Tidsskriftet Tidsskrift for Den norske legeforening

Teaching and telepathy

INVITERT KOMMENTAR

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The author has completed the ICMJE form and declares no conflicts of interest.

Teaching entails the transmission of thoughts from the teacher's head to the students' heads.

'The longest journey starts with a single step.' This is how I begin my lecture to medical students on gene expression regulation. The quote is attributed to the Chinese philosopher Lao Tzu, who lived approximately 2500 years ago (1). The order of letters as well as words in the quote is essential for it to make sense.

We know which molecules and letters our DNA is written with, but it is only when the letters are placed in the correct sequence as words, and only when the words are placed in the right order in a sentence, that we can understand what is being said and communicate something to someone else. This applies to the understanding of DNA and gene expression regulation, and also to teaching medicine to students.

Students must be able to reproduce knowledge, but reproducing knowledge is only a small part of learning a subject. The elements that are easiest to reproduce do not necessarily represent the essential aspects of the subject. This makes it difficult to learn and to teach to others.

To truly learn a subject, we need to take ownership of the field and make it our own. For that, you need inspiration. This can stem from, for instance, the feeling of sudden understanding, like when you see a connection that you had not previously thought of. It might be the realisation that what you are learning right now could be vitally important in your future career. Once you make the field your own, the learning continues long after the lecture. Therefore, teaching must also provide a foundation for further learning. Finally, the knowledge must be incorporated into a larger picture: where does this lecture fit into the broader context, and what does knowledge about DNA mean for people with an illness?

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Understanding basic sciences is essential for modern clinical medicine and enriches both clinical practice and the clinician's expertise. My field, oncology, is undergoing enormous change thanks to the growing understanding of the molecular mechanisms underlying diseases and treatment choices. When I began teaching medical students in 2017, I had idea of how relevant my own teaching would become for me as a specialist. At that time, I had already invested a lot of time and effort into learning about molecular biology and the data science principles underlying treatment choices – including a PhD on the subject.

In my lectures, I have focused on water chemistry, how genetic information is used to synthesise proteins, how cell growth is coordinated and controlled through the cell cycle, and how DNA is copied from the parent cell to the two daughter cells without introducing errors into the genetic material. Despite this being basic knowledge within the field, its application to clinical practice is not immediately obvious. But then it became clear. In 2020, I was invited to help develop Norway's largest clinical trial within cancer to date, IMPRESS-Norway (2). This experience has been enriching in many ways, including the opportunity to contribute to national interdisciplinary meetings on genetic diagnostics, which guide the selection of experimental cancer treatments for patients with no clear treatment options.

The first patient I included in the study had unfortunately experienced a brain cancer relapse. His form of cancer was caused by a genetic mutation in the BRAF gene, which means that signal cells divide uncontrollably. This gene provides the instructions for making the BRAF protein, which is one of the proteins that mediates growth signals from the environment to the cell nucleus to initiate the cell cycle. Due to the chemistry of water and the genetic mutation in the BRAF protein, this protein will always be activated and continually send growth signals to the cell nucleus.

Proteins are chains of amino acids, and amino acids are like beads on a string. Each amino acid is numbered from the first bead in the chain to the last. Under normal circumstances, when a growth factor binds its receptor, the healthy BRAF protein is temporarily chemically modified at the amino acids in positions 599 and 602, becoming strongly negatively charged. This

modification turns the protein from off to on. The negative charge at amino acids 599 and 602 changes these 'beads' from being fat-soluble to water-soluble, causing them to interact with the surrounding water molecules. In some cancers, a mutation in the BRAF gene can cause bead number 600 to change from the fat-soluble amino acid valine (V) to the water-soluble amino acid glutamate (E). This has the same effect as the on-off modification, but now the change is permanent because it is encoded in the gene, and all BRAF proteins produced from this mutated gene will always be active. Since the change occurs at position 600, and the amino acid valine (V) is replaced by glutamate (E), this mutation is called BRAF V600E.

> ***«Not only is clinical work enriched by basic sciences; basic sciences are also enriched by clinical relevance»***

For this specific gene mutation, there is now a treatment that is routinely used for melanoma, and fortunately, the treatment was also highly effective for the study patient with brain cancer.

Not only is clinical work enriched by basic sciences; basic sciences are also enriched by clinical relevance. Case histories such as this help generate new understandings of water chemistry and cancer treatment.

The goal of teaching is not exact replication, like when a cell divides without introducing errors into its genetic material; it is to transmit thoughts that inspire new thoughts, in the same way as Lao Tzu continues to communicate with us across time and space.

Many thanks to the medical students at NTNU who nominated me for the Norwegian Medical Association's Award for Teaching Undergraduate Medicine for 2024. It has been an honour.

The patient has consented to publication of this article.

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Publisert: 21 August 2024. Tidsskr Nor Legeforen. DOI: 10.4045/tidsskr.24.0327