Illustrating functional tissue units (FTUs) based on organ-specific anatomical structures, cell types and biomarkers

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Background

The Human BioMolecular Atlas Program (HuBMAP) is a consortium of diverse teams funded by the NIH Common Fund. We are working to create an open, global atlas mapping the human body at cellular resolution.

A Common Coordinate Framework (CCF) allows researchers to register tissue blocks in the Registration User Interface and creates a unique address for each cell in the human body.[1] See Figure 1.

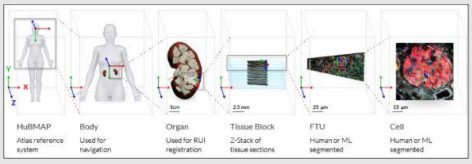

Figure 1. The Common Coordinate Framework connects data across scales.

Methods

Subject matter experts author and review organ-specific tables to organize hierarchical relationships between anatomical structures, cell types and biomarkers for each organ. These **ASCT+B Tables** describe nested hierarchical relationships by linking anatomical structures to cell types, and cell types to biomarkers. Terms are connected to Uberon and cell ontology IDs when possible.[2] (See Figure 2.)

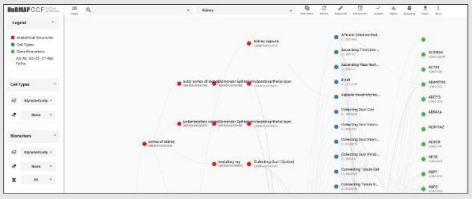

Figure 2. Partial ASCT+B Table Reporter visualization of the kidney.

Table authors are invited to define **Functional Tissue Units (FTUs)** for each organ. FTUs are the smallest tissue (i.e., cell population or neighborhood) that performs an organ's main physiologic function. FTUs are visually described using 2D illustration techniques, then segmented manually and using AI algorithms. Crosswalk tables connect segmented cell types populations to cell ontologies and other data sets.[3] (See Figure 3.)

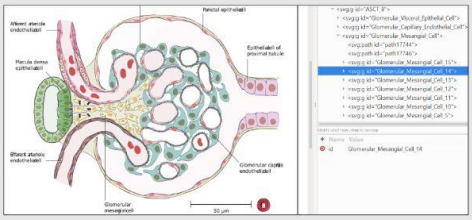

Figure 3. Cell type populations in the renal corpuscle illustration are connected to data using cell ontology IDs from the ASCT+B Table "Kidney 1.2."[4]

Discussion

Medical illustrators create illustrations of the functional tissue units by engaging in research on each organ system. Working closely with subject matter experts, the illustrator creates a pencil sketch of each proposed FTU. Early sketches are colorized ditigally and annotated for review. The team of experts reviews each illustration and provides guidance for edits prior to publication. Final art is digitized in Adobe Illustrator and segmented using a combination of Illustrator and Inkscape.

As new cell types are added to the ASCT+B table, FTUs may be updated to include the current data. The sketch-inspired illustration style points to this "work in progress" aesthetic.

Alternate illustration styles may be used to describe FTUs at different scales, with the goal being to visualize as many cells as is possible at each scale. At the largest scales, individual cell are no longer visible when observing the entire FTU, and in these cases, anatomical structures are illustrated instead.

A detailed Standard Operating Procedure for creating these illustrations can be found at: https://drive.google.com/file/d/1KoJCEGMTbpX-LOLNoAZhQgSWNY-CPTh41/view.

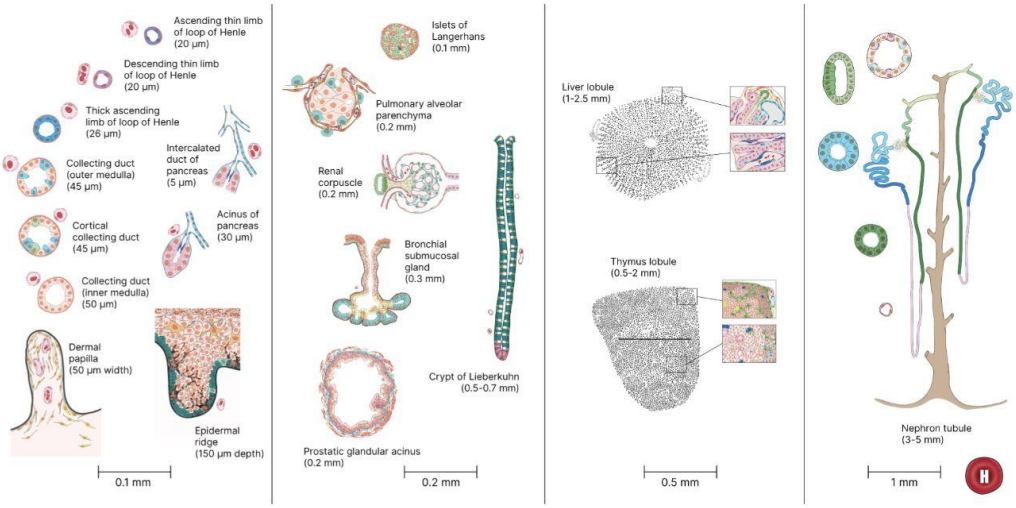

Figure 4. Published 2D FTU illustrations.[3]

Conclusion

Would you like to help? We would love your assistance as an organ-specific subject matter expert to review or author tables, share related research projects, or connect tissue data. Please get in touch!

Scan me to register as an expert

VHMOOC Scan me to learn more about HuBMAP

CCF Portal Scan me

Exploration User Interface Scan me to explore HuBMAP data

Registration User Interface Scan me to register tissue blocks

References

1. HuBMAP Consortium. The human body at cellular resolution: the NIH Human Biomolecular Atlas Program. Nature 574, 187–192 (2019). https://doi.org/10.1038/s41586-019-1629-x
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3. Bajema, R., Bidanta, S., Quardokus, E., Herr II, B. W., Börner, K. 2022. HuBMAP CCF 2D Reference Object Library. https://hubmapconsortium.github.io/ccf/pages/ccf-2d-reference-library.html. Accessed on May 6, 2022.
4. ASCT+B Reporter Visualization. HuBMAP, Cyberinfrastructure for Network Science Center, Indiana University, Bloomington. https://hubmapconsortium.github.io/ccf-asct-reporter/vis?selectedOrgans=kidney-v1.2&playground=false. Accessed March 21, 2023.

HuBMAP Consortium https://hubmapconsortium.org/
Human Reference Atlas https://humanatlas.io/
HuBMAP ASCT+B Reporter https://hubmapconsortium.github.io/ccf-asct-reporter/
CCF 2D Reference Functional Tissue Unit (FTU) Library https://hubmapconsortium.github.io/ccf/pages/ccf-2d-reference-library.html
The human body at cellular resolution: the NIH Human Biomolecular Atlas Program https://www.nature.com/articles/s41586-019-1629-x

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