A proposal to extend standardized organ mapping antibody panels (OMAPs) to integrate protein and RNA analysis in spatial biology

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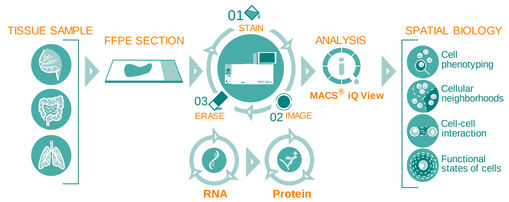
Abstract

The Human BioMolecular Atlas Program (HuBMAP) consortium has developed a new standard to report on normal histological samples using multicolor immunofluorescence imaging. An Organ Mapping Antibody Panel (OMAP) currently describes in a table the antibodies used, the cycle number assigned to a given reagent, and provides the rationale for using a particular antibody to better understand features of the tissue. This table is accompanied by antibody validation templates that show example images from the tissue described for the OMAP table. In addition, links to existing databases, gene symbols, the antibody features and colors are included. For each tissue, a further table called "Anatomical Structures, Cell Types, plus Biomarkers" (ASCT+B), which contains structures of the tissue, cell types in a given tissue structure, key RNA transcripts for a given cell type, and antibody stains as used in the OMAP table, is created. So far, this process has not been established for spatial multiomic datasets including protein and RNA detection on the same tissue section.

We have extended spatial biology methodology to combine cyclic RNA transcript detection with cyclic antibody-based protein detection using the MACSima™ Imaging Cyclic Staining (MICS) technology as well as H&E-staining on the same tissue section. For such datasets, the current OMAP data table needs to be extended by adding information on the RNA detection, cycle IDs and RNA validation templates, demonstrating the correct performance of a given RNA probe detection.

This poster will demonstrate a proposal to extend the OMAP table structure on an extended version of the “tonsil OMAP (OMAP-10)”, which was published on the Zenodo data repository page (https://zenodo.org/records/7875938). In addition, we will apply this extended OMAP to a colorectal cancer sample, to highlight the applicability and relevance of the OMAP structure for tumor tissue.

MACSima Imaging Cyclic Staining (MICS)



1 Concept of the extended OMAP table structure

The table below shows the concept of the “OMAP+” table structure, an extended version of the OMAP table, containing additional categories which allow adding relevant information for spatial multiomics methods combining RNA transcript detection and antibody-based protein detection, such as the MACSima Imaging Cyclic Staining (MICS) technology. The blue highlighted section shows information on RNA detection, the yellow highlighted section is presenting information on antibody-based protein detection. Columns are narrowed for visibility. The shown conceptual “OMAP+” table was generated for a data set acquired on a palatine tonsil sample.

omap_id	reagent_type	probe_type	probe_numbers	probe_sequence	mutation_specific	uniprot_accession_number	epitope	HGNC_ID	target_symbol	host	isotype	clonality	clone_id	vendor	catalog_number	lot_number	recombinant	concentration_value	dilution_factor	conjugate	rrid	Method	instrument	tissue_preservation	cycle_number	fluorescent_reporter	protocol_doi	manuscript_doi	author_orcid	vendor_affiliation	core_panel	rationale	organ	organ_uberon	cell_line	cell_line_ontology_id	antigen_retrieval
	RNA probe	padlock probe				P28070		HGNC:9541	PSMB4					Miltenyi Biotec	pending							pending	RNAsky MACSima	FFPE	1		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y*	PSMB4 contributes to the complete assembly of the 20S proteasome, which p	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P01730		HGNC:1678	CD4					Miltenyi Biotec	pending							pending	RNAsky MACSima	FFPE	1		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	CD4 is expressed by subsets of T cells. This marker is also expressed on a su	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P55072		HGNC:12666	VCP					Miltenyi Biotec	pending					PE	pending	RNAsky MACSima	FFPE	1		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y*	VCP is an ATPase enzyme present in all eukaryotes. This marker serves as a	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P01732		HGNC:1706	CD8A					Miltenyi Biotec	pending					APC	pending	RNAsky MACSima	FFPE	2		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	CD8alpha labels cytotoxic T cells. This marker represents a protected target in	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P11836		HGNC:7315	MS4A1					Miltenyi Biotec	pending					FITC	pending	RNAsky MACSima	FFPE	2		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	CD20 is expressed on the surface of all B cells, beginning as the pro-B stage,	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P42771;Q8N726		HGNC:1787	CDKN2A					Miltenyi Biotec	pending					PE	pending	RNAsky MACSima	FFPE	2		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		CDKN2A encodes for two proteins, p16 and p14ARF, both of which regulate c	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				Q13485		HGNC:6770	SMAD4					Miltenyi Biotec	pending					Vio780	pending	RNAsky MACSima	FFPE	2		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		SMAD4 is a transcription factor and marker of the TGF-beta signaling pathway,	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P04626		HGNC:3430	ERBB2					Miltenyi Biotec	pending					APC	pending	RNAsky MACSima	FFPE	3		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		ERBB2 (Her2) is a receptor tyrosine kinase, and functions as an oncogene in	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P15692		HGNC:12680	VEGFA					Miltenyi Biotec	pending					FITC	pending	RNAsky MACSima	FFPE	3		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		VEGFA is a growth factor involved in vascular permeability and angiogenesis.	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P04234		HGNC:1673	CD3D					Miltenyi Biotec	pending					PE	pending	RNAsky MACSima	FFPE	3		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	CD3d is an essential marker of T cells. This marker represents a core panel an	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P01106		HGNC:7553	MYC					Miltenyi Biotec	pending					Vio780	pending	RNAsky MACSima	FFPE	3		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		MYC is a transcription factor, which regulates cell cycle progression and apopt	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P16422		HGNC:11529	EPCAM					Miltenyi Biotec	pending					APC	pending	RNAsky MACSima	FFPE	4		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		EpCAM is expressed by epithelial cells and used to distinguish the epithelium f	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P08575		HGNC:9666	CD45					Miltenyi Biotec	pending					FITC	pending	RNAsky MACSima	FFPE	4		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	CD45 is expressed by all hematopoietic cells. This marker represents a priority	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P46013		HGNC:7107	MKI67					Miltenyi Biotec	pending					PE	pending	RNAsky MACSima	FFPE	4		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	Ki67 is essential for assessing cell division and proliferation. This marker repr	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P04637		HGNC:11998	TP53					Miltenyi Biotec	pending					Vio780	pending	RNAsky MACSima	FFPE	4		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		p53 is a regulatory protein, which is often mutated in many human cancer type	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P12004		HGNC:8729	PCNA					Miltenyi Biotec	pending					APC	pending	RNAsky MACSima	FFPE	5		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	PCNA is a cofactor of DNA polymerase delta and found in the cell nucleus. It p	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P23771		HGNC:4172	GATA3					Miltenyi Biotec	pending					FITC	pending	RNAsky MACSima	FFPE	5		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		GATA3 is a transcription factor and controls a variety of biological processes. I	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P60484		HGNC:9588	PTEN					Miltenyi Biotec	pending					PE	pending	RNAsky MACSima	FFPE	5		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		PTEN is a phosphatase in the Akt signaling pathway, which plays a role in cell	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P01857		HGNC:5525	IGHG1					Miltenyi Biotec	pending					Vio780	pending	RNAsky MACSima	FFPE	5		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		IGHG1 is expressed by plasma cells and, together with IGKC, is used to detern	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P00533		HGNC:3236	EGFR					Miltenyi Biotec	pending					APC	pending	RNAsky MACSima	FFPE	6		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		EGFR is a transmembrane receptor. Mutations can lead to overexpression in v	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P01116		HGNC:6407	KRAS					Miltenyi Biotec	pending					FITC	pending	RNAsky MACSima	FFPE	6		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		K-ras is a protein involved in cell proliferation and differentiation. It is frequently	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P10415		HGNC:990	Bcl2					Miltenyi Biotec	pending					PE	pending	RNAsky MACSima	FFPE	6		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	BCL2 is an anti-apoptotic protein highly expressed in mantle zone B cells and t	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P01834		HGNC:5716	IGKC					Miltenyi Biotec	pending					Vio780	pending	RNAsky MACSima	FFPE	6		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		IGKC is expressed by plasma cells and, together with IGHG1, is used to determi	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P34810		HGNC:1693	CD68					Miltenyi Biotec	pending					APC	pending	RNAsky MACSima	FFPE	7		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	CD68 is expressed by many subsets of myeloid cells (lingible body macrophag	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P0A2A4		HGNC:14582	LAMP3					Miltenyi Biotec	pending					FITC	pending	RNAsky MACSima	FFPE	7		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		LAMP3 (DC-LAMP) is almost exclusively found in mature dendritic cells.	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P08571		HGNC:1628	CD14					Miltenyi Biotec	pending					PE	pending	RNAsky MACSima	FFPE	7		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	CD14 is strongly expressed on the surface of monocytes and weakly on granu	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	RNA probe	padlock probe				P04626		HGNC:3430	ERBB2					Miltenyi Biotec	pending					Vio780	pending	RNAsky MACSima	FFPE	7		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y**	Negative control, randomized nucleotide RNA probes	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P01732		HGNC:1706	CD8A	Human	IgG1	Monoclonal	REA1024	Miltenyi Biotec	130-117-200		Yes	50	FITC	AB_2857414	MICS	MACSima	FFPE	1		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	CD8alpha is expressed on the CD8 positive subset of T cells, cytotoxic T cells.	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P08729		HGNC:6427	Cytokeratin 7	Human	IgG1	Monoclonal	REA935	Miltenyi Biotec	130-115-648		Yes	50	APC	AB_2857395	MICS	MACSima	FFPE	2		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		Cytokeratin 7 is a class II cytokeratin, which is more often expressed in the sim	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P12004		HGNC:8729	PCNA	Human	IgG1	Monoclonal	REA858	Miltenyi Biotec	130-114-702		Yes	50	FITC	AB_2726763	MICS	MACSima	FFPE	2		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		PCNA is a cofactor of DNA polymerase delta and found in the cell nucleus. It p	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P08575		HGNC:9666	PTPRC	Human	IgG1	Monoclonal	REA164	Miltenyi Biotec	130-112-097		Yes	50	APC	AB_2819365	MICS	MACSima	FFPE	3		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		CD45RA is an isoform of PTPRC expressed by naive T lymphocytes.	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P15391		HGNC:7656	NCAM1	Human	IgG1	Monoclonal	REA1142	Miltenyi Biotec	130-126-497		Yes	50	FITC	AB_2655709	MICS	MACSima	FFPE	3		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		CD56 (NCAM) is expressed by glial cells, neurons and cells of the hematopoie	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					Q12888		HGNC:11998	TP53	Human	IgG1	Monoclonal	REA1132	Miltenyi Biotec	130-119-502		Yes	50	PE	AB_2857470	MICS	MACSima	FFPE	3		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		p53 is a regulatory protein, which is often mutated in many human cancer type	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					Q15661		HGNC:12019	TPSAB1	Human	IgG1	Monoclonal	REA798	Miltenyi Biotec	130-126-287		Yes	50	APC	AB_2857771	MICS	MACSima	FFPE	4		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		Mast cell tryptase is the most abundant serine-protease in mast cells.	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P08575		HGNC:9666	PTPRC	Human	IgG1	Monoclonal	REA119	Miltenyi Biotec	130-126-373		Yes	50	FITC	AB_2876979	MICS	MACSima	FFPE	4		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		CD45RB is an isoform of PTPRC expressed by CD45RA expressing naive T ly	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P07766		HGNC:1674	CD3E	Human	IgG1	Monoclonal	REA1151	Miltenyi Biotec	130-120-267		Yes	50	FITC	AB_2876969	MICS	MACSima	FFPE	5		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		CD3 epsilon defines T cell lineage and is an essential component of T cells. This mar	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P46013		HGNC:7107	MKI67	Human	IgG1	Monoclonal	REAL1047	Miltenyi Biotec	130-127-837		Yes	50	FITC	AB_2905309	MICS	MACSima	FFPE	6	Y	https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	Ki67 is expressed in the nucleus of proliferating cells. It defines dark zone (Ki6	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P01730		HGNC:1678	CD4	Human	IgG1	Monoclonal	REA1307	Miltenyi Biotec	130-127-806		Yes	50	PE	AB_2921815	MICS	MACSima	FFPE	6		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		CD4 is expressed by subsets of T cells. This marker is also expressed on a sul	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P04264;P13647;P13645;P02533		HGNC:6412;HGNC:6442;HGNC:6413;HGNC:6416	KRT1;KRT5;KRT10;KRT14	Human	IgG1	Monoclonal	REAL645	Miltenyi Biotec	130-125-779		Yes	50	APC	AB_2877037	MICS	MACSima	FFPE	7		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		High molecular weight cytokeratins comprise a major component of cytoske	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P62736		HGNC:130	ACTA2	Human	IgG1	Monoclonal	REAL650	Miltenyi Biotec	130-123-363		Yes	50	FITC	AB_2857589	MICS	MACSima	FFPE	7		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		Alpha smooth muscle actin defines the fibroblastic reticular network and vascu	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P21997		HGNC:1820	CEACAM8	Human	IgG1	Monoclonal	REA306	Miltenyi Biotec	130-104-414		Yes	50	PE	AB_2658984	MICS	MACSima	FFPE	7		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		CD66b is expressed by neutrophils and eosinophils.	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P01903		HGNC:4947	HLA-DRA	Human	IgG1	Monoclonal	REAL550	Miltenyi Biotec	130-123-076		Yes	50	FITC	AB_2857572	MICS	MACSima	FFPE	8	Y	https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	HLA-DR is expressed on antigen presenting cells. It defines B cell follicles (HLA	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					O95170		HGNC:29902	PDPN	Human	IgG1	Monoclonal	REA446	Miltenyi Biotec	130-117-687		Yes	50	PE	AB_2751407	MICS	MACSima	FFPE	8		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		Podoplanin is a transmembrane glycoprotein expressed by lymphatic endothel	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P35222		HGNC:2514	CTNNB1	Human	IgG1	Monoclonal	REA480	Miltenyi Biotec	130-123-632		Yes	50	FITC	Pending	MICS	MACSima	FFPE	9		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		beta-catenin is involved in cell-cell adhesion and cell developmental processes	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P34810		HGNC:1693	CD68	Human	IgG1	Monoclonal	REA1306	Miltenyi Biotec	130-128-345		Yes	50	PE	AB_2905104	MICS	MACSima	FFPE	9		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		CD68 cannot be used to define a specific anatomical structure but is expressive	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P08606		HGNC:20412	KRT20	Human	IgG1	Monoclonal	REAL753	Miltenyi Biotec	130-125-685		Yes	50	APC	AB_2877036	MICS	MACSima	FFPE	10		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		Cytokeratin 20 is a class I cytokeratin. Combined analysis with cytokeratin 7 is	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P11836		HGNC:7315	MS4A1	Human	IgG1	Monoclonal	REA1087	Miltenyi Biotec	130-118-292		Yes	50	PE	AB_2857425	MICS	MACSima	FFPE	10	Y	https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	CD20 is expressed on B cells and defines B cell follicles This marker represent	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P21181		HGNC:1698	CD79A	Human	IgG1	Monoclonal	REA1168	Miltenyi Biotec	130-120-939		Yes	50	PE	AB_2784280	MICS	MACSima	FFPE	10		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		CD79a is an antigen highly expressed by plasma cells and B cells. CD138 is also	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P13647;P02538;P04259;P48668;P05787;Q04695;P08727		HGNC:6442;HGNC:6443;HGNC:6444;HGNC:20406;HGNC:6446;HGNC:6427;HGNC:6436	KRT5;KRT6A;KRT6B;KRT6C;KRT8;KRT17;KRT19	Human	IgG1	Monoclonal	REA1141	Miltenyi Biotec	130-120-096		Yes	50	APC	AB_2857503	MICS	MACSima	FFPE	11		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		Cytokeratins are expressed by epithelial cells and used to distinguish epitheliu	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P08575		HGNC:9666	PTPRC	Human	IgG1	Monoclonal	REA611	Miltenyi Biotec	130-126-429		Yes	50	APC	AB_2656369	MICS	MACSima	FFPE	11	Y	https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes	Y	CD45RO is an isoform of PTPRC expressed by memory T cells.	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P18827		HGNC:10658	SDC1	Human	IgG1	Monoclonal	REA929	Miltenyi Biotec	130-127-999		Yes	50	PE	AB_2904717	MICS	MACSima	FFPE	12		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		CD138 is a marker for plasma cells along with CD79a markers. Most plasma c	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P16422		HGNC:11529	EPCAM	Human	IgG1	Monoclonal	REA1311	Miltenyi Biotec	130-127-909		Yes	50	PE	AB_2928418	MICS	MACSima	FFPE	13		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		EpCAM is expressed by epithelial cells and used to distinguish the epithelium f	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P13647		HGNC:6442	KRT5	Human	IgG1	Monoclonal	REA899	Miltenyi Biotec	130-127-016		Yes	50	PE	AB_2905179	MICS	MACSima	FFPE	14		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		Cytokeratin 5 is an isoform of cytokeratin expressed by stratified epithelium.	palatine tonsil	UBERON:0002373		HIER TE pH 9.0
	antibody					P04626		HGNC:3430	ERBB2	Human	IgG1	Monoclonal	REA1315	Miltenyi Biotec	130-127-979		Yes	50	PE	AB_2905194	MICS	MACSima	FFPE	14		https://doi.org/10.1101/202	https://doi.org/10.1101/2023.10.27.564191	0000-0002-1297-9725	yes		ERBB2 (Her2) is a receptor tyrosine kinase, and functions as an oncogene in	palatine tonsil	UBERON:0002373		HIER TE pH 9.0

2 Concept of the “RNA Probe Validation Report”

In addition to the extended “OMAP+” table structure, we are suggesting a validation report for RNA probes, similar to the existing Antibody Validation Reports currently generated for HuBMAP. A concept of the “RNA Probe Validation Report (RVR)” for a targeted padlock probe detecting MKI67 transcripts is shown below. Like the Antibody Validation Report, the “RVR” includes example images from the tissue described for the “OMAP+” table. To the right a combined visualization of RNA and protein detection for Ki67 via targeted padlock probe and antibody is shown. Images show a germinal center within a palatine tonsil, and the tumor area of a colorectal cancer tissue sample. Scale bars = 50 µm.

Antibody Validation Report HuBMAP

I. Target Information

Target name	MK67
HGNC ID	HGNC:7107
UniProt accession number	P46013

II. Antibody Information

RRID	AB_2905309
Host	human
Isotype	IgG1
Clonality	monoclonal
Vendor	Miltenyi Biotec
Catalog number	130-127-837
Recombinant (Y/N)	yes
Tissue preservation method	FFPE
Organ or tissue used for validation	Palatine tonsil
Organ Uberon ID	UBERON:0002373
Antibody-based imaging method	MICS (MACSima)
Conjugate	FITC
Author ORCID	0000-0002-1297-9725
Vendor Affiliation	www.miltenyibiotec.com

RNA Probe Validation Report HuBMAP

I. Target Information

Target name	MK67
HGNC ID	HGNC:7107
UniProt accession number	P46013

II. RNA Probe Information

RRID	
Probe type	Padlock probe
Probe number	
Mutation specfic	No
Vendor	Miltenyi Biotec
Catalog number	pending
Tissue preservation method	FFPE
Organ or tissue used for validation	Palatine tonsil
Organ Uberon ID	UBERON:0002373
Antibody-based imaging method	MICS (MACSima)
Conjugate	PE
Author ORCID	0000-0002-1297-9725
Vendor Affiliation	www.miltenyibiotec.com