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COMPONENTS OF FLUX measured with a tracer

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Dear Weishi

Once again the math finds something we knew physically.

It is definitely not possible (and NOT NEEDED) to have all concentrations zero!!! So do not worry. That case is clearly nonphysical because it prevents steady time independent current flow. (Zero concentrations are possible for nonsteady time dependence but requires Maxwell's first equation --- Poisson plus displacement current ---and is not of interest to us here.)

We need to have zero concentrations ONLY for the definition of components of flux. **Those components are called UNIDIRECTIONAL fluxes and are ALWAYS MEASURED ONLY I repeat ONLY with tracers.** I have not mentioned tracers (very much) because I wanted to keep the discussion simple. But the math forces me to discuss them now and fortunately they simplify things, if I can only describe them clearly.

Tracers are used to measure the components of flux.
Let's take an example. We have sodium present just as you always do. Then we add a tiny amount (absolutely negligible in concentration) of a radioactive isotope of sodium called Na^{24}. This isotope can be easily measured by its radioactivity.

COMPONENTS OF FLUX ARE MEASURED BY MEASURING THE FLUX OF THE ISOTOPE. The isotope has EXACTLY the same properties as the main species (the diffusion coefficient of Na^{24} and of Na are the same, the diameter is the same, etc etc.)

The EXPERIMENT is arranged so that the radioactivity on one side of the channel is kept nearly zero (by flowing solution by the channel).
The total flux of the isotope Na^{24} is into a solution of zero concentration of isotope Na^{24}.

So the total flux of isotope Na^{24} is equal to the unidirectional flux of the isotope Na^{24}.

> The unidirectional flux of the isotope Na^24 is proportional to
> the unidirectional flux of the NONradioactive Na.
>
> So we measure the component of nonradioactive Na flux by measuring the tracer
> flux of radioactive Na^{24}.
>
> So what does this mean for the math.
>
> To do the analysis of components of say sodium, you need THREE species,
>
> one regular sodium (nothing changed)
>
> another radioactive Na^{24} which has zero concentration boundary condition on one side and is present
> in a very very small concentration on the other side of the channel
> (that can only be detected by its radioactivity. The radioactivity TRACES the movement of regular
> sodium and so the name tracer.) All the parameters of

the tracer are exactly the same as those of regular nonradioactive sodium (same diameter, diffusion coefficient, etc, charge) except of course the concentration.

> (The small concentration guarantees that there are no interaction terms of the new
> species Na^{24} with itself etc)
>
> The third species is the anion chloride for example just as you do now.
>
> If you try to do a component analysis with only two species, you will have math troubles
> I suspect because of electroneutrality issues. THESE DO NOT NOT NOT ARISE
> in real experiments because real experiments include three species, Na (which provides
> electroneutrality), chloride (or other anion), and TRACER Na^{24} (which alone has the
> homogeneous Dirichlet absorbing boundary condition).

so you do the analysis JUST BY MATH using three species. to avoid confusion
I suggest you call one Na, one Cl, and the other T (for tracer). ONLY T HAS
THE HOMOGENEOUS DIRICHLET CONDITION.

You do the analysis twice, once with the homogeneous condition on one side
of the channel, and the second time with it on the other side.

THE RATIO OF THE FLUXES OF T (from one side and then from the other)
IS THE KEY VARIABLE THAT HODGKIN etc HAVE STUDIED AND WE
NEED TO STUDY.

> I hope this explanation is clear!
> If not, please ask.
>
> As ever
> Bob

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