BREATHES AROUND 25,000 TIMES A DAY*

*and in the process moves more than 12,000 liters of air – based on an average of 17 breaths a minute.

×

AROUND 300 MILLION ALVEOLI* ARE RESPONSIBLE FOR ABSORBING OXYGEN.

*They measure between 50 and 250 microns on average. Their surface area can be up to 120 square meters.

FROM 0 TO 21%*

*The oxygenation of the atmosphere around 2.4 billion years ago by protozoa, algae, and plants.
Even months later, it is still possible to hear the pride in the voice of Henning Schneider, Head of the IT department at the University Medical Center Hamburg-Eppendorf (UKE), about what has been achieved. In spring 2014 the hospital received official confirmation for the second time that it provides the highest level protection against unauthorized access of its electronically managed patient records. “Every UKE employee plays a significant role in this on a daily basis,” he says.

Data protection is a highly sensitive issue in hospitals. Patient details which are especially worthy of protection are collected, processed, and archived here. The UKE certification is based on the “IT Baseline Security” catalog as defined by the German Federal Office for Information Security. This lists around 40,000 measures which organizations can use to thoroughly test their hardware, software, and emergency procedures.

The certificate must be renewed every three years. Schneider invested close to a million euros and a fifth of the working time of his employees in the project. “Security costs money,” he says. “You need certification because otherwise you wouldn’t take the time to adopt the necessary security measures.”

A tested network infrastructure may protect it from external attacks by hackers and other data thieves, but it is unable to completely prevent improper access by hospital staff. Accordingly, the UKE has banned paper from their filing systems and switched to electronic patient records (EPRs). The EPR brings together sensitive patient data such as address, X-rays, and medication in a central IT-supported database which can be accessed from anywhere, regardless whether doctors and health professionals are at the station or in the operating room.

**Eight levels of digitalization**

However, a comprehensive authorization concept controls who can and cannot view the records. “With the help of the EPR, patients can see who has viewed their data,” says Schneider explaining the benefits of digitalization. Furthermore, the records can no longer get lost and are always up to date. “EPRs not only increase security in terms of who is able to access patient records, but also the safety of patients while they are being treated.”

The Healthcare Information and Management Systems Society (HIMSS) establishes how frequently they are being used by means of the EMRAM model, which uses an eight-level scale to measure...
The Electronic Patient

Addresses, X-rays, diagnoses: data is increasingly being digitalized in hospitals. Yet how secure are the IT systems from attacks and how can organizations comply with DATA PROTECTION regulations?
Face-to-face meetings with the data protection authorities create transparency

said managing director Chris Durovich at the time. “It shows the great efforts we have made to increase the quality and security of our information technology.” The certification followed a framework program agreed by HITRUST and the Texan health authorities beforehand. Here, too, the size of the hospital played a key role. The Children’s Medical Center is the sixth largest pediatric hospital in the United States. Why is that the case and why don’t small hospitals in particular apply for this certification? “There are three fundamental reasons for this,” says Thomas Jäschke, Professor of IT Security at the FOM University of Applied Sciences for Economics and Management in Essen. Firstly, the issue is not high on the list of priorities of those responsible. Secondly, there is a lack of specialized staff. “And lastly, the data protection officers and IT managers have to work closely together to secure certification, but this often breaks down due to the data protection officer’s lack of IT expertise.”

Lack of trust in the cloud

At the same time, data protection and the security of IT systems are not an individual option, but a legal obligation. Those who fail to comply could have harsh sanctions imposed on them by the German data protection authorities in cases of doubt, not to mention the damage to the image caused by data thieves hacking into the EPRs and patient data ending up in the hands of third parties. Data protection officers and the IT industry
At a glance: electronic medical records show their knowledge where it is needed

Electronic patient records: how often are they used in hospitals?¹

<table>
<thead>
<tr>
<th>Country</th>
<th>Generally strong (levels 4 to 7)²</th>
<th>Generally weak (levels 0 to 3)²</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>61.0%</td>
<td>39.0%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>50.8%</td>
<td>49.2%</td>
</tr>
<tr>
<td>Spain</td>
<td>50.6%</td>
<td>49.4%</td>
</tr>
<tr>
<td>Austria</td>
<td>38.1%</td>
<td>61.9%</td>
</tr>
<tr>
<td>Germany</td>
<td>12.8%</td>
<td>87.2%</td>
</tr>
</tbody>
</table>

Source: HIMSS
¹ = USA: Q2/2014; rest: Q4/2013; ² = according to EMRAM = Electronic Medical Record Adoption Model

have launched a number of initiatives to address this difficult issue.

In July 2011 the conference for data protection officers of the German federal government and states published a guide to designing and using hospital information systems that comply with data protection regulations. This sets out the requirements resulting from current data protection laws, the regulations governing medical confidentiality in hospitals, and the use of information systems in hospitals. Furthermore, it describes procedures relating to their technical implementations. A revised version of the guide was released in April 2014.

The IT industry in turn wishes to assist hospitals by offering cloud services. Yet after Edward Snowden revealed the practice of eavesdropping by security services, the trust of IT specialists in the security of cloud services has evaporated like snow in the Sahara. The German data protection authorities have also reacted. In July 2013 they announced that they would no longer authorize the new operation of cloud applications from “insecure third-party states” due to data protection concerns.

Cloud services have not yet come under consideration in the UKE’s data protection concept. Nonetheless, the hospital is working closely with the authorities in Hamburg. “We are committed to open and transparent cooperation,” says Schneider explaining his recipe for success. “Part of this includes meeting representatives from the data protection authorities quarterly.”

Frank Grünberg
Septic Shock
A Race against Time

Every minute counts with BLOOD POISONING. Those affected only have a good chance of survival if intervention is quick and decisive.
There is an illness from which 137 people die every day in Germany alone, which causes huge expense, and the name of which most people do not even know. It is an illness that is never in the limelight and is associated with a high mortality rate, dire long-term consequences, and dozens of dismal failures in an attempt to develop suitable medication: septic shock, the final escalation stage of an infection against which the body defends itself with all its resources. Septic shock results in an intensification of an infection and the immune response. Each process escalates the other with fatal consequences for the entire body.

This escalation follows a fateful choreography; the blood carries the micro-organisms to every corner of the body. In turn, the immune system produces a whole armada of immune cells. The generalized inflammation damages the inside of the blood vessels, fluid leaks out, the blood pressure drops, coagulation control is broken down, and the organs are ultimately brought to their knees – if the escalation isn’t halted in time. It often all begins with an infection of the respiratory tract, abdomen, bones, or soft tissue. The escalation proceeds in three stages. The first is the sepsis stage, during which bacteria in the blood cause an inflammation of the entire body. This is followed by severe sepsis, which is accompanied by organ failure, mostly the kidneys. When the condition progresses to septic shock the cardiovascular system also fails. The risk of death increases with every stage.

Hippocrates, the most famous doctor of ancient times, classified it as putrefaction of the blood. More than two thousand years later the German Nobel Prize winner for medicine, Paul Ehrlich, called it “horror autotoxicus” – literally, the horror of self-toxicity. It is commonly referred to as blood poisoning. It is not only in Germany that more people die from septic shock than from breast cancer or bowel cancer. Few talk about it. In the ICUs septic shock is the leading cause of death nationwide, the third most common cause of death after cardiovascular disease and cancer. Despite all the medical progress made, sepsis is occurring more frequently, because the population is getting older and therefore sicker, because a greater number of complicated operations are performed, and because more multiresistant germs are in circulation.

As with all acute life-threatening illnesses, time is a crucial factor here. An emerging case of sepsis is not easy to identify and it is soon too late. There is not one single laboratory value which can reliably diagnose sepsis. The clini-
Sepsis can be a thief and take a life

The golden hour

In a case of sepsis the microorganisms must be rendered harmless as quickly as possible and the negative effects on the body stemmed. That is why antibiotic therapy should be started as early as possible. Studies have shown that every delay and every mistake in choosing the antibiotics diminishes the patient’s prognosis. If septic shock has already set in, the mortality rate increases by seven percent with every hour that passes without antibiotics being given. “There is a golden hour during which treatment can be the most successful,” says Gründling. “However, you cannot prescribe the antibiotics indiscriminately. That would promote resistance.” Gründling is aware of the dilemma of making a fast and reliable diagnosis while avoiding overdoing the therapy. “We recently discussed this problem at a conference. In the end everyone agreed that since there is currently no better treatment than acting fast with the right antibiotics, there is also no alternative to this form of therapy.”
Drug development also falters when it comes to sepsis. A few years ago the only approved medication at the time was withdrawn from the market. There are now at least twenty five drugs on the list of failed clinical developments. “Maybe the individual phases and the underlying pathomechanisms were incorrectly weighted,” says Gründling commenting on the situation. “In cases of sepsis there is not only generalized inflammation, but also immunodeficiency.” According to what we currently know, the immune system is overactive at the beginning of the illness. The immune cells are so exhausted later on that it leads to immunodeficiency. Most candidates from the clinical development phase have focused on stemming the inflammation and immune system activity. Although these therapies may work in the early stage, they are harmful once the immunodeficiency kicks in. Perhaps these insights have to be more carefully considered in clinical development.

**Sepsis or stroke?**

“Since sepsis is often disguised as an accompanying symptom of another illness, an operation, or polytrauma, we must learn to predict it more accurately,” says Gründling. “To this end, we must look for the initial signs by regularly taking measurements of all vital and laboratory parameters, establishing excretion levels, and developing an acute sense of whether patients are agitated and confused due to an imminent case of sepsis or perhaps due to a stroke.” In emergencies, sepsis must be considered as a differential diagnosis until it can be safely ruled out. In Greifswald it has been possible to reduce the average septic shock mortality rate from the common figure in Germany of 54 percent to 31 percent through better training, careful monitoring, and systematic checking of test results (see also: sepsisdialog.de).

**An infection runs amok**

**The three escalation stages**

*Source: lindgruen-gmbh.com for World Sepsis Day*

1. **Sepsis:** the infection spreads

   - Brain
   - Infection
   - Lungs
   - Liver
   - Kidneys

2. **Severe sepsis:** an organ fails, generally the kidneys

3. **Septic shock:** the cardiovascular system fails

**Frequency of post-traumatic stress disorder after:**

<table>
<thead>
<tr>
<th>Event</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rape</td>
<td>55.5%</td>
</tr>
<tr>
<td>War</td>
<td>38.8%</td>
</tr>
<tr>
<td>Lifesaving in ICU</td>
<td>22%</td>
</tr>
<tr>
<td>Abuse</td>
<td>11.5%</td>
</tr>
<tr>
<td>Fire/natural catastrophes</td>
<td>4.5%</td>
</tr>
</tbody>
</table>

*Source: lindgruen-gmbh.com for World Sepsis Day*

In conjunction with Greifswald University Hospital, Dräger has now developed a piece of software for identifying cases of sepsis. SmartSonar Sepsis stores a patient’s data as it accumulates and then compares it with the threshold values for sepsis. If they are exceeded, the program notifies the clinical staff.”
Sepsis-related deaths are especially high in developing countries

**Good intensive care medicine saves lives**

*Source: lindgruen-gmbh.com for World Sepsis Day*

> doctor still decides on whether there is an infection and whether to start antibiotic therapy. The program identifies and reports critical developments to enable us to react quickly,” says Gründling. The plan is for Gründling and his colleagues to conduct a clinical study with SmartSonar Sepsis in 2015. The study is also set to be conducted and randomized in Hamburg, Kiel, and Dresden. There are still discussions about the primary and secondary end points. “What we know at present is that early identification of sepsis should lead to earlier use of antibiotics and thus a lower mortality rate. It is also conceivable that earlier use of antibiotics reduces the long-term effects of sepsis,” says Gründling.

Patients who have survived severe sepsis often suffer physical, cognitive, and psychiatric aftereffects. In contrast to other patients, the risk of them dying within the next five years is twice as high. Many also suffer from post-traumatic stress disorder, because the dramatic hours spent in the ICU have penetrated deep into their minds (see also p. 8 ff.) Their memories are sometimes unable to account for weeks and months. In many hospitals they have even started keeping diaries so that those affected can later comprehend what has happened to them during this time. The recently published World Sepsis Declaration has one primary aim: to reduce sepsis and the number of sepsis-related deaths. A great deal can be achieved through education, prevention, and determined intervention.

**Dr. Hildegard Kaulen**

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**Sepsis is an emergency**

**Early use of the right antibiotics saves lives**

*Source: lindgruen-gmbh.com for World Sepsis Day*

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**Developing countries**

More than 1,120 sepsis-related deaths per 100,000 people

**Emerging countries**

More than 540 sepsis-related deaths per 100,000 people

**Industrialized countries**

More than 13 sepsis-related deaths per 100,000 people
What can SmartSonar Sepsis do?

The software helps the doctor to identify a case of SIRS and the escalation stages of sepsis as early and as accurately as possible. It assesses and classifies up to 30 vital parameters, all the data collected over the previous 24 hours, and the most essential information needed to make a diagnosis. It uses all of this to ascertain a sepsis severity level, to which a color-coded symbol is assigned. SmartSonar Sepsis currently receives the data via the ICM patient data management system (PDMS) from Dräger. There are also plans to set up an interface to the Dräger Innovian Solution Suite. An overview page lists all the patients being monitored. The detailed page shows current values and those on which decisions can be based, a 24-hour trend, and any potential organ failure. The logbook provides information on how a therapy-related decision has been made. All clinical decisions are stored in the system and can be viewed for up to seven days. A chronologically ordered table shows changes in the sepsis status and specifies what has led to the change in status.

SIRS
A systemic reaction to a non-specific impairment with at least two of the following symptoms:

- Temperature $> 38^\circ C$ or $< 36^\circ C$
- Heart rate $> 90/min$
- Breathing rate $> 20/min$ or $\text{PaCO}_2 < 33 \text{ mmHg}$
- Leucocytes $> 12,000/\text{mm}^3$ or $< 4,000/\text{mm}^3$ or $> 10\%$ immature neutrophilic granulocytes

Sepsis
SIRS with suspected or proven infection

Severe sepsis
Sepsis with $\geq 1$ organ dysfunction

- Cardiovascular (refractory hypotension)
- Renal
- Respiratory
- Hepatic
- Hematologic
- CNS
- Metabolic acidosis with no discernible cause

Mortality within 28 days

Sepsis is a common, but often overlooked illness

Source: lindgren-gmbh.com for World Sepsis Day

<table>
<thead>
<tr>
<th>Disease</th>
<th>Frequency per 100,000 inhabitants of the USA</th>
<th>Cost of government-funded research in millions of US dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sepsis</td>
<td>377</td>
<td>$91</td>
</tr>
<tr>
<td>Stroke</td>
<td>223</td>
<td>$317</td>
</tr>
<tr>
<td>Cancer</td>
<td>331.8</td>
<td>$2,277</td>
</tr>
<tr>
<td>Heart attack</td>
<td>208</td>
<td>$1,236</td>
</tr>
<tr>
<td>HIV</td>
<td>22.8</td>
<td>$2,900</td>
</tr>
</tbody>
</table>

Source: Sepsis guidelines of the German Sepsis Society
BIG DATA

Measuring the World
What if the speeds of modern means of transport doubled every two years? 200 km/h today, 400 km/h in two years, and 800 km/h in four years. Soon everybody would be neighbors. We could meet anyone – anytime and anywhere. This kind of acceleration is already reality with computers: processors are getting ever more powerful and memories are getting ever larger, allowing data to be analyzed, sorted, and relocated ever more quickly. The effect is similar: data is becoming more condensed.

Experts have high hopes for big data. Hidden among the masses of data are new insights into science – and new opportunities for business. High hopes are also being pinned on big data in the area of medicine. How do diseases spread? How can they be identified early and successfully treated? Big data is said to hold the answers to these and other questions.

The word “big” reveals what it’s all about here: size. It’s also about amassing mountains of data in order to distill valuable information from it using clever calculation methods. Quality from quantity. The technology analysts from the consulting firm Gartner define big data as “high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making”. Gartner also talks of the “three Vs”: volume, velocity, and variety. Just a few years ago a terabyte (one trillion or 1,000,000,000,000 bytes) was considered a large amount of data. These days most hard drives hold this much. In 2012 mankind produced 2.8 zettabytes of new data every day (see graphic on page 42). Cell phones, cameras, RFID labels, credit cards, sensors, servers – they all contribute to the swelling data deluge.

The subject of data and performing calculations with it may sound somewhat dry, but one of the first ever big data projects, Google Flu Trends, reveals just how fascinating the findings can be. In 2009 the Internet corporation Google announced this project in the world-renowned science magazine Nature. The idea is to forecast impending flu epidemics using Google search engine requests. It is as simple as it is ingenious. If an increasing number of people in a certain area start entering “fever”, “leg compress”, “24-hour pharmacy”, or other flu-related search terms, then there must be something in the air.

“With big data sets we can do things that were previously not possible”

It was not only the media that lauded the project. The US Centers for Disease Control and Prevention (CDC) expressed delight at being able to track the spread of influenza without having to examine one single patient – in real time and extremely cheaply. The Google developers didn’t even have to get deeply involved in the subject. They simply left all the work to the algorithms. It seemed as if they had conjured knowledge out of nothing, although this naturally isn’t quite the case: no corporation possesses...
Big data is no more magic than the act of alchemy, which was once said to have turned worthless metal into gold – but big data can tap into rich veins of gold.

> bigger amounts of data than Google. Yet Google Flu Trends was merely demonstrating a much broader principle. Even the physician and Google pioneer Larry Brilliant was rhapsodizing: “I envisage somebody going online and being warned about a cholera outbreak in his street.” The wealth of data can not only be used to forecast waves of infection, but also financial crises and famines. “With big data sets we can do things that were previously not possible,” says Kenneth Cukler, big data expert at the British magazine *The Economist*. “The only way of mastering global challenges – feeding people and supplying them with energy and medicine – is by using data effectively.

The birth of Google Flu Trends can also be considered the beginning of big data. Data mining techniques were already being used a few years previously, but it wasn’t until 2009 that the subject went “big” and was surrounded by real hype. A widely acclaimed article in the digital culture magazine *Wired* already saw “the end of theory” coming. The authors prophesized that scientific theories and statistical models could one day be superfluous. “With enough data the figures speak for themselves.”

Sure enough, scientists did achieve breakthroughs that otherwise wouldn’t have been possible – or at least not as quickly. Decoding the human genome once took an entire decade due to the complex calculations involved. With today’s automated sequencing it could be done in less than a day. Another triumph is the discovery of the Higgs boson at CERN, the European Organization for Nuclear Research. The Large Hadron Collider produces 15 petabytes (15,000,000,000,000,000 bytes) of data, which is roughly equivalent to 15,000 years of digital music. Researchers had to filter out the weak signal of the Higgs boson from this immense mass.

A significant element of particle physics these days involves poring over large amounts of data. Yet does this development really spell the end of theory? Physicists would dispute that. They still need their theory in order to know what they are searching for among the mountains of data. It is generally accepted that the first wave of euphoria surrounding big data went too far.

**Computers identify suspicious disease**

The limitations of big data are now becoming visible – but so are the opportunities. It is simply not the case that the figures speak for themselves. The deceptive appearance of objectivity is a risk. Algorithms are fallible; they cannot accomplish the step from data to knowledge on their own. The developers of Google Flu Trends also had to learn this. The political scientist David Lazer compared the prognoses with reality and discovered that Flu Trends was frequently wrong. The system kept triggering false alarms. The media, who had initially lauded Flu Trends, were now pouring scorn on it. “Google Flu Trends gets its wrong three years in a row,”
wrote the otherwise technology-friendly magazine *New Scientist*. Lazer in no way only discovered bad things about Flu Trends. He showed that the developers had made a few momentous – albeit avoidable – mistakes. When you look at the system in a wider context, it remains very useful. If, for instance, you compare the Flu Trends prognoses with the classically collected findings of the CDC, you get forecasts that are much more reliable than Flu Trends and CDC individually.

In other words, big data can be an important complement to conventional methods. Meanwhile, developers, scientists, and physicians are unlocking the real potential, allowing researchers at the University of Toronto to save the lives of premature babies by recording their vital functions and using big data methodology to analyze suspicious patterns. The algorithms warn of impending infections with greater accuracy. This only works because computers have extracted these suspicious patterns from huge amounts of data – they wouldn’t have been visible to the naked eye.

At the New York Genome Center oncologists are also attempting to save lives by testing big data as a weapon against cancer. The idea is to tailor the therapy to each individual case. The doctors take a tissue sample of the tumor and sequence the genetic material in order to identify cancer cell mutations. They then focus the medication on these mutations. The real art is distinguishing the harmless mutations from those which induce tumor growth. A mainframe should help to do this. The physicians feed it with genetic data and the computer compares it against a huge database in which several million professional medical articles are stored and develops a therapy proposal. As such, the mainframe plays a key role in the treatment process without making people superfluous. Doctors still have to evaluate the proposed therapies and the researchers still have to write the articles which the computer trawls through. Furthermore, its proposals can only be as good as the data that is fed into it. Big data is no more magic than the act of alchemy once being able to turn worthless metal into gold. Yet big data can open up rich veins of gold which were inaccessible using earlier methods.

**Statistician correctly predicts election results in all US states**

According to *The Economist*, the data analysis market is growing at a rate of ten percent a year – twice as fast as the software industry as a whole. Big data is also booming in the health care sector. The leading mind behind Google Flu Trends, Matt Mohebbi, has now left the company and founded his own start-up. The business idea is to use big data methods for guidance when deciding on the medication a patient should be prescribed. Note the key word: guidance.

Big data has also gained a foothold in areas not usually associated with computers and algorithms, such as the world of politics: during the successful election campaign for his second term as American president in 2012, Barack Obama relied heavily on big data. A team made up of one hundred analysts, equipped with tremendous computing power, evaluated polls, press reports, and social media. The statistician Nate Silver even correctly predicted the election results in all 50 US states using clever algorithms, beating all pollsters who tried to do the same with traditional tools.

**The tools of the data miner**

Trawling through large amounts of data for valuable nuggets is a special technical challenge. The first thing you need is ample data storage – but capacity isn’t everything. It is first and foremost about speed. It must be possible to access the data quickly. Ordinary hard drives with normal data connections are generally too slow. Solid-state drives and direct attached storage systems that can react at lightning speed are often used for big data applications. The calculations are frequently performed in massively parallel processing (MPP) databases, which can carry out many different calculation processes at once. In order to save time in this manner, the calculations have to be subdivided into several parts which can run alongside each other – this is often only possible with plenty of resourcefulness on the part of the programmer. The algorithms that are run may be very simple search methods or sophisticated calculation tools – such as statistical analyses or genetic algorithms which continually improve themselves in a selection process. Some IT firms now supply ready-made hardware and software solutions for big data.
The key is to distill relevant forecasts from tremendous amounts of data

> Two years later, during the US Congress elections in November 2014, big data had already become part of the standard arsenal of many candidates. A whole range of companies offer big data services for professional politicians. FiscalNote, for instance, founded in 2013 in Silicon Valley, California, forecasts the results of ballots in the state legislatures and in the US Congress in Washington on the basis of election results, polls, and election campaign budgets. The algorithms already have an accuracy level of 95 percent, which is set to rise to 99 percent in the coming years. The New York-based start-up Estimize is pursuing a similar aim in the economic sector. It is attempting to use elaborate algorithms to forecast the future earnings of companies based on previous financial data.

All of this is still predominantly an American phenomenon. Yet German firms are also beginning to look into the possibilities. There is an attempt, for instance, to change over to big data methods to monitor long-distance trains. The idea is to use networked sensors to monitor the condition of doors, air-conditioning systems, and drive systems, plus use algorithms to analyze the data and to identify damage at an early stage. Universities are also reacting: Bauhaus University in Weimar has created the first German chair in big data analytics. One area of focus for the research involves improving the performance of search engines with new data analysis methods.

With the hunger for data grows the tendency to abuse it

In the face of these successes, the limitations should not be forgotten. At the heart of big data is the ability to use pure computing power to distill forecasts from large amounts of data which are unmanageable with the human eye. How substantiated and reliable can these forecasts be? Since the way in which they are produced is so opaque, in many cases it is difficult to assess. A highly contentious case is that of climate research with its models of the earth’s atmosphere based on huge amounts of data and considerable computing power. Far-reaching
political decisions are predicated on their forecasts. Even climate researchers do not always agree on the margin of error. Due to the very fact that the human mind is unable to comprehend big data analyses, they do not necessarily have the same powers of persuasion as scientific arguments.

And then there is the objection that no success as big as this can refute: with the hunger for data grows the tendency to abuse it. A health insurance company, for instance, which gains access to the credit card transactions of those it insures and then slaps on a risk premium for being overweight if they have ordered oversize clothes, is crossing the line into snooping. The privacy of users must remain protected for the very reason that this data holds so much potential.

The largest big data organization in the world is America’s National Security Agency, the NSA. According to the news magazine Der Spiegel, the data center commissioned in Bluffdale, Utah, in 2013 alone is purported to have storage capacity of one yottabyte – one trillion terabytes! From this huge amount of data, primarily fished from global communication networks, they are trying to forecast subversive activities. Algorithms can soon label people potential terrorists. Nothing demonstrates more clearly that, despite the significant potential, big data can never be the whole truth. If you want to generate knowledge from data, then the human perspective must always play a part.

“The more data, the more personal”

PROF. CHRISTIAN HESSE is a lecturer in mathematical statistics at the University of Stuttgart. He is one of Germany’s leading experts on big data.

Professor Hesse, there is currently a great deal of discussion about the potential of big data. Where do the limits lie?

Christian Hesse: For big data, the natural line is drawn when it reaches the personal rights of individuals. It is now possible to sequence and evaluate the genomes of patients in a cost-effective manner. If a health insurance company used this data to slap a risk premium on an insured person with a disposition to a hereditary disease, then it would be crossing this line.

That is the ethical side. What about from a technical perspective? Don’t we still need a doctor who can cater to the needs of each individual patient?

Yes, we do – at the very least to conduct specific examinations. But big data in the medical world is about individually tailoring therapy to a patient’s needs. The more data, the more personal.

How does it work?

You take all the available data on a patient: measured values, medication, genetic data – this could amount to several thousand data points – and compare it with the data of millions of other patients. The computer finds similar cases using the “nearest neighbor” method. It can see which therapies have been successful and support the doctor with proposals.

Why is that better than the conventional approach?

It’s usually like this: a doctor learns which symptoms indicate which diseases. On top of that is his practical experience. That is a comparatively small radius. Big data methods are based on a much broader foundation.

Can big data therefore make medical diagnoses superfluous to requirements?

No, but they can provide considerable support. What big data does make superfluous to requirements is the previous approach with all its complexity and susceptibility to error. Every year in Germany 300,000 hospital stays and several thousand deaths are caused by erroneous medication dosages. Big data methods can help to prevent at least some of them.
This fully furnished dental practice dates back to the first third of the 20th century.
The Lifeblood of the Museum

A new special exhibition shines a spotlight on the history and future of MEDICAL TECHNOLOGY. Until summer 2015, visitors can explore a fascinating kaleidoscope of technical, scientific, and social developments – with more than 700 exhibits.

The melody of life with its pounding beat can be heard at the entrance to the exhibition at the Technoseum in Mannheim. “Lifeblood” is the name of this journey through medical technology on an area covering 900 m² – from the beginnings in the anatomical theater and the Enlightenment to visions of robots in medicine. The projection of a magnetic resonance tomography scan of a pumping heart sets the rhythm at the very start, accompanied by regular heartbeats. In front of the installation stands a transparent torso whose heart is connected to a modern support system. This exhibit represents the interface between medical technology and the organ which – depending on perspective – is considered the center of the soul or a high-performance blood pump.

Until June 7, 2015, “Lifeblood – the History and Future of Medical Technology” follows two narrative threads: on the one hand, it’s about how medical technology informs our view of the human body and expands the possibilities of diagnosis and therapy.

On the other hand, it raises the question of how this technology will progress. Both aspects provide a holistic view of ideas and stories of innovation which not only include many life-saving developments, but also atrocities such as the human experiments performed during the Nazi era. Before treatment comes the understanding of what happens in the body with a disease: innovations on the basis of scientific insights have been presenting new ways of looking at and inside the body since the 19th.
Thus, the X-ray (whose yet to be interpreted picture the author Thomas Mann accurately perceived as the “inner portrait”), stethoscope, blood pressure monitor, and clinical thermometer established new diagnostic possibilities on the basis of precisely quantifiable and therefore comparable health data. The art of healing harnessed scientific methods and instruments. Measuring the body was also among the basic principles of new treatment methods right up until operative procedures under anesthetic. And it paved the way for the laboratory techniques on which around two thirds of all diagnoses are made today.

Blue Henry behind glass

Many pioneering achievements have since become standard in the medical profession. “Self-monitoring of blood sugar or blood pressure, for instance, is something that goes without saying these days, but it would have been inconceivable 100 years ago,” says Dr. Alexander Sigelen. The historian and his team curated the exhibition in two and a half years. They not only wanted to provide an insight into the engine rooms of doctor’s surgeries, hospitals, laboratories, and pharmacies, but also establish links to the various worlds in which people have lived through the ages. Thus, among the exhibits are a porcelain toilet flush handle and the “Blue Henry”, a widely used pocket sputum flask for tuberculosis patients, as symbols of the hygiene movement.

The exhibition impressively showcases the development of anesthetics as.
a technology-oriented science over the last century. Two exhibits on loan from Dräger and positioned next to one another span the hundred-year period from the early era of anesthetics to the current state of this technology. The Roth-Dräger mixed anesthesia apparatus dates back to the beginning of the 20th century. Directly next to it, a Dräger Perseus A500 represents state-of-the-art technology in the area of anesthetics.

**Polio: scourge of humanity**

Besides these loan items, technology also features in other areas of the exhibition – such as when it comes to safely managing gases in the medical field. This applies to the complete operating room from the 1950s with anesthetic and ventilation technology as much as it does to the legendary “iron lung” used for ventilating polio patients. The now almost forgotten machines used to be the only hope for many sick people during the polio epidemic. That’s because until a vaccine was invented (by US immunologist Jonas Salk in 1954), polio was one of the worst scourges of humanity. The Mannheim exhibition is showcasing more than 900 exhibits in total, many of them from the Technoseum’s collection built up over the last 25 years and now consisting of around 3,000 items. In esthetic terms, the presentation of equipment is a common theme throughout the exhibition. This is also stressed by Ruudi Beier, the designer of the show: “It is important to us to not only display the exhibits in the context of their impact, but also clearly showcase them as technical devices.”

Peter Thomas

The 450-page catalog accompanying the exhibition is available in the museum for 24.95 euros and in bookstores for 29.95 euros.
Setting up a tube in a glass flask is precision work.

There is something in the air.
The DRÄGER ANALYSIS SERVICE identifies a wide range of substances and their concentrations – in operating rooms, industrial plants, and offices.
How on earth is it possible to fit this “sponge” of around 1,000 square meters in a narrow glass tube? “In principle, it is very easy,” says Dirk Rahn-Marx. “It only takes a gram of activated charcoal!” However, this isn’t just any old activated charcoal; it has been extracted from coconut shells – with an especially large surface. Dräger’s analysis service, led by the chemical engineer, captures volatile and invisible substances from the air in order to identify and quantify them. The floating materials settle in the pores of the activated charcoal and accumulate. This makes it possible to identify substances whose concentration is measured in parts per billion (ppb). This is roughly equivalent to trying to find five people among the earth’s entire population.

Like ECG curves

In the mid-1980s the analysis service was only available to the in-house development division. These days, hospitals have the concentration of aesthetic gases in their operating rooms analyzed. Uta Speth, an employee from the very start, still remembers how complex such (largely manual) analyses and their evaluation were at the time: “The results were stored on long, perforated strips of paper, rolled up, and secured with rubber bands!” Nowadays gas chromatographs and mass spectrometers are used, which are capable of separating the individual particles from the air sample and displaying them in graph form within an hour – similar to an electrocardiogram (ECG). Every peak is a detected substance and the amplitude represents the extent of its concentration in the sample.

“We primarily distinguish between measurements in the workplace, in the office, and outdoors,” says Dirk Rahn-Marx, “but we also analyze the purity of compressed air in production environments.” There was one case where an office had been renovated and half of the employees suffered from headaches after moving back in. Was there perhaps a hazardous substance in the air? Maybe a chemical factory wishes to go further than the legal regulations specify by checking what remains in the air from their production operation beyond the factory fence. And then there are people who are convinced that their neighbors are trying to poison them with “some kind of vapors”. The Dräger analysis service, accredited in accordance with ISO 17025, can help in these and other cases.

“First of all, however, we get a very precise picture of the situation,” says Rahn-Marx explaining a typical procedure. This information – which, in the area of corporate business, almost always comes from experts – zeroes in on the task and the substance(s) being looked for. There is a difference between looking for and proving the presence of formaldehyde, benzene, or terpenes in the wooden floor of a newly renovated office. Once this task is completed the Dräger experts set up their instruments – and the customer knows which tubes or measurement sets are the right ones for their particular situation. The collection tubes are often filled with activated charcoal or other chemico-physical “sponges”. Methanol, for instance, or the source materials (isocyanates) used in plastic production cannot be trapped in this way. Other porous materials, such as silica gel, or materials which have been impregnated with a chemical substance are needed for this purpose so that the material being measured reacts to form stable bonds during sampling (chemisorption).

In most cases the customer takes the sample using one of two methods: short- or long-term measurement. The short-term >
It is sometimes like trying to find five people among the earth’s entire population”

method is primarily used in workplaces with concentrations in the ppm (parts per million) range. To this end, the glass tube, which is melted together at both ends, is opened with a special tool that works in a similar way to a pencil sharpener. To take the sample, the tube is then inserted in an automatic pump (e.g. the Dräger X-act 5000) which allows a set amount of air to pass through. The concentration of the hazardous substance couldn’t be calculated in any other way later on.

Some people cannot believe it

For long-term measurements there are special diffusion collection tubes which are sealed at both ends with cellulose acetate. “The hazardous substances from the ambient air pass through these filters and diffuse on the activated charcoal – paint fumes for instance,” explains Rahn-Marx. “We can then establish the concentration throughout the duration of the measurement.” The ORSA diffusion collection tubes are secured in the room or perhaps attached to a jacket collar by means of a clip. “Once the sample has been taken properly, the customer sends it to Lübeck where it is given an individual number and stored at around six degrees Celsius so that it stays fresh and the contents and concentration remain virtually unchanged.” The next stage involves analyzing the samples. To do this, the collected substances are washed out of the activated charcoal and a set amount of this liquid is poured into a small glass container, with which the analysis devices are loaded. Gas chromatography with a mass spectrometer, thermodesorption, liquid chromatography, and infrared spectrometry are some of the processes employed to screen the samples for every possible kind of molecule using every trick in the book.

“This often results in long lists of substances and their concentrations,” says Dirk Rahn-Marx while showing the results of a chromatogram. However, these are just interim results. “Assisted by a huge database, we now have to identify all the signals and check the plausibility of the results.” Once the hazardous substances have been identified and their concentrations established, the results are then documented. In turn, the customer can rely on the results, even when they are somewhat surprised by them – such as the time when the analysis service identified oil in a compressed air sample. The compressor was definitely running without lubrication, only production at the customer’s factory had been halted due to this measurement. “They didn’t want to believe the results and had the test repeated – with the same outcome,” recalls Rahn-Marx. Two experts from the company even came to Dräger in the end to audit the analysis service. Yet everything there was as it should have been. “At that,” says Rahn-Marx, “we looked more closely at the process of taking the sample at the customer’s premises. It turns out that the sample had actually been fed through a new plastic tube which was still outgassing traces of oil-like fumes. And that is exactly what we found!” When the compressed air was then taken and measured directly from the valve, everything was as it should have been.

This provides an insight into how important it is to keep a constant eye on the entire process chain when taking high-precision measurements, starting with the manufacturing of the collection tubes. In addition to fully automated production, some are still filled by hand, for instance those with activated charcoal. Even the simple tubes feature collection and control layers separated by retention elements.

Complex works of art

However, there are also complex collection systems which additionally feature an impregnated fiberglass filter (for formaldehyde among other things) or a molecular sieve (for laughing gas among other things). Some of them are like real works of art as a result of their elaborate design. Their production requires extreme concentration and a great deal of experience. “Some colleagues have been doing it for decades,” says Rahn-Marx. After a number of checks, the ends of most of the tubes are melted and sealed closed using a machine with two lots of ten flames. They undergo further quality control before being delivered to ensure that they meet the requirements for recording high-precision measurements. Even if some people are not satisfied with the infallible results, as Dirk Rahn-Marx recalls with a grin: “As yet, we have been unable to prove that someone has wanted to poison their neighbors.”

Photo gallery: How Dräger tubes are produced
www.draeger.com/110/analysis
The rotating tubes are melted by gas flames that increase in size.

The samples are screened using every trick in the book during gas chromatography.

Many different peaks appear in the chromatogram, which are then matched with various substances.

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Dräger Safety AG & Co. KGaA, Lübeck, Germany, manufactures the following products: PSS 5000 (page 5); sampling systems (page 48 ff.); X-act 5000 (page 50); and Interlock 7000. Dräger Medical GmbH, Lübeck, Germany, manufactures the PulmoVista 500 (page 26); SmartSonar Seepsis (page 33 ff.); the Intensive Care Manager (ICM, page 37); and Perseus A500 (page 47). Dräger Medical Systems, Inc. (Telford, USA) manufactures the Infinity Delta Monitors (page 16) and Innovian Solution Suite (page 37).
Ready When You Are

The Interlock 7000* checks how much the driver has had to drink. The ignition can be switched on and the engine started (or not, as the case may be) depending on the blood alcohol limit. The breath alcohol-controlled immobilizer consists of a handset 1 and a control unit 2. As optional extras a GPRS module and a camera are available.

The device is ready to use in seconds even when temperatures are hovering around freezing point. The biodegradable mouthpiece 3 is heated, as is the sensor inside the handset with its color display 4 and user guide (currently available in 23 languages). When the driver blows into the mouthpiece, a bellows channels the breath sample to the sensor ensuring that no saliva or food residue reaches it. The breathed air escapes via the aperture 5. Once a successful measurement has been taken, the colored LEDs 6 display the status at the same time as various audio tones: pass (green), fail (red), or the prompt to repeat the test (blue). The data is conveyed to the control unit via a spiral cable 7 and is stored there in encrypted form. The infrared camera (with biometric face recognition) can be used in all light conditions and makes sure that the breath sample is provided solely from the driver’s seat. Recordings during the journey can identify any potential change of driver and take action if necessary.

The GPRS module allows data communication with a server via a mobile connection. It also features a GPS module for establishing the location during set events, such as a repeat test. In addition, the module can communicate certain abnormalities identified by the device. The Interlock 7000 was developed for preventive use in trucks, buses, and taxis, but also for participants in so-called offender programs with their sometimes highly individual requirements.

*Only used for law enforcement purposes in the United States.