clearly localizes any ventilation defect. Of great value is also the image of the diffusion coefficient since it measures the dimensions of the open structures down to the sub-millimetre scale of the alveolae. Hence, it discriminates between the finely structured healthy lung tissue with a high surface to volume ratio from inefficient blown-up cavities of a diseased lung (Fig. 5). Still, one has to remember that gas MRI has only access to ventilated air spaces. Neither non-ventilated open spaces nor the tissue itself contribute to the signal. Diseased tissue that may spread over the lung like cancer or fibrosis must still be diagnosed by other radiological means such as computer tomography (CT). The EU network PHIL [7] which has gathered European groups interested in ^3He MRI has confined its clinical aims to a systematic survey over about 200 emphysema patients in Denmark (Copenhagen), England (Sheffield) and Germany (Mainz). This large sample will form the base for establishing a reliable and differentiated ^3He MR diagnosis of this, frequently encountered, serious disease. The survey is observing a fixed protocol of ^3He procedures comprising static and fast ventilation scans, a diffusion scan and in some cases an oxygen-sensitive scan. It is accompanied by complementary traditional diagnostic means on the same sample for comparison.

Conclusion and outlook

The physics of manipulating spins via OP and NMR seems to remain forever fresh due to a high rate of methodological innovations opening new fields of application in fundamental and applied science. Polarizing large quantities of noble gases to a high degree was a demand of particle and neutron physics in the case of ^3He and an aim of surface physics in the case of ^{129}Xe. Then the potential of these polarized gases for MRI was discovered, in particular for imaging the air spaces in the lungs. This stimulated a new wave in radiology. Today, we count around 20 groups in the US and Europe who are actively pursuing research in this field. Approval of MR lung tomography for ^3He as a contrast agent is being sought on both continents and will probably soon pass the final Phase III. The further fate of the method, its clinical success, will then not lie predominantly in the hands of scientists anymore. However, they will have to assist industry and clinicians in the coming phase with extensive R&D in order to optimize the methods and to realise the ultimate potential of the technique. The need for improved diagnostic tools is obviously there: Lung diseases are about number four in killing people and quite often after many years of painful suffering. Early diagnosis could help to prevent this fate.

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Czochralski's contribution: 50 years on

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This article commemorates Jan Czochralski's contribution fifty years after he passed away and was buried in his home town, Kcynia, roughly mid-way between Warsaw (Poland) and Berlin (Germany).

The seminal work published by Czochralski in *Zeitschrift für physikalische Chemie*, received for publication on August of 19th, 1916, but published two years later [1], was an example, rarely met in our days of conciseness and concreteness in presenting research results. On three pages the author reports on his new finding: that a method of pulling metallic monocrystals had been discovered, and had been applied for testing three metals of interest: *Sn*, *Pb*, and *Zn*. This earned him much praise, and in consequence, he is still recognized as one of the fathers of todays semiconductor technology [2] although his method was thoroughly elaborated only for the above metals. It should be noted that Jan Czochralski invented his method during his stay and work in Berlin for the AEG (Allgemeine Elektrizitäts-Gesellschaft) company (Fig. 1) using the AEG lab facilities. He also benefitted from collaboration with a German physicist W. v. Mollendorff [3] and developed much of his knowledge on the crystallography of metals during this time.

In order to augment his activity in metal science and technology he moved from Berlin to Frankfurt on Main, where he worked intensively on metallurgical methods to obtain new alloys, as well as on metal based composites, leading to the production of bearings (metal *B*) [2], and on *Al*-based wires and contacts in electrotechnics. He also became interested in the durability of materials. However, with his German coworkers, his main focus was on the principles of the metallurgical processes, such as: the role of defects, additives, and specifically of dislocations, in efficiently yielding pure metals and alloys; stress-strain aspects; characteristics of recrystallisation; phase equilibria and transitions associated with their appearances, etc. It is also to be noted that during his time in Frankfurt he proposed in one of his papers "Radiotechnics in Service of Metal Science" in 1925 [4] a kind of radiomicroscope, serving to detect non-metallic inclusions in the outer layer (surface) of a metallic sample. This can in some way be

▲ **Fig. 1:** Young Jan Czochralski (beginner), first from left, in an AEG lab in Berlin 1907 (courtesy of Z. Czochralska).

anticipated as a possible prototype of the scanning microscope, with the AFM (atomic force microscopy) included. In the year 1929 he accepted the invitation of the Polish State President, Ignacy Mościcki, himself quite a recognised chemist, and moved to Warsaw, where a Warsaw University of Technology professorship in chemistry had been offered to him. Since it was likely that Czochralski had no matriculation, this was only formally possible after the university presented to him the prestigious title of *doctor honoris causa*. In Warsaw he also became interested in X-ray methods in service of metal structure research, though it is not clear whether he had any Röntgen device at his disposal while working in Warsaw [2].

▲ Fig. 2: The mature Jan Czochralski (professor), second from left, in a Warsaw University of Technology lab in the nineteen thirties (courtesy of Z. Czochralska); Polish State President, I. Mościcki – first from right.

It is interesting to note that his research activity peaked in the years 1936 and 1937 (15 papers in 1936 is the best 'quantitative' result), and thereafter decreased slowly toward the years 1939 and 1940 when probably his last paper on research results on *Al* in Poland appeared [2]. (The total number of his papers is estimated to number about one hundred [2].)

In the beginning of the fifties, shortly before he died, Jan Czochralski moved to Kcynia and until the end of his life he devoted his activity in two main directions: he conducted, as dr. Wojciechowski (the "commercial" surname taken unofficially from one of his daughters, Leonia, after she married), his small chemical enterprise *Bion*, that was in fact a pharmacy and drugstore; and he tried to work out a Polish version of his *Moderne Metallkunde in Theorie und Praxis* (English: Modern Metal Science in Theory and Practice), published in 1924 by the Julius Springer Publishing Company in Berlin, see [2] for details. (There appeared even in 1950 a first draft of that translation, with some extensions and changes, but it disappeared, most probably because of too strong invigilation of Czochralski by the Polish secret police under unknown circumstances.)

The main reason for such a division of his mostly scientific activity and also for a certain slowing down was the following: the Warsaw University of Technology's highest council (*Senat*) suspended him in December 1945 from his professorial duties, strongly referring to certain unproven suspicions that Czochralski had operated against Polish interests from the beginning of World War II [2]. That biased decision was not changed after the war ended and lasted until his death. Although many of us over many years have been taught the way that the semiconductor monocrystals are pulled from the melt by using Czochralski's or, as abbreviated, the *CZ* method, and at the same time being aware that the method has been readapted and technically expanded by other authors to be the method suitable for semiconductors, we are still surprised to learn from Scheel [5] that recently obtained semiconductor crystals are pulled by another method due to Teal and Little [6]. For an explanation of why Teal and Little's method can be termed an adaptation of *CZ* method, see [7].

There is no doubt that Jan Czochralski was a personality, satisfying criteria of open-mindedness quite far exceeding his specialised activities. Two examples support this viewpoint. There exists a paper witnessing his activity as a geochemist [8]. While a chemistry professor in Warsaw he was kindly asked by the local authorities of Kcynia to resolve a "burning" problem: Are there any underground resources of natural oil in Kcynia, and in its surroundings (Pałuki region), or is there something else behind it? His answer after investigation was: There are no underground oil resources there, and the fluid that wets the nearby grounds comes from long-existing storage places for fuel, tar, lubricants and other, mostly liquid, materials, where the barrels containing them, neither tight nor free of corrosion, have systematically polluted all the surroundings by creating over many years sewage areas of high pollution. There is also information that points to Czochralski's wide-ranging activity in the field of ecology. Firstly, because in a renowned *McGraw-Hill* dictionary there appeared a notion that the Czochralski process was roughly equivalent to the term '*antropopression*', well known in ecology [9]. But until now, it has not been proved in a satisfactory way that he coined that term.

Czochralski died in 1953 at the age of 68, up until the end of his life being constantly watched by the Polish secret police, following some denunciations by a few people, unfortunately those coming also from the circle of his university colleagues. Fortunately, none of which have ever been proved [2].

To sum up: Jan Czochralski contributed quite substantially to many aspects of, what we now call, applied physics and chemical technology as well as of materials science. For example, his theory of recrystallization, though being particularly (and first) proposed for *Sn* [10], deserves recognition. He also contributed much to interdisciplinary research. It is worth noting that formally since the year 1986 [2], a systematic revival of Czochralski's reputation can be observed, at least in Poland. After the political changes in Poland had come about (around 1990), one may observe a visible revalidation of Czochralski's work and a better reception of his well-spread life style, mostly that during World War II, when he had to decide on how to live between Polish and German, historically different, standpoints, and under the critical conditions of the War.

For further reading see: www.unipress.waw.pl/emrs/ and http://www.ptwk.org.pl/ where some recent events organised in Poland have been chosen.

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Most readers enjoy having a better understanding of physical phenomena in everyday life, and being able to explain them to the layman. This has some extra relevance in view of the upcoming World Year of Physics 2005. This "Physics in daily life…" column is aimed at doing just that. Since it will span a wide variety of phenomena, most of which are outside the research expertise of the author, he welcomes comments, additions or corrections, especially from readers who happen to be more familiar with the topic. email: Hermans@Physics.LeidenUniv.nl

Physics in daily life: Moving around efficiently

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Ever considered the efficiency of a human being moving from A to B? Not by using our car or a plane, but just our muscles. Not burning oil, but food.

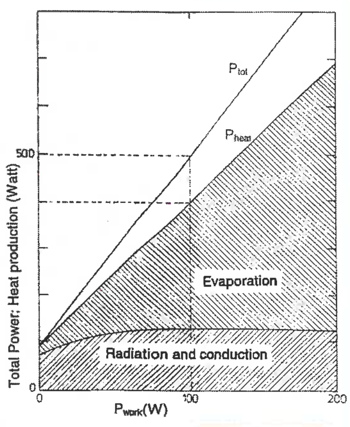
Many physicists will shout immediately: a bike! Use a bicycle! It is because we all know from experience that using wheels gets us around roughly 5 times as fast with the same effort as going by foot. But just how efficient is a bike ride? First, we have to examine the human engine. The power we produce is easily estimated from climbing stairs. If we want to do that on a more or less continuous basis, one step per second is a reasonable guess. Assuming a step height of 15 cm and a mass of 70 kg, this yields a power of roughly 100 W. Mountain climbers will find the assumed vertical speed quite realistic, since it takes us about 500 m high in an hour, and that is pretty tough.

Riding our bike is pretty much like climbing the stairs: same muscles, same pace. In other words: we propel our bike with about 100 W of power. But that is not the whole story. The efficiency of our muscles comes into play. With this type of activity, the efficiency is not so bad (a lot better than, e.g., weight lifting). We may reach 25%. The total energy consumption needed for riding is therefore around 400 W.

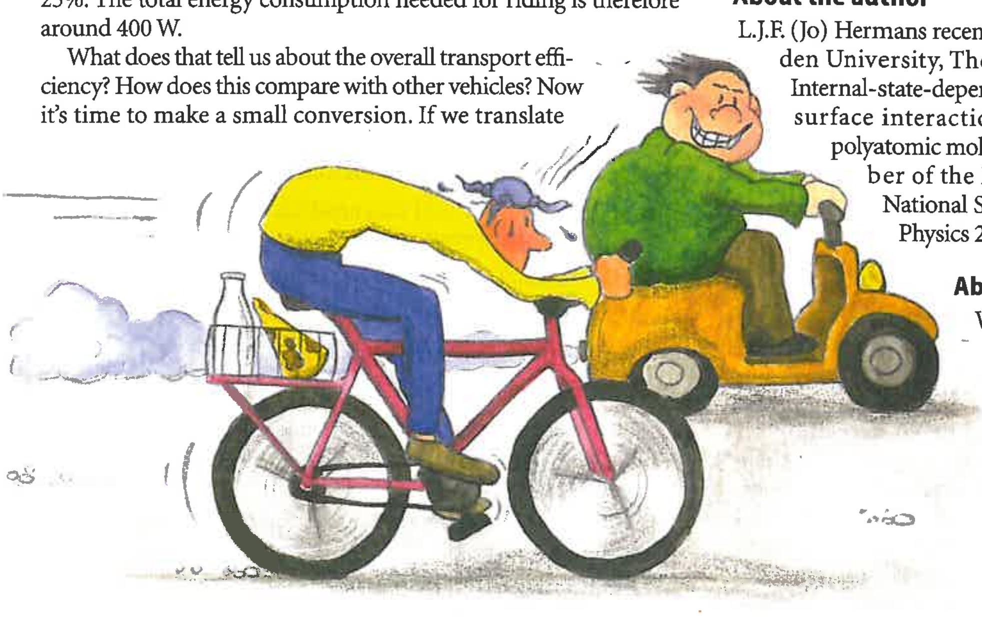
What does that tell us about the overall transport efficiency? How does this compare with other vehicles? Now it's time to make a small conversion. If we translate 400 W continuously in terms of oil consumption per day, we find pretty much exactly one litre per day, given that the heat of combustion of most types of oil and gasoline is about 35 MJ per litre. In other words: if, for the sake of the argument, we ride 24 hours continuously, without getting off our bike, we have used the equivalent of 1 litre of gasoline in keeping moving. How far will that get us? That, of course, depends on the type of bike, the shape of the rider, and other parameters. If we take 20 km/h as a fair estimate, the 24 hours of pedalling will get us as far as 480 km. In other words: a cyclist averages about 500 km per litre.

That's not bad, compared to our car, or even a motorbike. So, we should all ride our bike if we want to conserve energy? Careful, there is a catch here. We have been moving on food, not oil. And it takes a lot more energy to get our food on the table than its energy content may suggest. A glass of milk, for example, takes roughly 0,1 litre of oil, a kg of cheese roughly 1 litre. It's because the cow has to be milked, the milk has to be cooled, transported, heated, bottled, cooled again, transported again, etcetera. Same (or worse) for the cheese. Etcetera.

Conclusion: Riding our bike is fun. It's healthy. It keeps us in shape. And if we have to slim down anyway, it conserves energy. Otherwise—I hate to admit it: a light motorbike, if not ridden too fast, might beat them all.



◄ **Erratum:** This figure, omitted from the first Physics in daily life column, "The human engine: How to keep it cool," [EPN 34/4, page 153] demonstrates schematically that each 100 W of released heat that has to be compensated by evaporation requires a glass of water (0.18 l) per hour.



About the author

L.J.F. (Jo) Hermans recently retired as professor of Physics at Leiden University, The Netherlands. Main research topics: Internal-state-dependence of intermolecular and molecule-surface interactions, and nuclear spin conversion in polyatomic molecules. In the 1990s he served as a member of the EPS council. Presently he chairs the National Steering Committe for the World Year of Physics 2005.

About the illustrator

Wiebke Drenckhan (26) is currently doing her PhD in the "Physics of Foams" in Trinity College Dublin, Ireland. She has studied and worked in Germany, USA, New Zealand and France, being largely supported by the German National Merit Foundation. Additionally to taking a scientific approach to the world, she likes to capture its oddities in cartoons.