

A BRIEF HISTORY OF THE STUDY OF DIFFUSION AND OSMOSIS IN THE CONTEXT OF DIALYSIS

Authors: A. Zulkarnaev

Hospital: Moscow Regional Research and Clinical Institute, Russian Federation. Surgical department of transplantation and dialysis

Currently around 3 million people are treated with haemodialysis. Haemodialysis has had a long journey from the first attempts with a membrane from cellulose tubing for sausage manufacture up to the high technology membranes with excellent biocompatibility and apart from that, with high sorptive capacity. But what happened before that? How did the theoretical prerequisites come to be to make this possible?

Haemodialysis is based on diffusion – the movement of molecules across the semi-permeable membrane along the concentration gradient. The first described aspect of diffusion is osmosis – the process of diffusion across the semi-permeable membrane of the solvent towards the more concentrated solution. This phenomenon was first observed by the French abbot Jean-Antoine Nollet in 1748. However, it was the doctor René Joachim Henri Dutrochet who first described it in detail and introduced the term “osmosis” 80 years later. When studying the generation and movement of sap in botanic tissues, he described “endosmosis” – the rapid transfer of solvent water in tissues, and exosmosis - the slower transfer of solute in the opposite direction. During trials, the scientist found the same effects were produced in animal tissues. Dutrochet is also known for the invention of the first osmometer. It is interesting that the scientist initially considered osmosis to be the manifestation of the “vital force”. He tried replacing the biological membrane with a porous clay vessel, expecting this experiment to fail, however he still observed the osmotic movement of liquid. Thus, Dutrochet showed that osmosis is purely a physical phenomenon, and he “forever united physics with physiology”.

Thomas Graham, already famous for his work on gas diffusion (“Graham’s Law”), in the middle of IX century continued and complemented the work of Dutrochet. During his study of diffusion of liquids he introduced the term of colloids (slow diffusing and able to crystallise). Whilst studying the processes of osmosis and diffusion of liquids, Graham experimented with various membranes (glass jars, crockery pipes, sheets of parchment and paper, plaster, perforated metal sheets, graphite, clay and others.) In his applied research he made fundamental findings. He is the author of the systematic studies of liquid diffusion and is also rightly considered the founder of colloid chemistry. The scientist discovered a method of purifying colloid solutions from the soluble low-molecular compounds by the use of a semi-permeable membrane and named this “dialysis”. He wrote “The sized paper has power to act as a filter ... molecules permeate this septum but not masses. The molecules are also moved by the force of diffusion ... It may perhaps be allowed to me to apply the convenient term dialysis to separation by the method of diffusion through a system of gelatinous matter.”

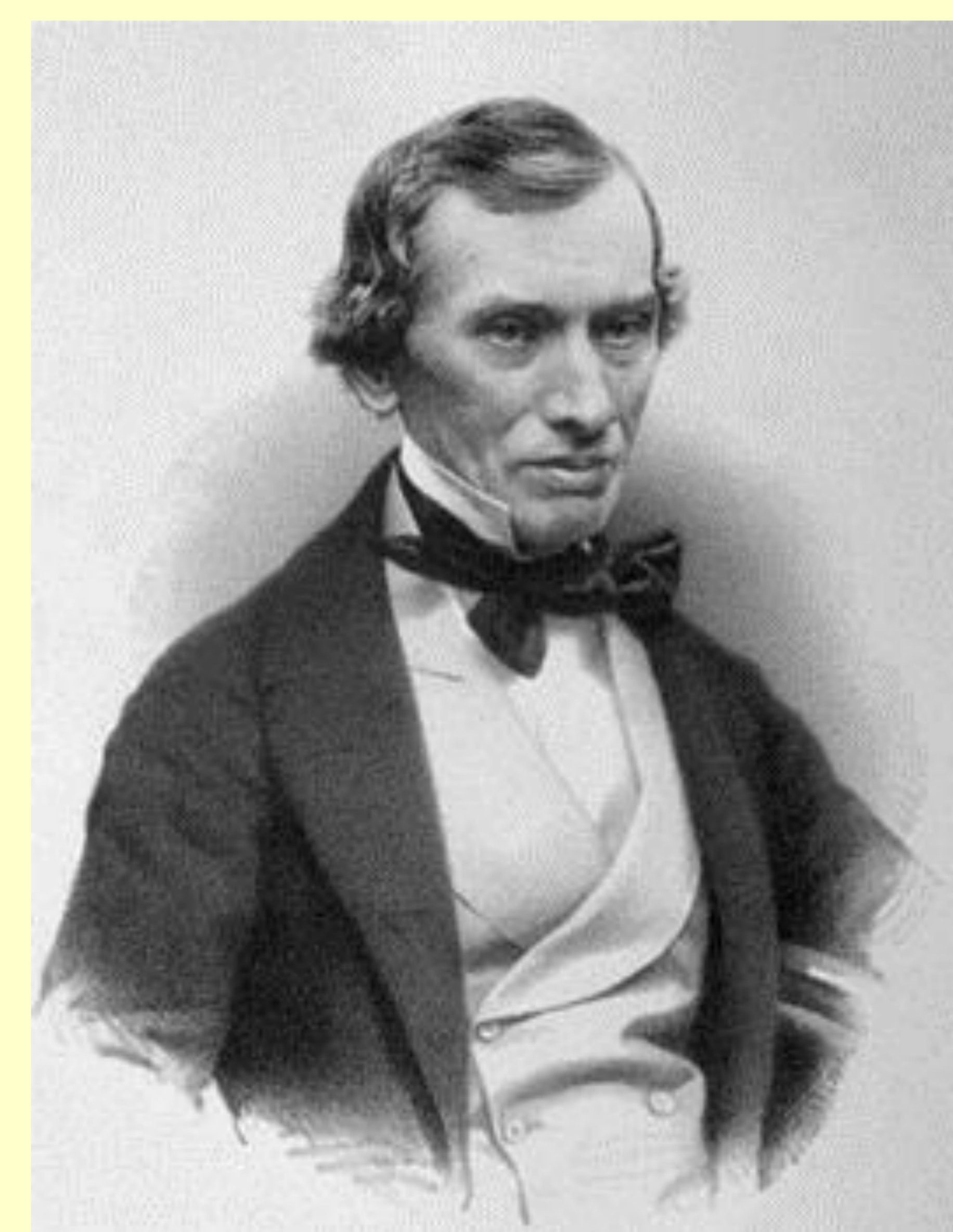
The so called “dialyzer”, used by Thomas Graham, is a far rudimentary forerunner of the modern devices routinely used in the dialysis machines today. In his article from 1861 Thomas Graham made one very interesting observation, which could be called prophetic: “...half a litre of urine, dialyzed for 24 hours, gave its crystalloid constituents to the external water. The latter, evaporated in a water-bath, yielded a white saline mass. From this mass, urea was extracted by alcohol in so pure a condition as to appear in crystalline tufts upon the evaporation of the alcohol.” There still remains around 50 years until the creation of the first dialysis machine (John Jacob Abel, (1913)) and experiments on dogs. But that is another story...



Jean-Antoine Nollet. 1700-1770



René Joachim Henri Dutrochet. 1776-1847



Thomas Graham. 1805-1869