In one fell swoop scientific breakthroughs advance our understanding of the world and enhance our ability to make impactful changes. Whether the breakthrough stems from a seemingly simple observation of everyday life or the decade-long development of a new technology, it goes without saying that the fruits of science affect the lives of billions of people worldwide. It is surprising then that these breakthroughs do not always lead to immediate cascades of development and change. On this note Dr. Sabel began his seminar with a story about forest reindeer, which for generations grazed on the Finnish side of a fence that bordered Russia. When the fence was dismantled the reindeer didn’t rush to greener pastures on the other side but oddly continued to respect the boundaries of a now phantom fence. It took several generations and probably a few courageous reindeer before they finally ventured across into Russia. Likewise, scientific breakthroughs often create fruitful landscapes ripe with opportunities but for a variety of reasons go unrealized and underexploited.

Rigid reindeer aside, Dr. Sabel’s seminar mainly dealt with vision loss and the conceptual boundaries preventing its successful treatment. It’s long been accepted that the visual system does not recover very efficiently after injury. This has meant that patients with visual defects caused by damage to the central nervous system, i.e. retina, optic nerve and various brain regions, have little hope of having their vision restored. This no longer seems to be the case as Dr. Sabel has found ways to restore vision in partially-blind patients using relatively conventional techniques and widely accepted ideas. The real advance occurred when he realized that injuries to the visual system rarely lead to complete vision loss. Because some undamaged neurons remain they can be stimulated to improve in function and thus compensate for the permanently damaged neurons. His work has shown that the visual system does indeed have the potential for plasticity and self-repair, and comes as a paradigm shift in the field.

An important aspect of restoring vision requires that the extent of the visual defect be mapped with high resolution. This is done using computerized perimetry whereby a patient stares at a blank screen and indicates whether they can see beacons of light as they are flashed at fixed positions within their visual field. Over time the resulting visual field chart looks like a giant checkerboard; white squares represent regions of intact vision (where respondents saw the flashing light) and black squares represent areas of blindness (where respondents did not see the flashing light). After repeated testing at near-threshold levels, grey areas often emerge, meaning sometimes the patient sees the light and other times does not. These grey squares of so-called areas of residual vision (ARVs) are normally concentrated at the visual field borders and appear as islands within regions that are presumed to be to totally blind.

Dr. Sabel believes that ARVs hold the key to vision restoration since they represent vision from intact residual neurons. His somewhat new idea stems from the old observation that when a neuronal network is repeatedly stimulated, synaptic transmissions are strengthened. In normal neuronal networks this is called long-term potentiation, i.e. learning, but Dr. Sabel imagined this
principle would also hold true for partially damaged networks. His idea is scientifically interesting and also clinically relevant. If correct, residual neurons might be coaxed into working overtime to cover for their damaged counterparts and thus restore the patient’s vision. At a physiological level, surviving neurons must first be activated to above average levels. Because patients tend to focus on their intact visual fields damaged neurons often receive insufficient attention, which further reduces their synaptic strength. The challenge is to restore these “residual structures” by reengaging them through repeated activation and stimulation.

To do this, Dr. Sabel first discussed his work using vision restoration training (VRT). It’s a computer-based therapy where visual stimuli are repeatedly presented to patients within their ARVs. The specifics of the VRT regiment can vary, but patients typically receive training for 1 hour each day for 6 months. Several VRT trials have now shown that repeated training of the ARV leads to border shifts and an overall expansion of the visual field.

Dr. Sabel has also helped pioneer the use of alternating current therapies to in the treatment of vision loss. This non-invasive therapy is based on stimulating the visual system using electrical impulses and is aimed at influencing brain physiology on the network level. Here, electrodes are attached to the patient’s eye orbit and repetitive, transorbital, alternating current stimulation (rtACS) is applied. The idea is to stimulate the underlying residual structures until phosphenes are perceived. (A phosphene is a luminous impression caused by stimulation of the visual system, the most common being pressure phosphenes caused by rubbing the closed eyes) In a double-blind clinical trial, optic nerve patients were treated with rtACS therapy for 20-40 min each day for 10 days. In comparison to the placebo group, the rtACS group showed a ~40% detection improvement. Even more promising is that much of the improvements were stable at a 2-month follow-up. Dr. Sabel thinks that rtACS leads to increased neuronal network synchronization, particularly for “good” alpha-waves. By firing impulses at particular frequencies in the brain, neuronal networks are forced to propagate synchronous firing, which over time causes a learned synchronization response.

One of Dr. Sabel’s patients receiving rtACS treatment is JL who suffers from glaucomatous optic neuropathy. He’s also an experienced filmmaker and decided to chronicle his experience in the documentary film Going Blind. Dr. Sabel kindly showed a 10-minute clip which depicted JL’s day-to-day struggles with vision loss and his joyful sentiments when part of his vision was restored. Before treatment JL was about to change his New York Times subscription from the normal print version to a large print version designed for the visually-impaired. After part of JL’s vision was restored he was proud to say that he still reads the normal print version. Thus, even small improvements in detection ability have very real effects on the patient’s quality of life and mean more than is usually appreciated.

To wrap it up, Dr. Sabel spoke about the future of residual vision activation therapies. They’re encouraging, since vision restoration can apparently be activated at any time following injury, to patients of all ages with a variety of visual field defects. These therapeutic successes continue to dispel the notion that the visual system has no capability for repair and provide hope to patients suffering from vision loss. Though promising, there are some limitations; complete vision restoration is rare and roughly one-third of patients do not currently respond. Therefore, as these therapies are brought into wider use, managing patient expectations and understanding why some are sensitive to treatment will be important. Future research will no doubt address
these issues and hopefully continue to extend our understanding of visual impairments beyond the conceptual borders now in place. In this regard, Dr. Sabel believes we are just at the beginning and the brightest opportunities are still to come.