

# Modeling Intraglomerular Transport in Diabetic Kidney Disease



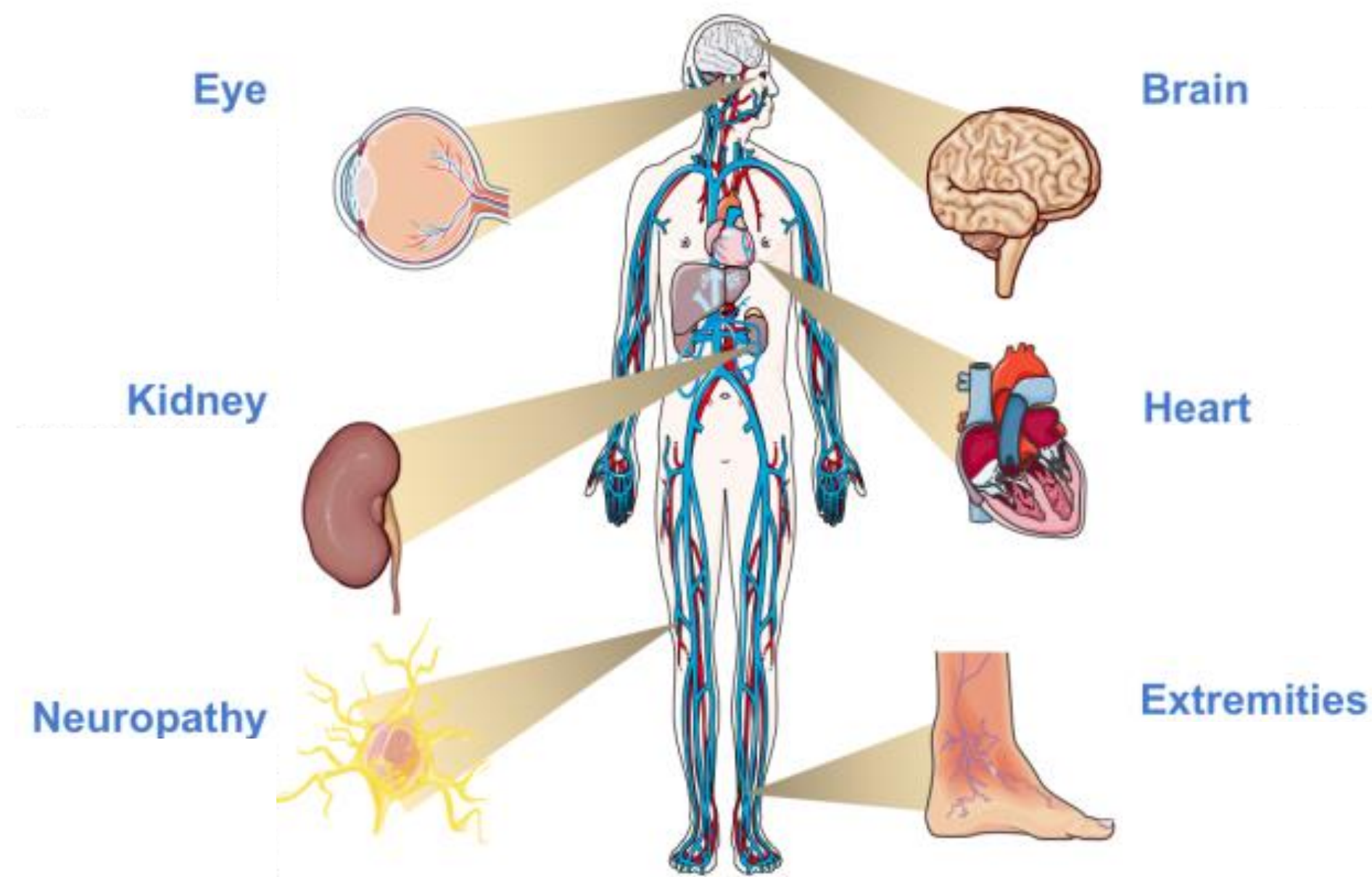
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## Introduction

### Diabetic kidney disease

- 44% of all new kidney failure cases are diabetics
- Kidneys are a filtration system, and DKD makes this process less effective
- Kidneys have many different cells with many different functions

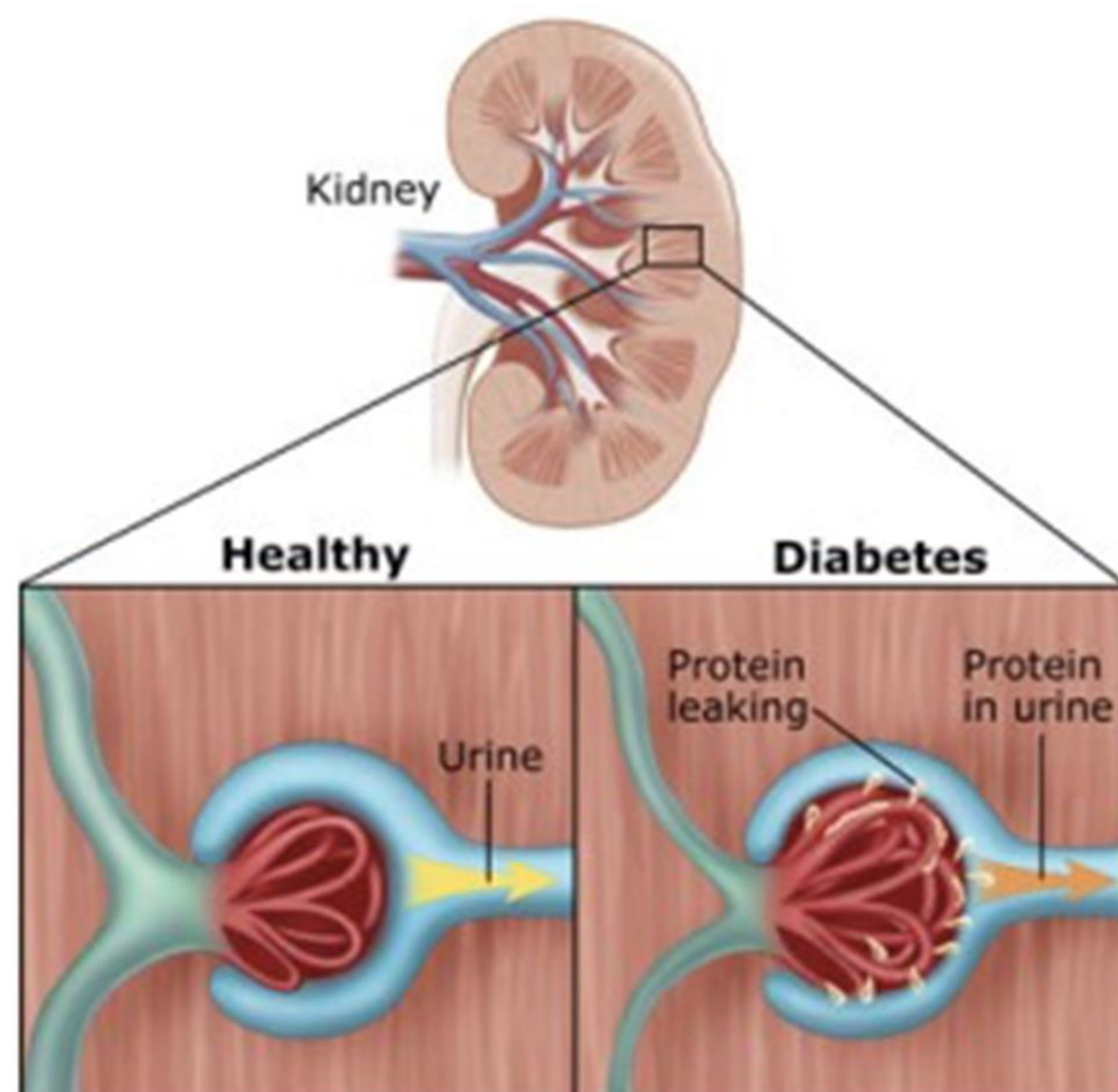
### Increased blood glucose and decreased insulin sensitivity cause damage all over the body



<https://pdb101.rcsb.org/global-health/diabetes-mellitus/monitoring/complications>

### Damage in the kidney

- Filters of the kidneys become damaged
- Kidneys leak abnormal amounts of protein into the urine



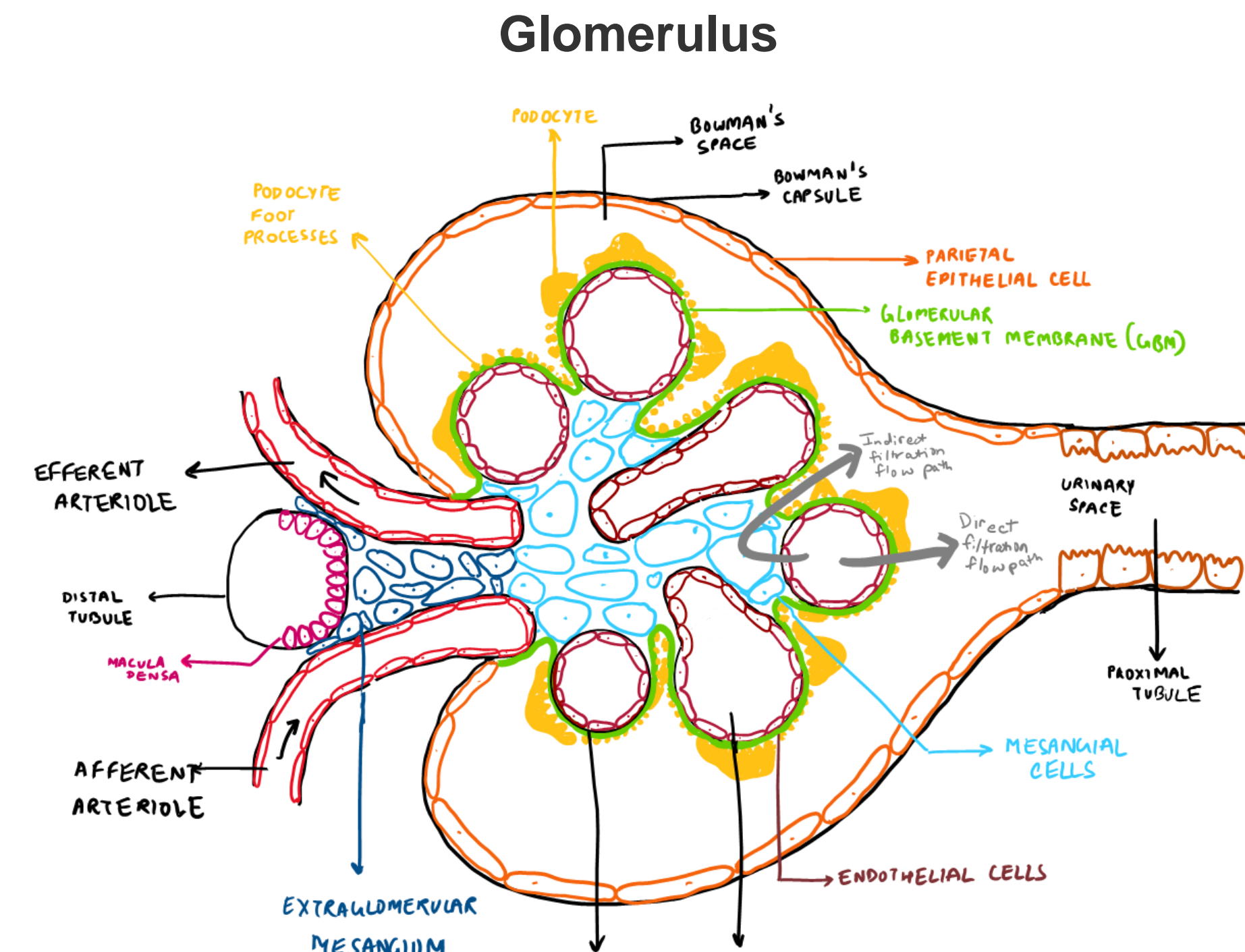
[https://nmkdney.org/kidney\\_edu/kidney-related-diseases/](https://nmkdney.org/kidney_edu/kidney-related-diseases/)

## Purpose

Create a mathematical model to represent the transport of glucose in the glomerulus and the transport of key biochemicals that respond to glucose during injury.

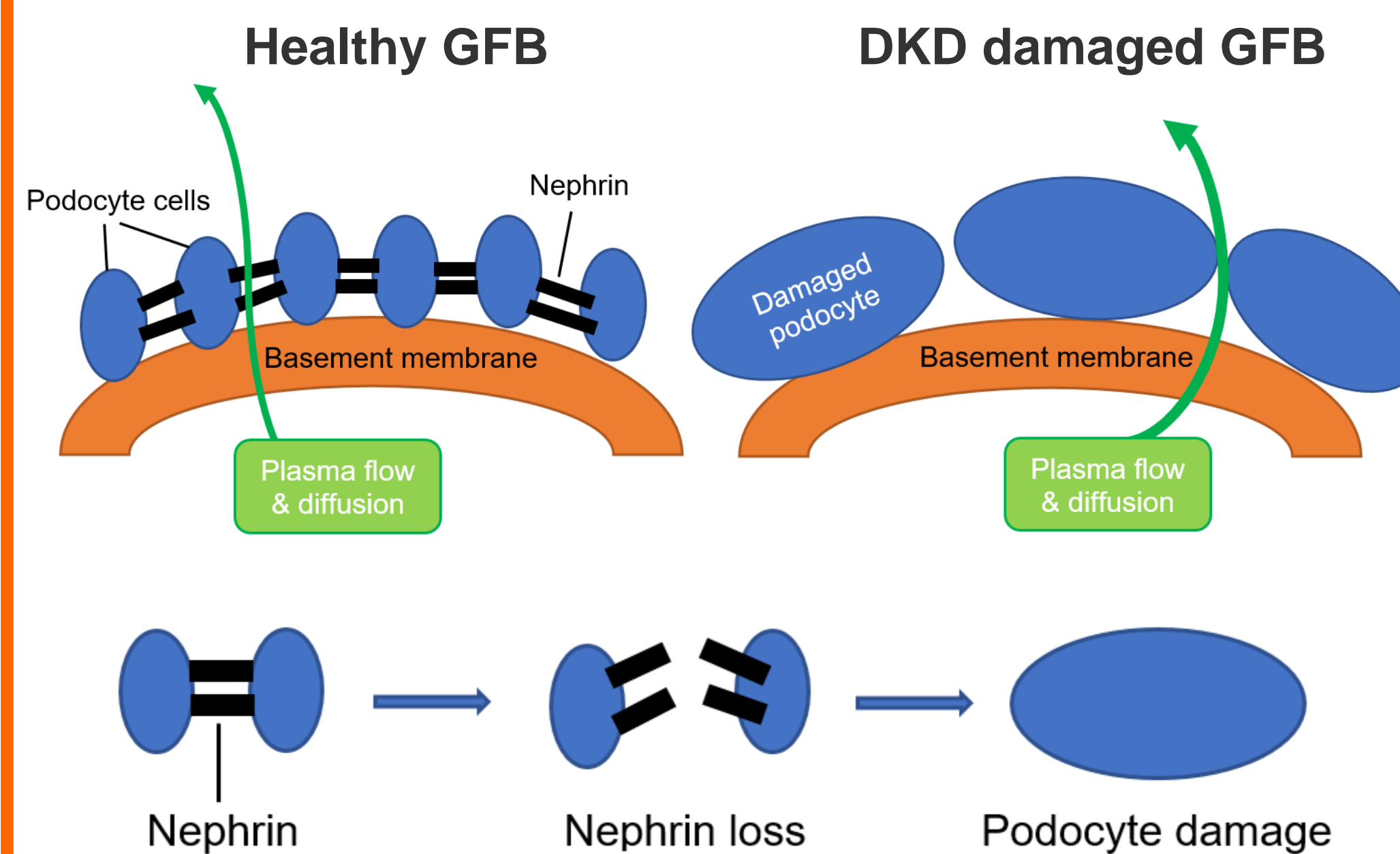
## Kidney Damage by Diabetes

### Kidneys filter blood through glomeruli



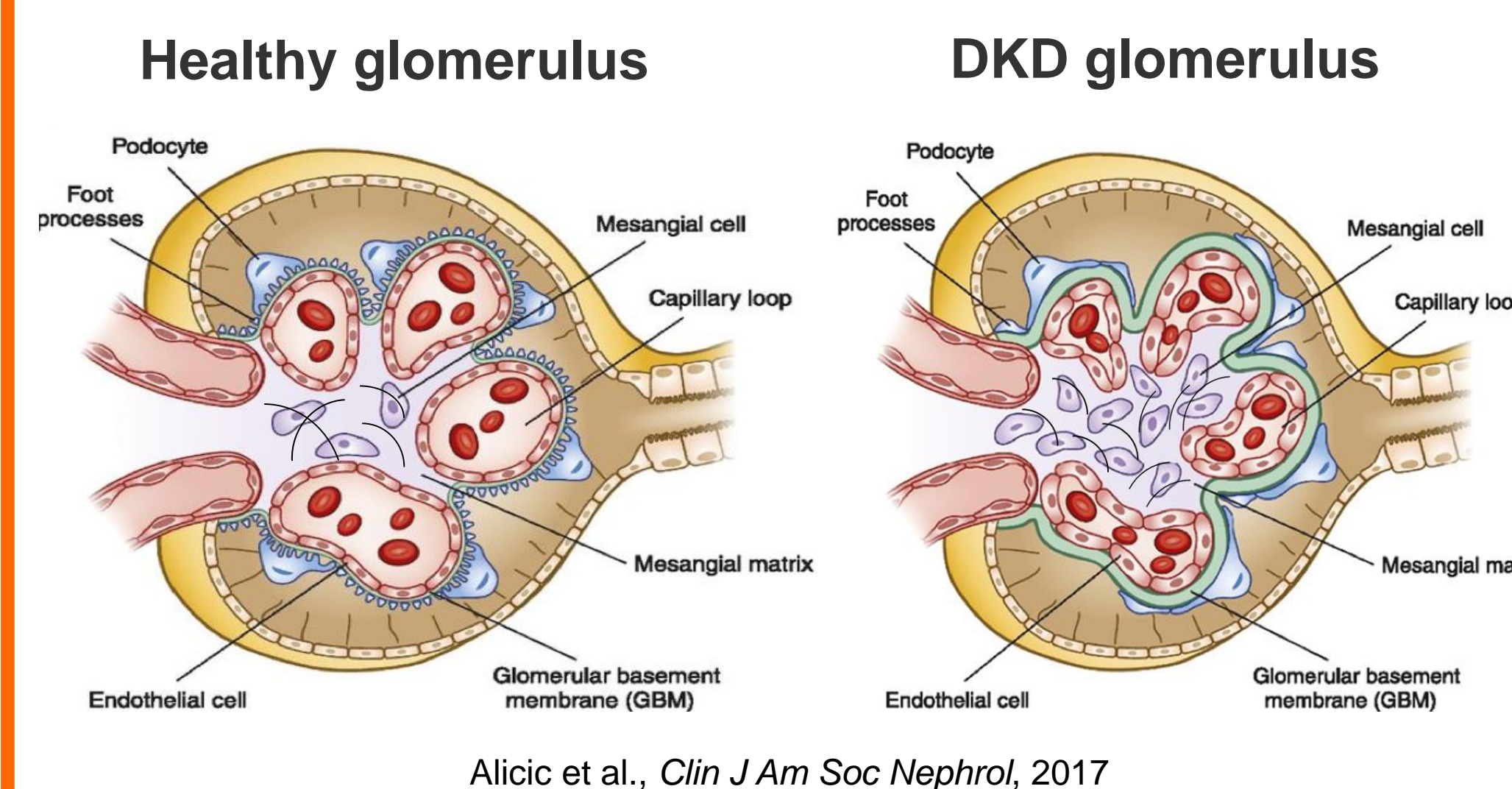
### Nephrin loss breaks the final layer of the glomerular filtration barrier (GFB)

- Nephrin holds the podocyte cells together
- Loss of nephrin causes the podocyte cells to collapse and fuse together



### Mesangial cells are cells in the kidney that make up the mesangium

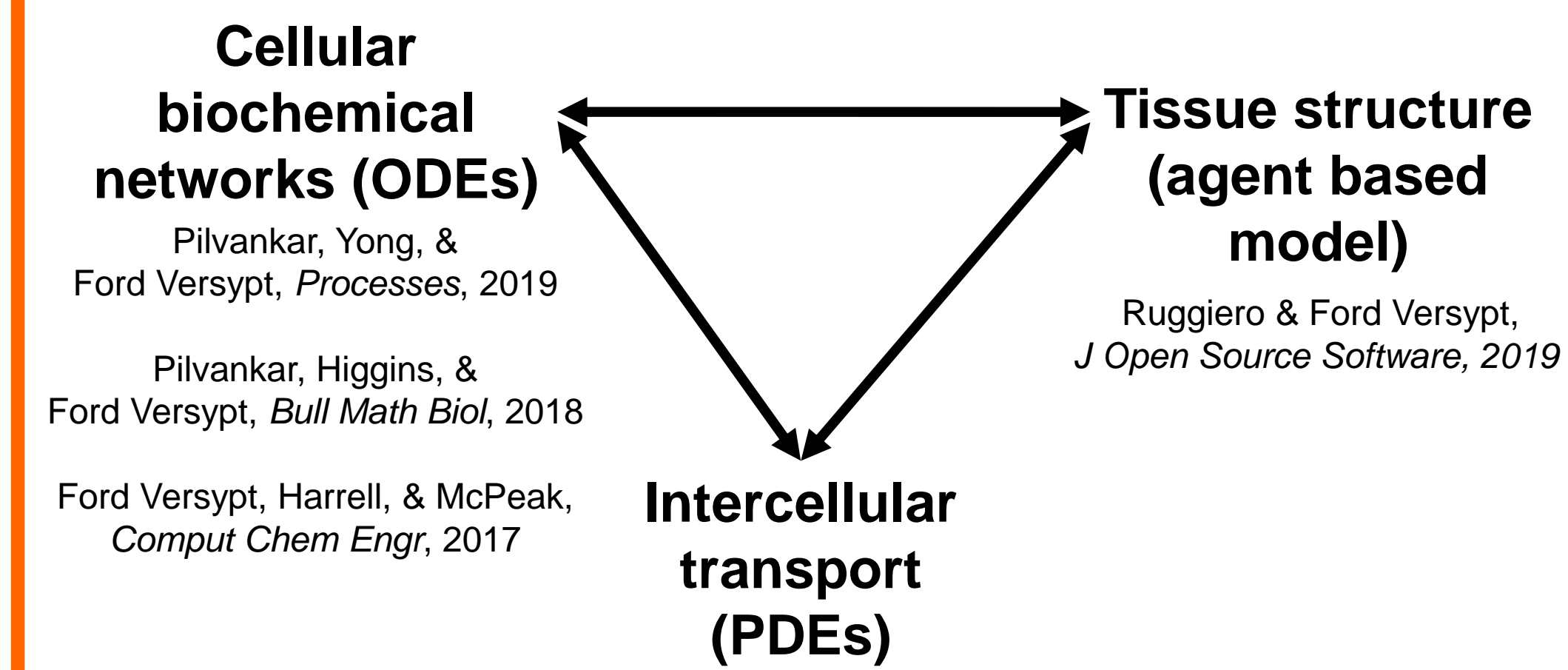
- Located inside the glomerulus and in between the capillaries
- Mesangial cells multiply and capillaries begin to change shape



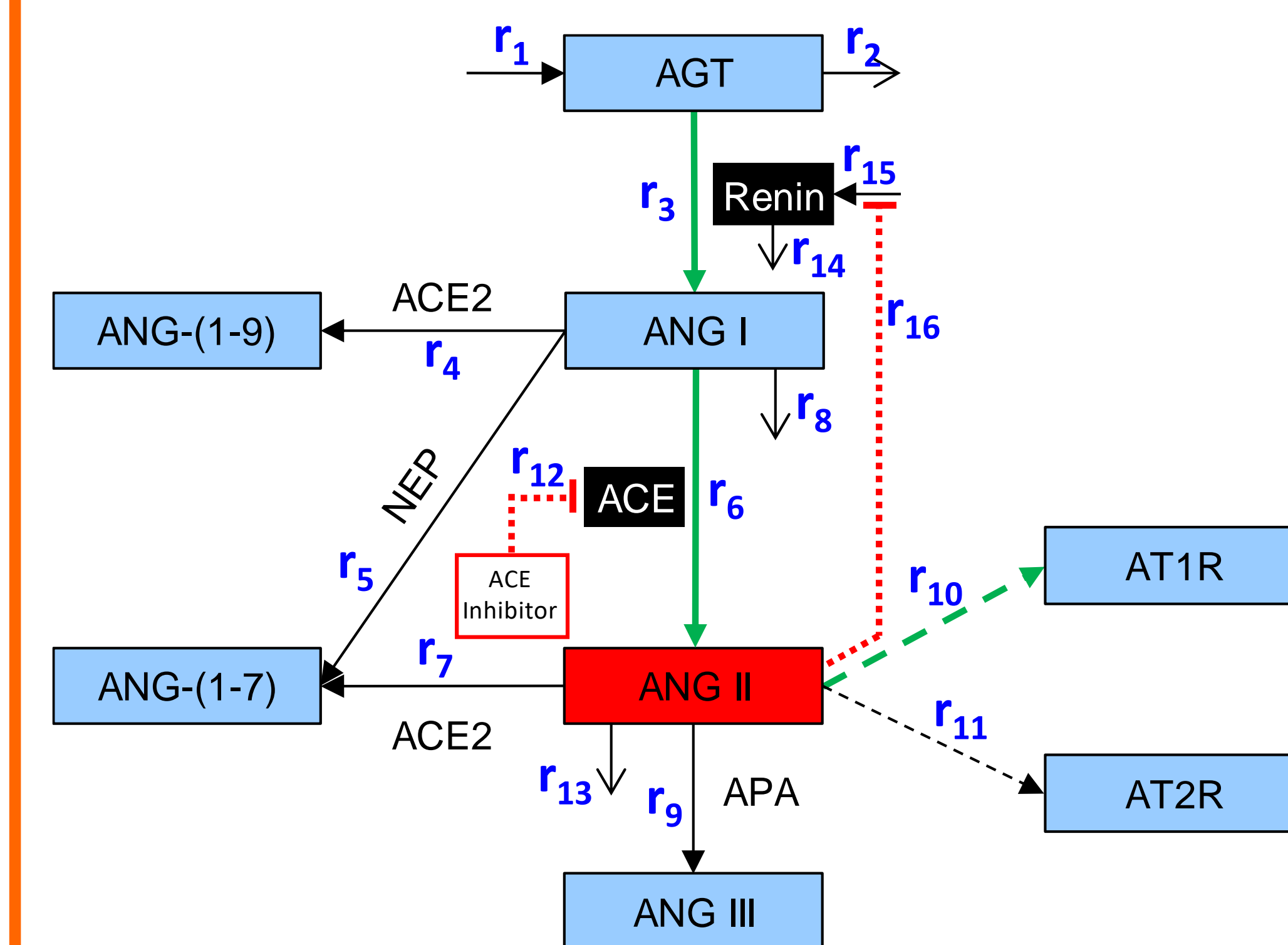
Alicic et al., *Clin J Am Soc Nephrol*, 2017

## Modeling Approach

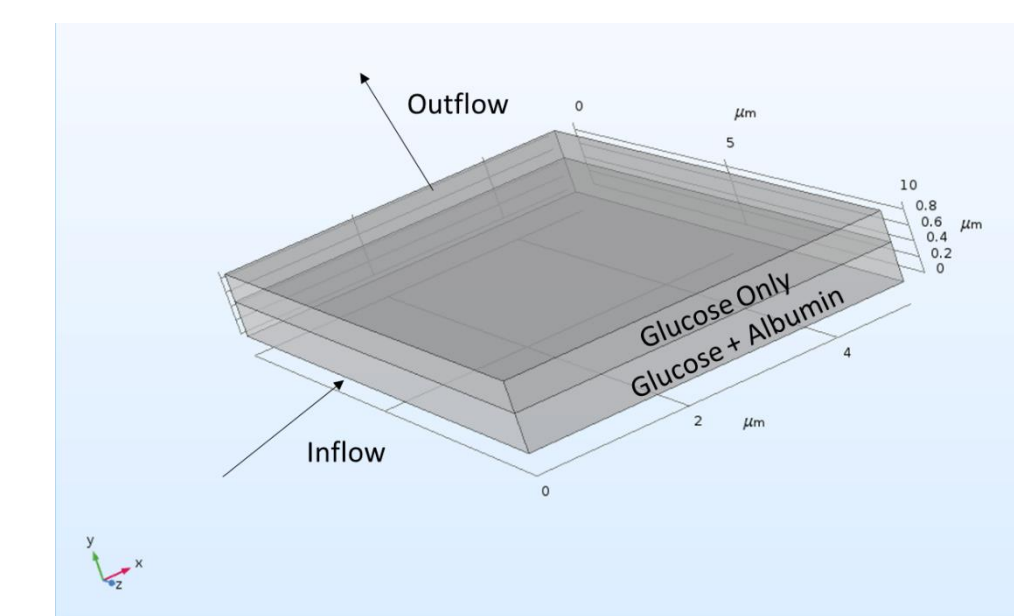
### Connect submodels for glomerular components into a multiscale model



### Renin-angiotensin network sensitive to glucose affects podocyte health



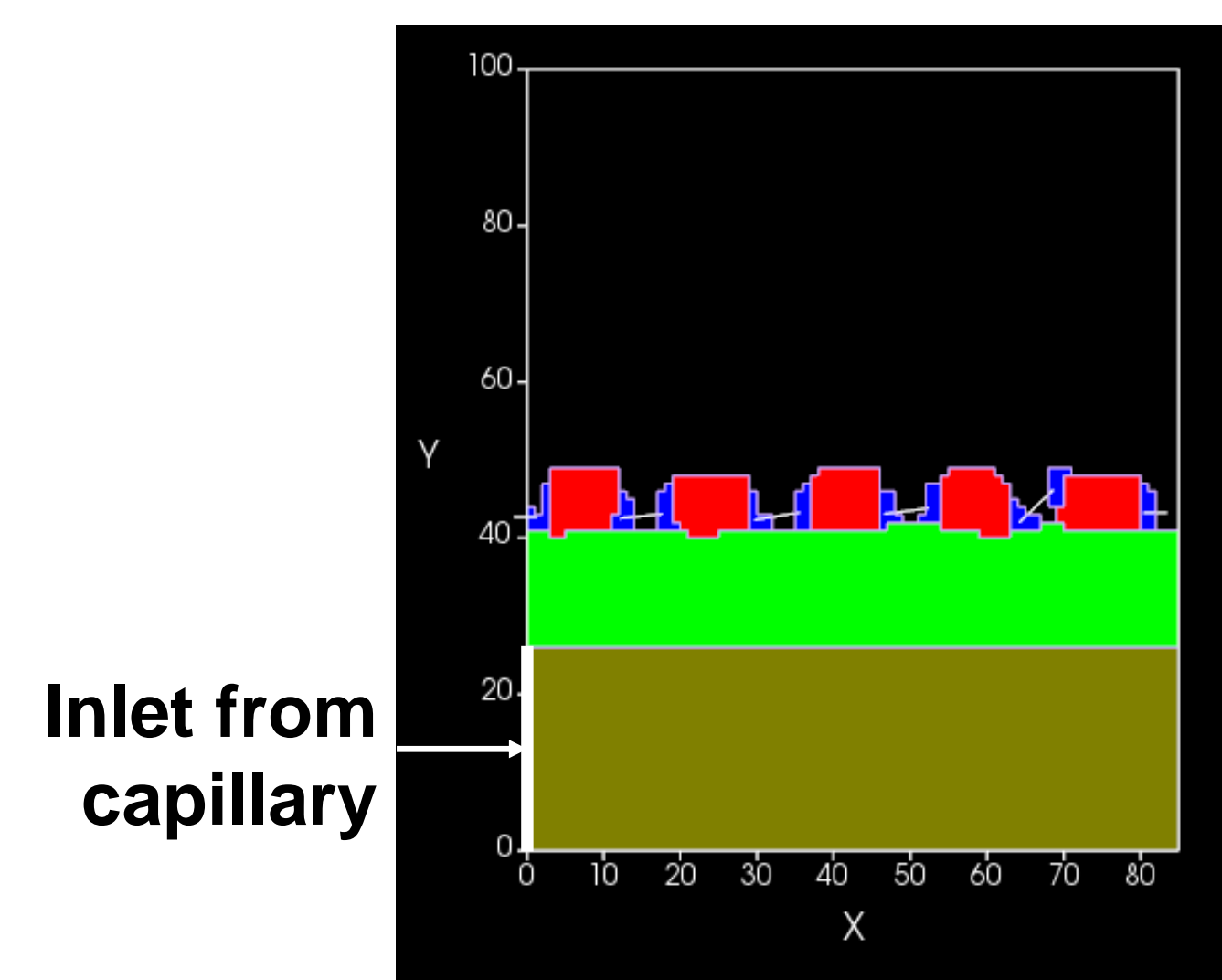
### Glucose transport through mesangial matrix and GFB using Darcy flow CFD in COMSOL



$$0 = \nabla \cdot \vec{v} = -\nabla \cdot \frac{\kappa}{\mu} \nabla P$$

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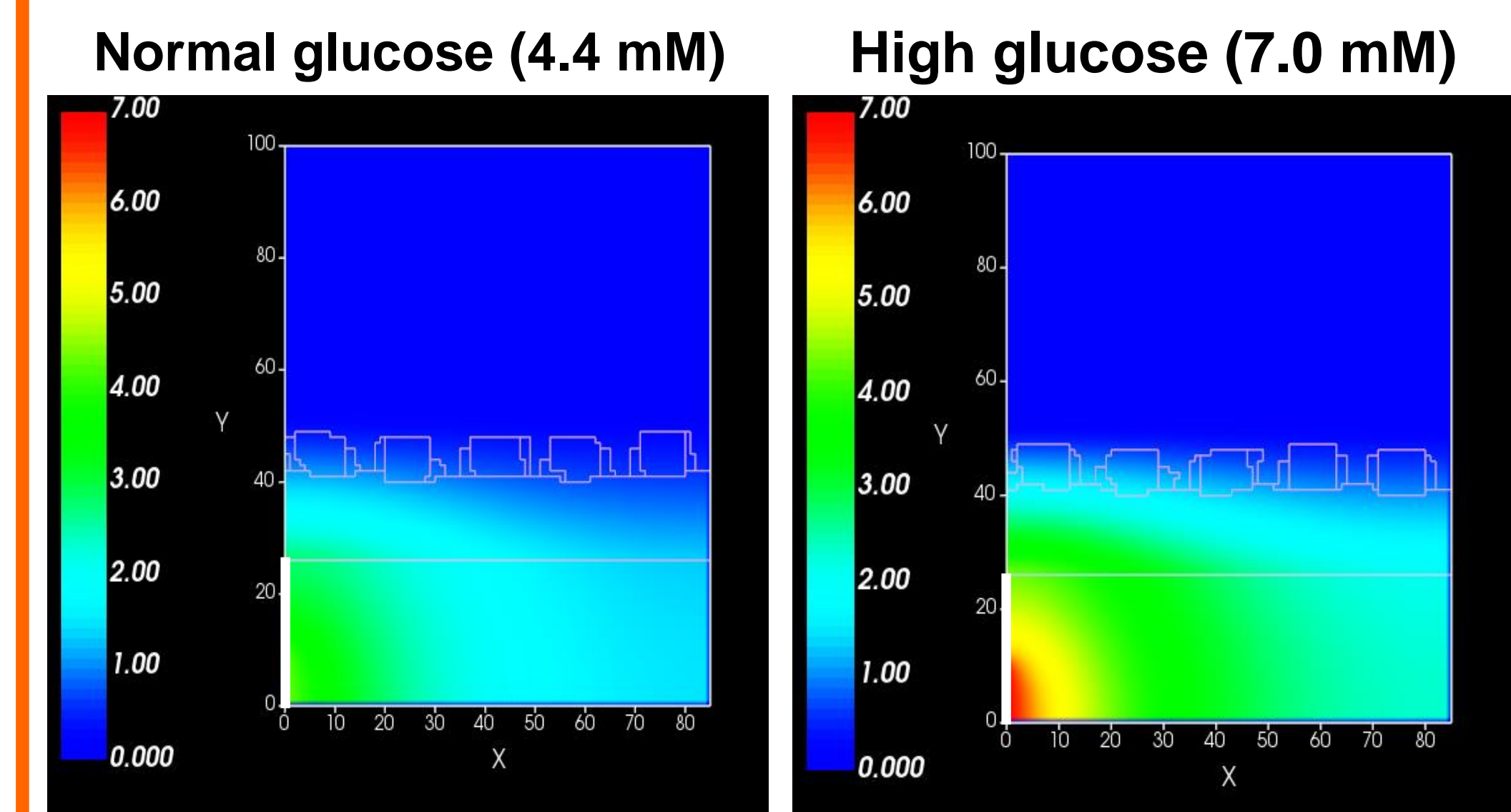
### CompuCell3D for hybrid agent-based and differential equations-based dynamic tissue model



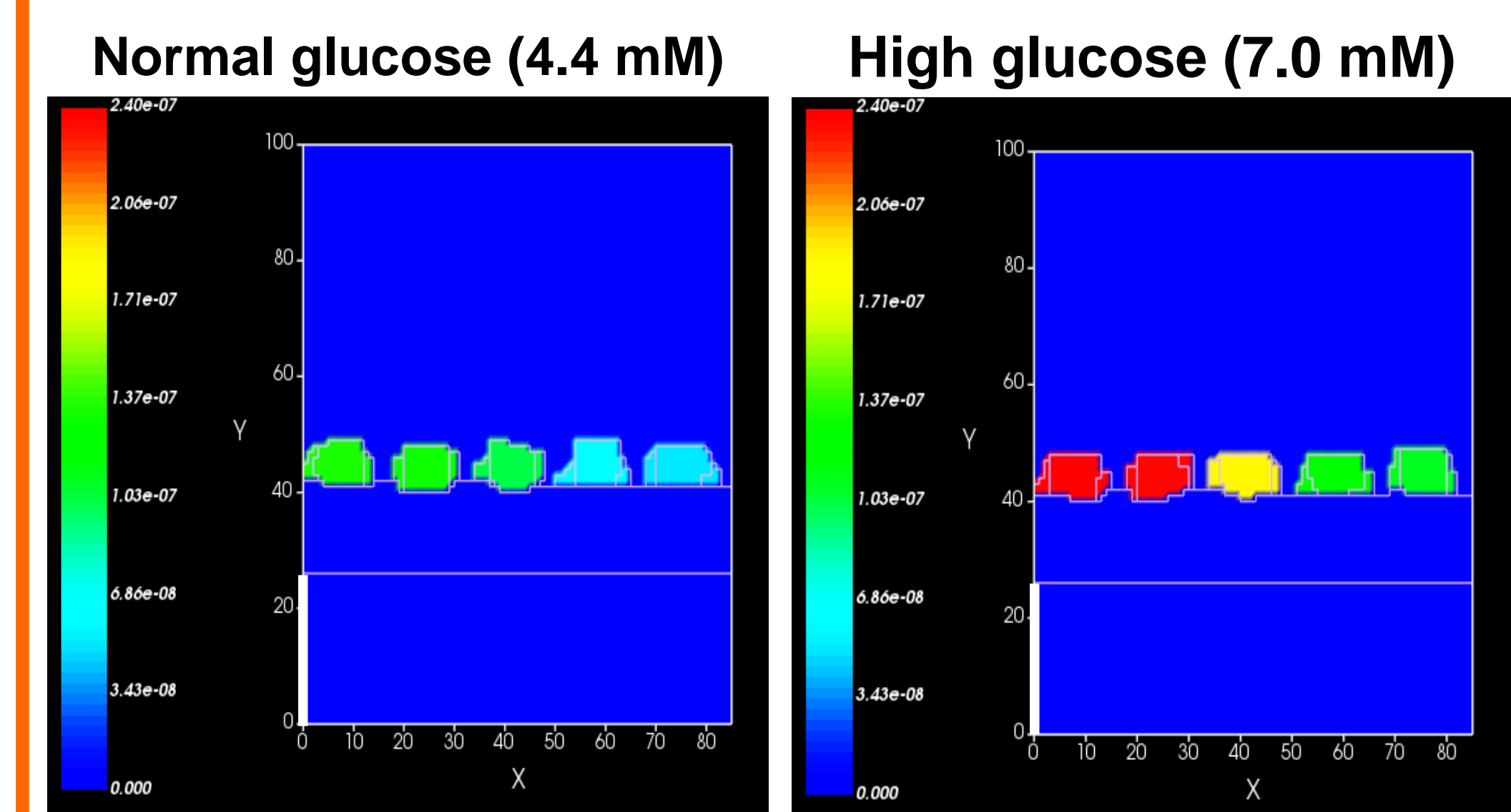
Bowman's space  
Podocytes  
GBM (small  $\kappa$ )  
Mesangium (large  $\kappa$ )

## Results

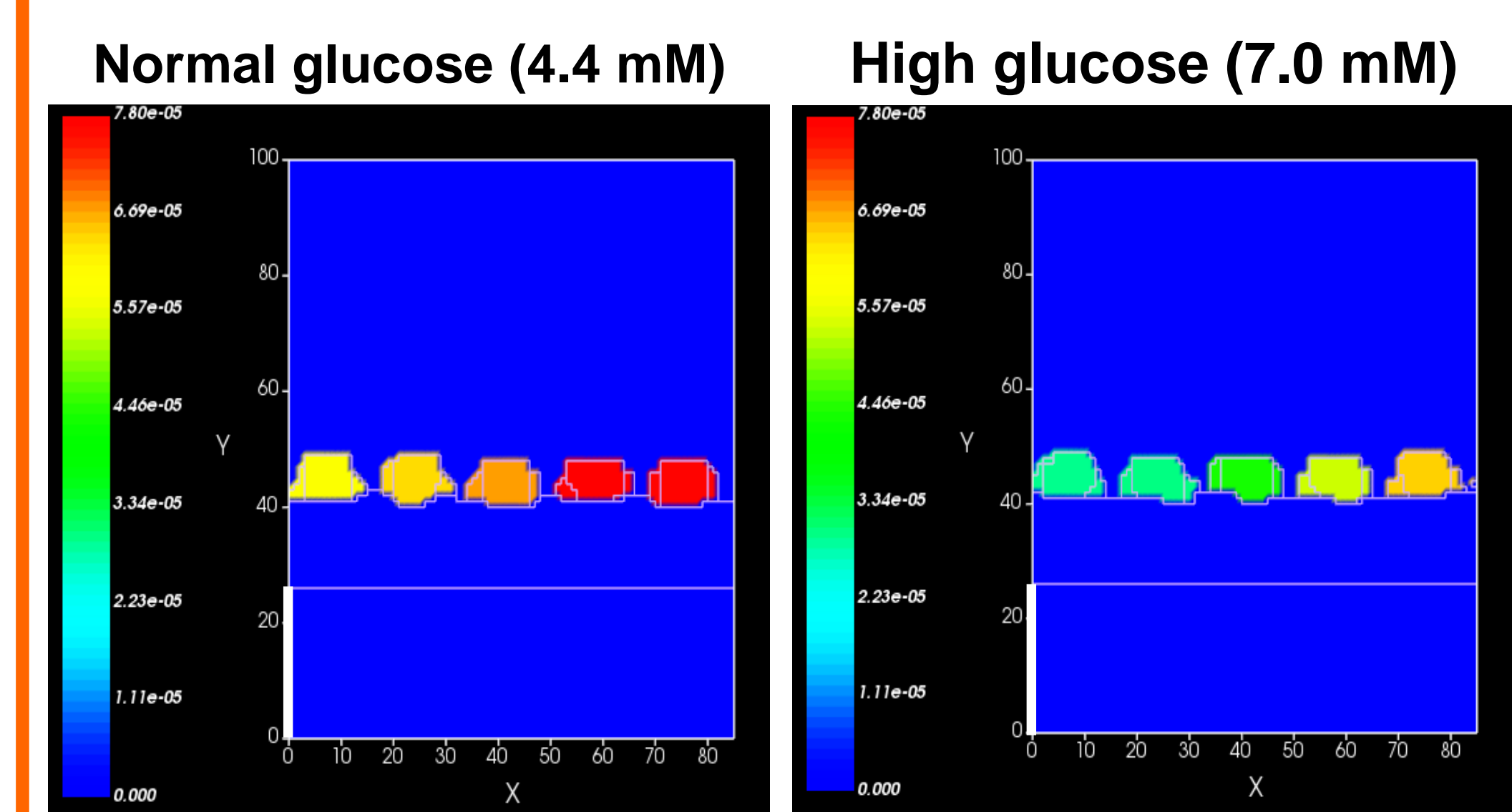
### Glucose concentration (mM)



### Renin concentration (mM)



### ANG I concentration (mM)



### ANG II concentration (mM)

