Nordic immunohistochemical Quality Control

NordiQC

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I

Immunohistochemical double stainings – overview, considerations and applications

Michael Bzorek

Histotechnologist

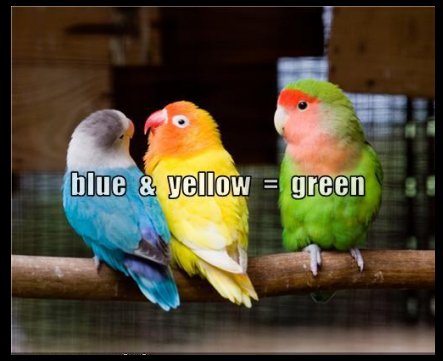
Department of Surgical Pathology

University Hospital, Region Zealand, Denmark

Multiplex staining techniques (IHC)

Multiple staining can be defined as the detection of two or more antigenic epitopes on one slide

- ❑ Determine whether targets are present in different cells
- ❑ Determine whether targets are present in the same cell
- ❑ Determine whether targets are present in the same cellulare compartment



Double or multi-labeling techniques - Advantages:

Save tissues due to increasing demand for less invasive sampling techniques (smaller and fewer specimens available)

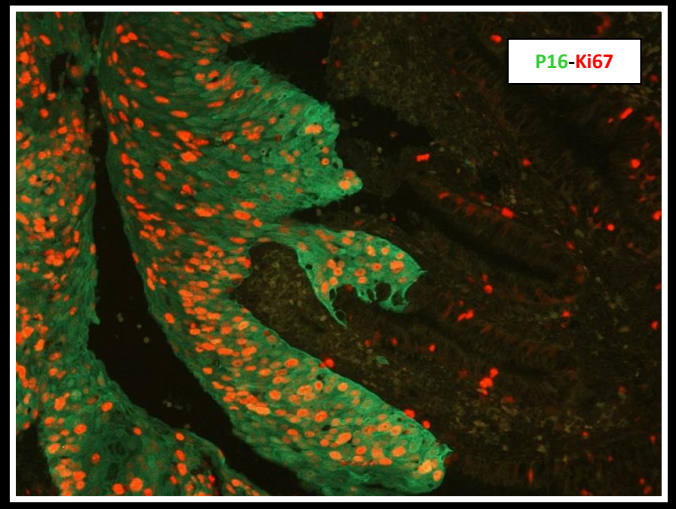
Overcomes some of the problems related to performing serial sections

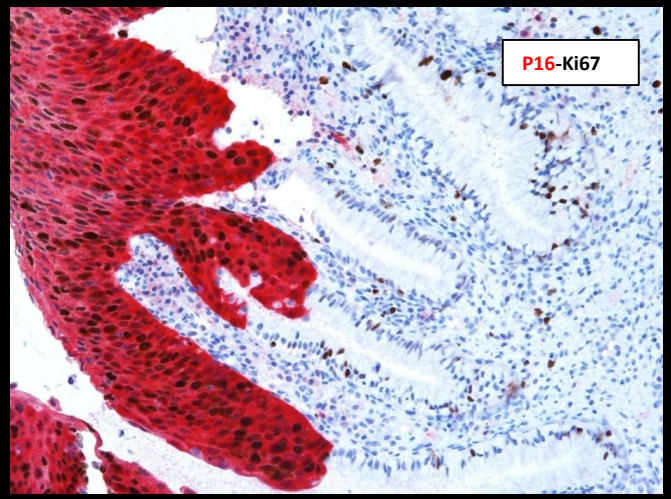
- ➢ Cellulare structures or small foci of tumor cells may be lost during processing.

Saves time (quick overview)

Saves “reagents”

Cervix / dysplasia





Double labelling techniques (IHC)

Basic procedures:

- ❑ Cocktails single staining technique (e.g. PAN-CK, AE1/AE3; PIN)
- ❑ Sequential double-staining technique
- ❑ Simultaneous double-staining technique
- ❑ Double (multi) sequential & erasing staining technique (SIMPLE)
- ❑ Virtual double (multi) staining technique

Immuno-enzymatic techniques

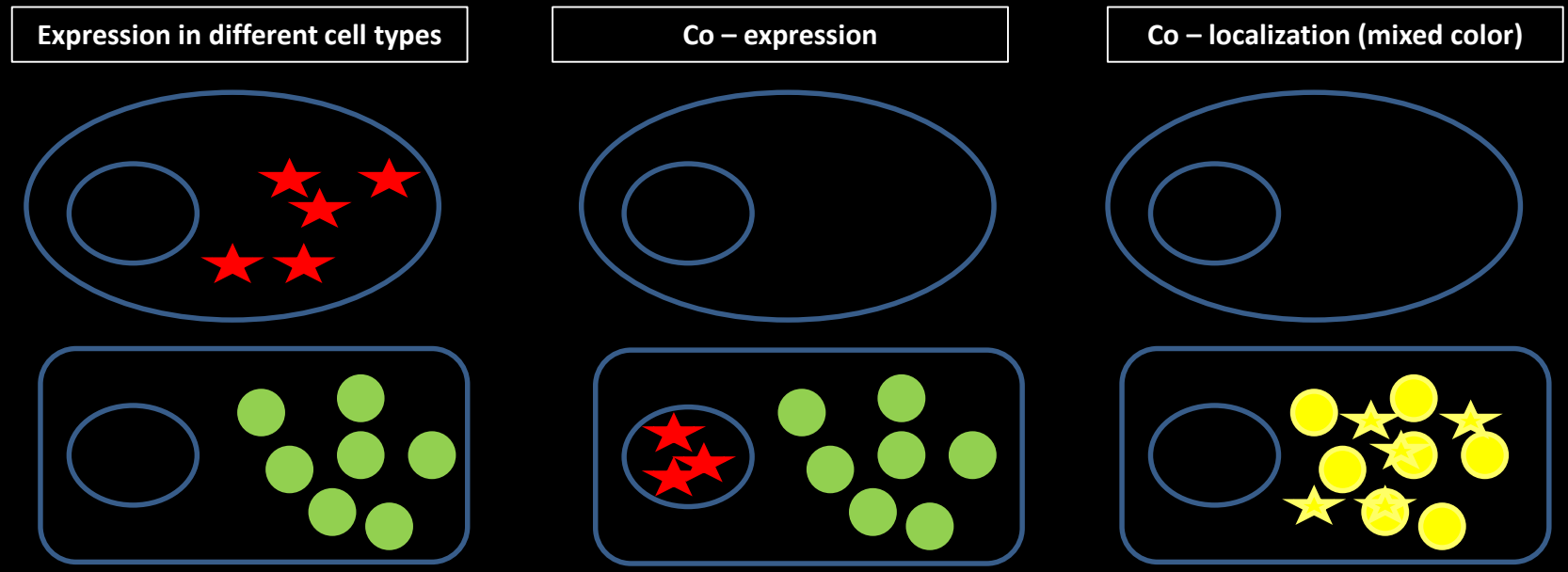
Immuno- fluorescence techniques

Multiplex staining techniques (IHC)

Requirements ("traditional double-staining techniques") :

- Two different visualization systems showing no cross-reactivity
- Two different chromogens showing high color contrast and allowing mixed colors at sites of co-localization

Expression patterns:



Challenges or considerations performing multiplex staining techniques:

Which double or multi-staining technique should I use ?

Pre-treatment - do the antigens of interest require the same Epitope retrieval procedure ?

Is the primary Abs available and in which form (important using simultaneous labelling techniques) ?

Is the primary Abs made in different host (e.g. mouse, rabbit) ~ If not
Is the primary Abs of different Immunoglobulin type (e.g. IgG, IgM) or subclass (e.g. IgG1, IgG2) ~ If not
Is the primary Abs available as conjugate (e.g FITC, biotin)
Do the primary Abs have the right specificity and sensitivity

Is the detection systems of choice specific and sensitive - Interspecies cross reactivity (specificity) ?

Is secondary Abs (app. conjugate) available matching choice of the primary Abs (important using simultaneous techniques)
Interspecies cross reactivity between primary Abs and secondary Abs (detection system) – pre-absorbed ?
Interspecies cross reactivity between secondary Abs (secondary Abs made in different host`s) – pre-absorbed ?

Which chromogens /fluorochroms should I use - depending on:

Type of conjugate (e.g. HRP, AP, Fluorochrom)
Color compatibility and allowing mixed color of chromogens (spectral differentiation) at sites of co-localization
Equipment (bright field versus fluorescence microscopy)

How can I inactivate the first set of antibody reagents (important using sequential labelling techniques) ?

Elution of immuno-reagents (Abs) / Heat inactivation
Take advantage of that DAB, DAB based or metallic deposit can shelter /block for following immunoreagents
How can I control the efficiency of the inactivating protocol

Controls

iCAPs - compare individual staining results of the multi labelling technique with optimal single staining procedure (routine)

Double staining using sequential technique (Immuno-enzymatic)

- Preferred method to detect antigenic epitopes in different cell types or in different cellular compartments (e.g. nuclei and cytoplasma)

- The primary antibodies is applied in sequence , detected and visualized individually with two different detection (HRP and/or AP conjugates) & chromogen systems (e.g. DAB and/or Fuchin-Red).

- Each antibody: antigen reaction will yield a specific color of staining that can be easily identified.

- Primary antibodies may be of either the same or different host , Ig-type/subclass (e.g. mouse/IgG1)

- Visualization with DAB, DAB based chromogens or EnzMet (metallic silver) in the first sequence(s) of the detection procedure shields for un-wanted reaction of the following primary antibodies or detection reagents

Not suitable for detection of co-localized signal.

Double staining using sequential technique (Immuno-enzymatic)

Sequential procedure (Immuno-emzymatic):

Pre-treatment (Antigen Retrieval)

First primary Ab (same or different host, Ig-type or subclass) (20 min).
Detection with Quanto/HRP (10+10 min).
Visualization with Deep Space Black (DAB/Ni ?) (10 min).

Second primary Ab (same or different host, Ig-type or subclass) (20 min).
Detection with Hi-Def /AP (10+10 min).
Visualization with Warp Red (Fuchin-Red) (7-20 min).

Counterstain, dehydration and mounting.

DAB reaction product of the first set of immunoreagents create a barrier that is impermeable for the second set of immunoreagents ~ no cross reactivity

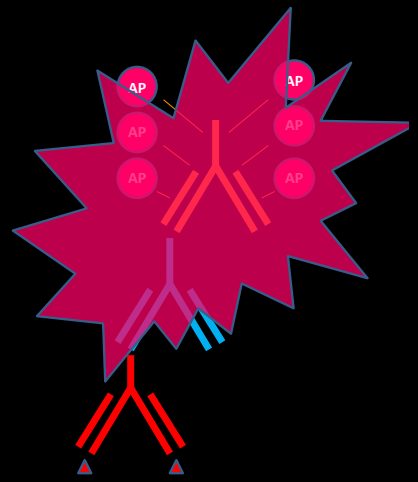
Sternberger LA, Joseph SA. J Histochem Cytochem 27:1424, 1979

Valnes K and Brandtzaeg P . J Histochem Cytochem 1982; 30(6) 518-524.

Metallic deposits (e.g. EnzMET) has the same ability

Inactivation step or blocking procedures not needed

1.Set of Immuno-reagents
Deep Space Black
DAB/Ni ?



2. Set of Immuno-reagents
Warp Red
Fast Red / Fuchin-Red

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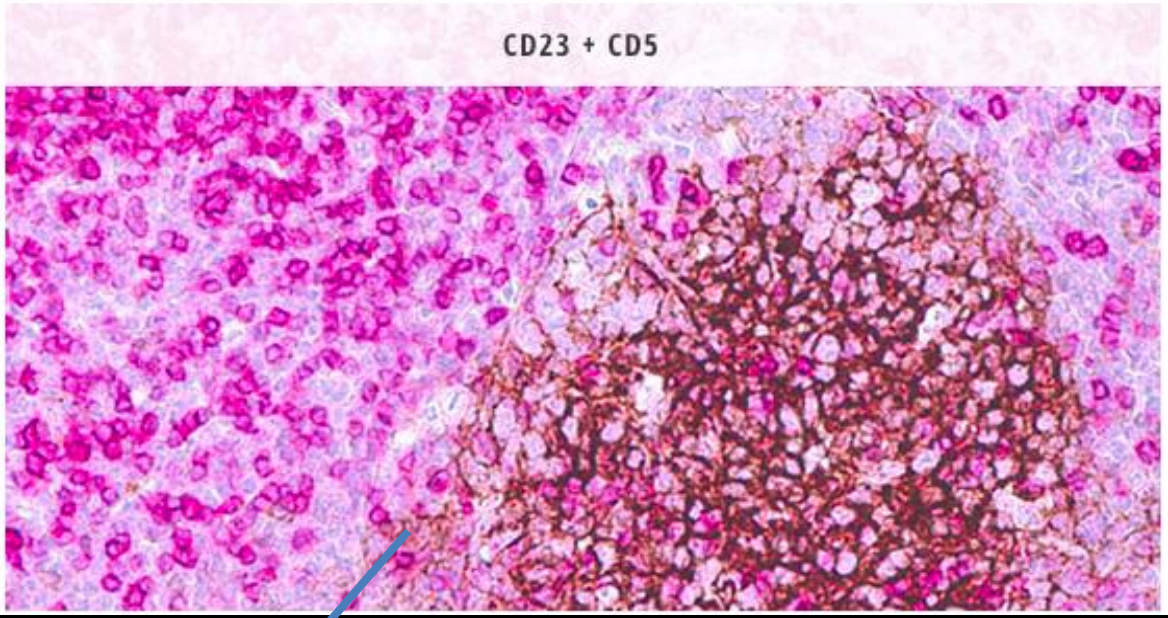

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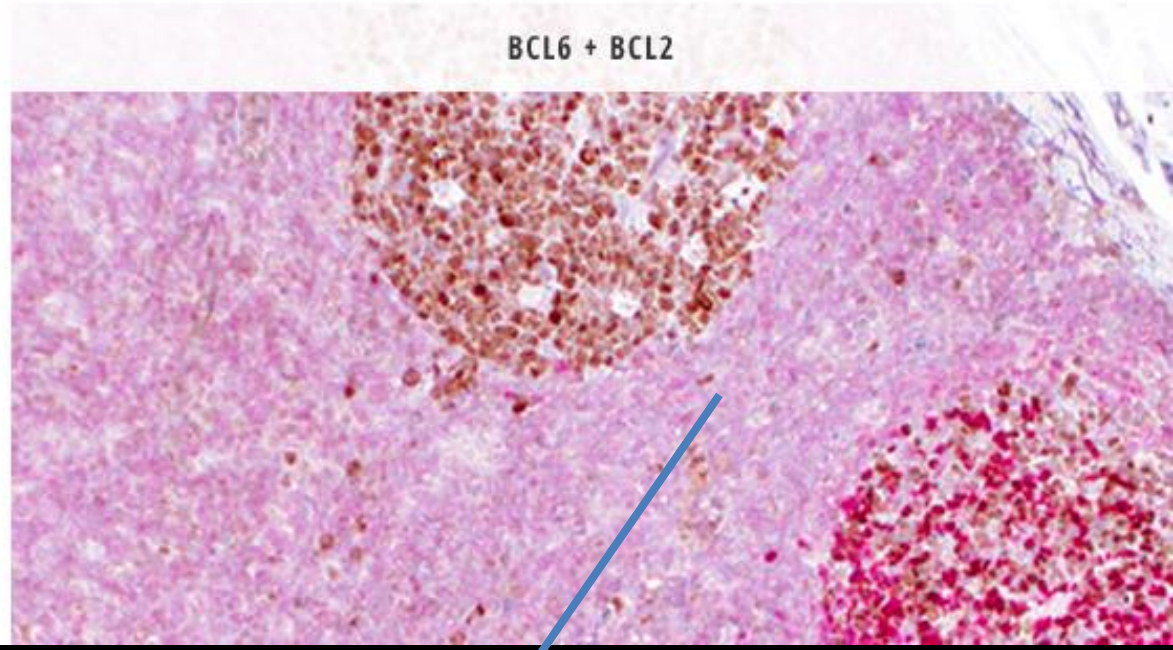


Poor demonstration of both BCL2 and BCL 6

Co-localization in CLL ? (DAB deposit shields for demonstration of the second antigen of interest)

Be critical in selection of antibody pair combinations and performance of the assays giving by different manufacturer´s

Optimizing double immuno-staining protocol

Sequential staining : Either DAB based (shielding properties) or with blocking procedures between reaction series A & B

Testing:

- Antibody A (dilution series) → Detection A → Chromogen A
- Antibody B (dilution series) → Detection B → Chromogen B

→ Calibrate titre (both primary antibody A & B) according to iCAPs

- Antibody A → Detection A → Chromogen A
- Diluent → Detection B → Chromogen B

→ Control 1 (only reaction for A should be observed – no co-localized signals)

- Diluent → Detection A → Chromogen A
- Antibody B → Detection B → Chromogen B

→ Control 2 (only reaction for B should be observed – no co-localized signals)

- Antibody A → Detection A → Chromogen A
- Antibody B → Detection B → Chromogen B

→ Double staining

Remember:

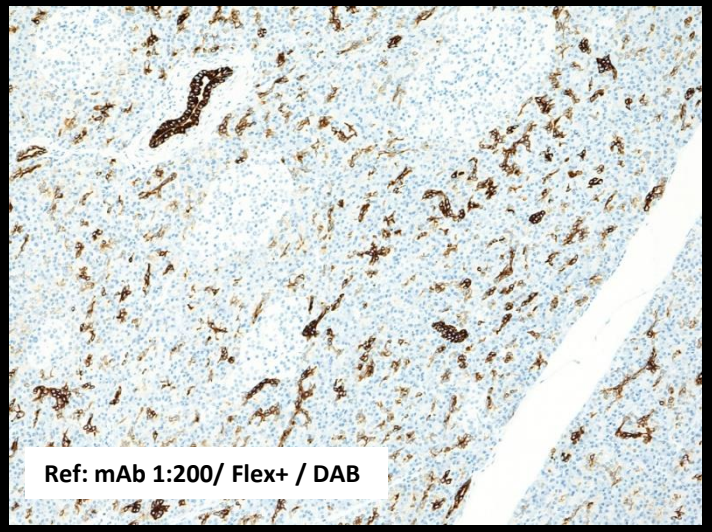
Not suitable for detection of co-localized signal as a DAB based chromogen is involved in the first set of immuno-reactions (Sequence A).

Typical end-result including controls: Optimizing the protocol

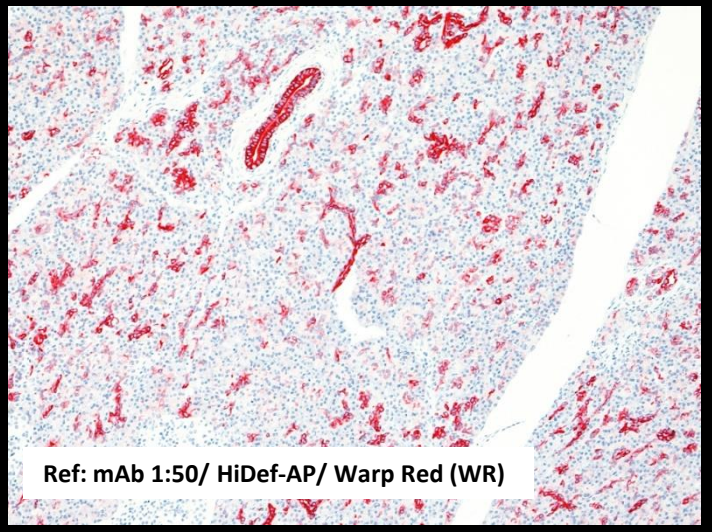
CDX2 (EP25) + CK7 (OV-TL 12/30)

Pancreas

CK7, OV-TL12/30

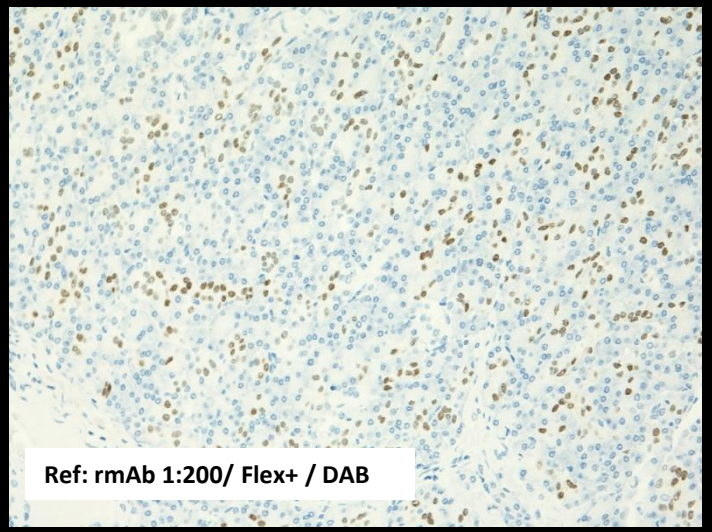


Ref: mAb 1:200/ Flex+ / DAB

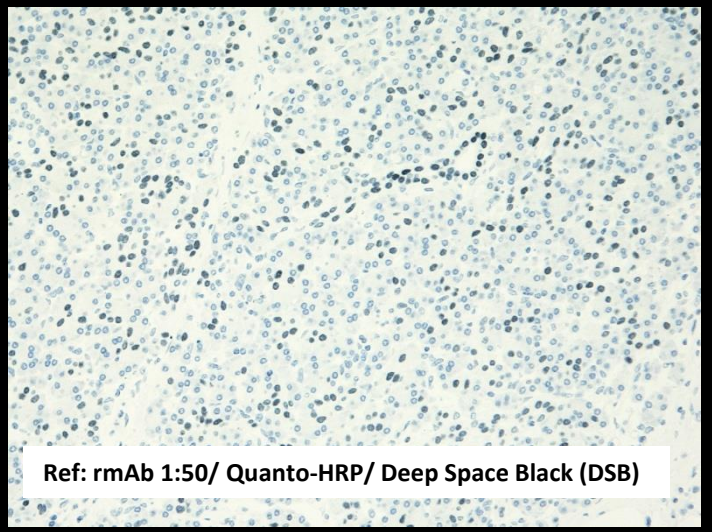


Ref: mAb 1:50/ HiDef-AP/ Warp Red (WR)

CDX2, EP25



Ref: rmAb 1:200/ Flex+ / DAB

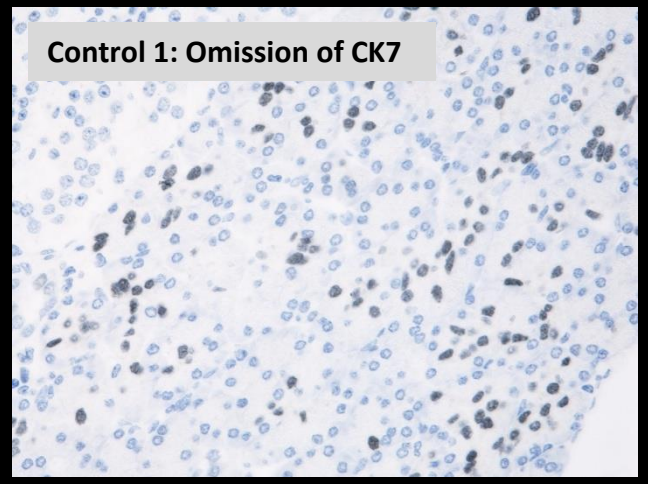


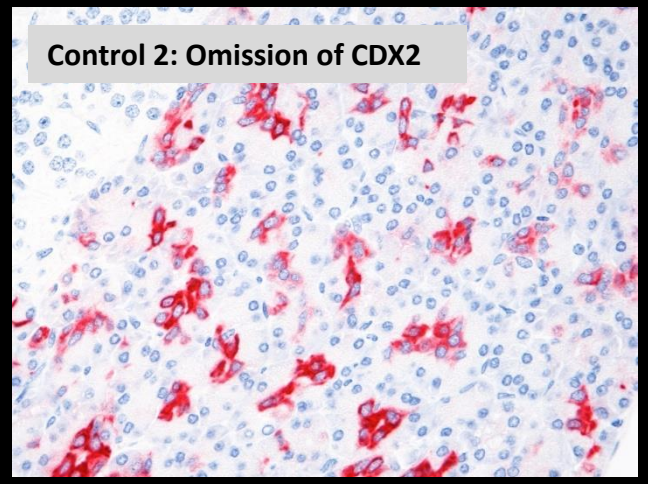
Ref: rmAb 1:50/ Quanto-HRP/ Deep Space Black (DSB)

Typical end-result including controls: Optimizing the protocol

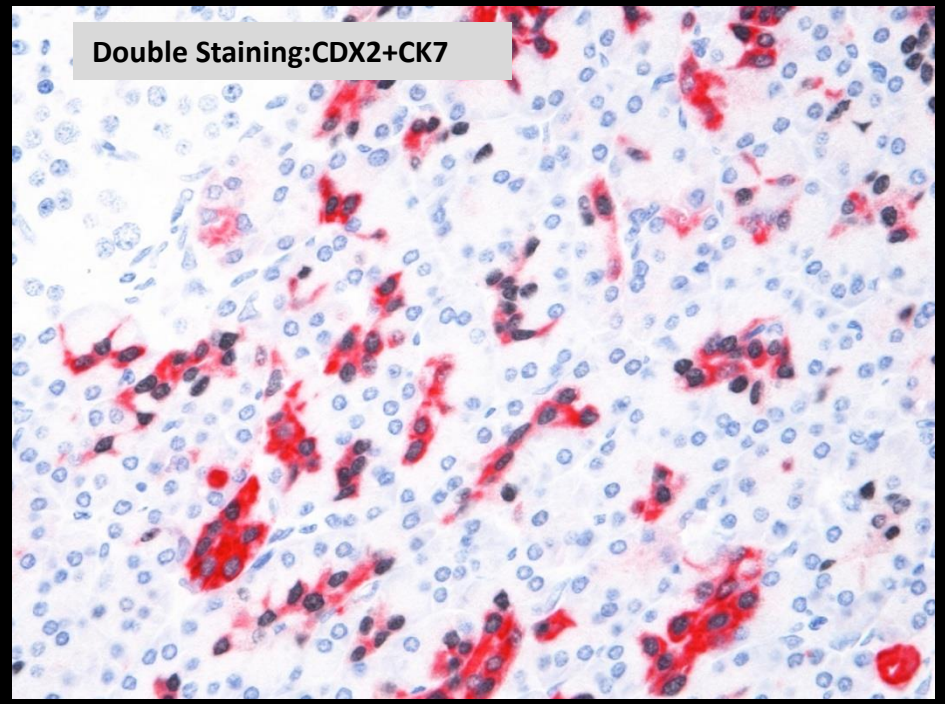
Optimal dilutions of CDX2 (EP25 1:50) and CK7 (OV-TL 12/30 1:50)

Sequential staining : Quanto-HRP/ DSB followed by HiDef-AP/WR





Pancreas

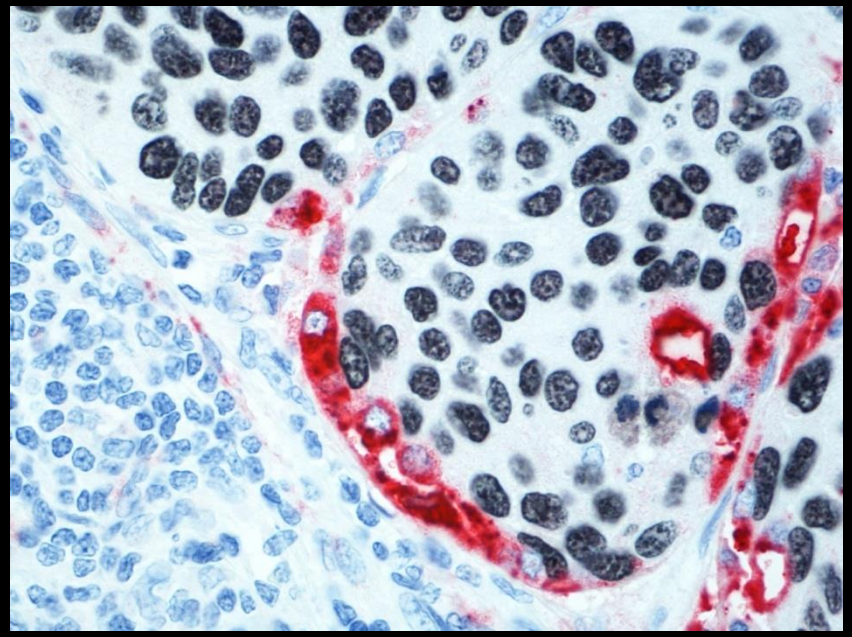


Note : Efficient sheltering capacity of Deep Space Black

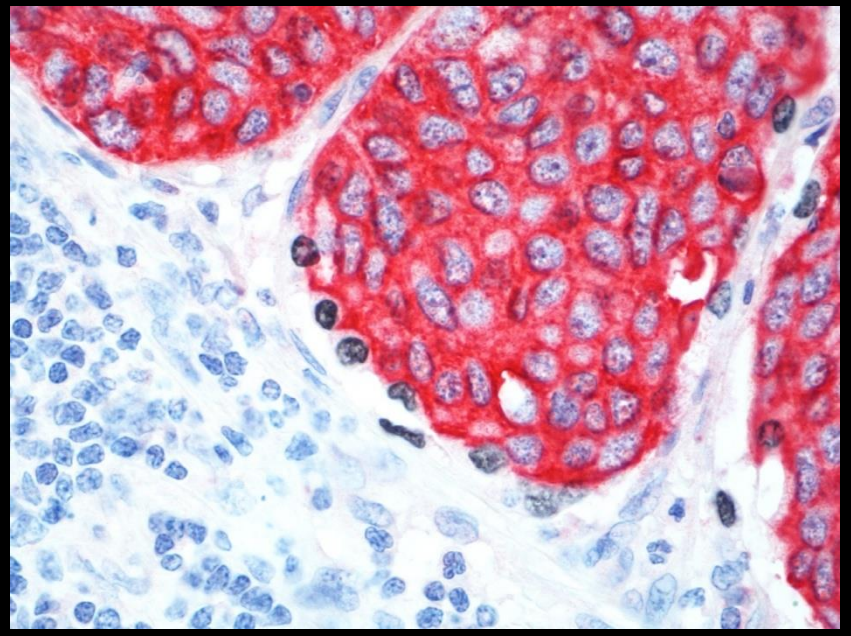
No mixed colors or double colors within controls and in the double staining for CDX2+CK7 (Intercalating ducts of the pancreas are positive for both markers)

Double staining using sequential technique (Immuno-enzymatic)

P40, BC28 (1:25) + Napsin, IP64 (1:100) (Mab+Mab)



TTF1, SPT24 (1:25) + CK5,XM26 (1:100) (Mab+Mab)



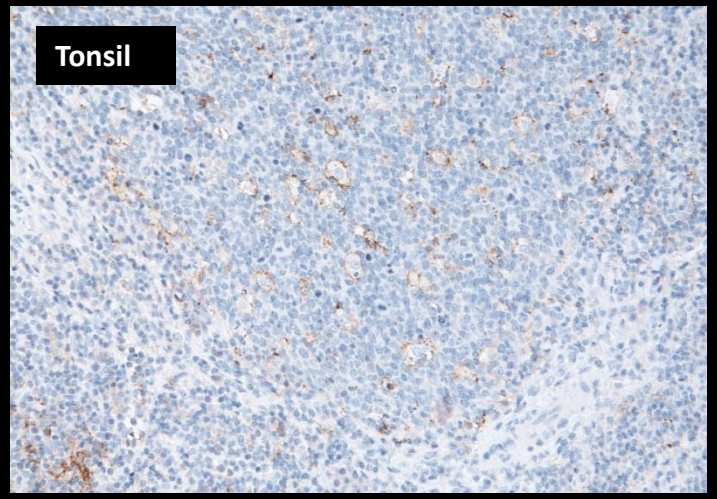
Lung : Squamous cell carcinoma

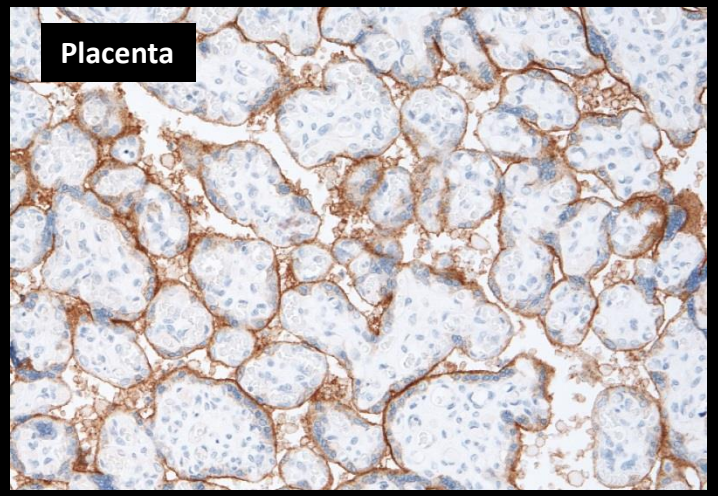
Other useful combinations: P40 + CK5 and/or TTF-1+ Napsin A

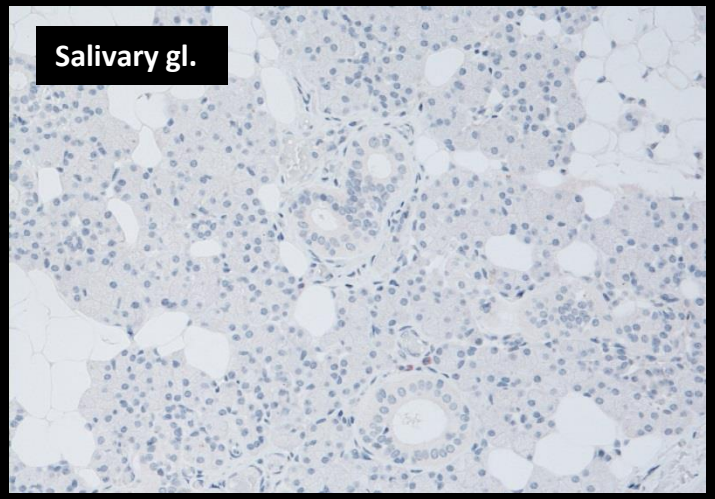
Double staining using sequential technique (Immuno-enzymatic)

Lung adenocarcinoma (metastasis to the intestine)

Controls (PD-L1)

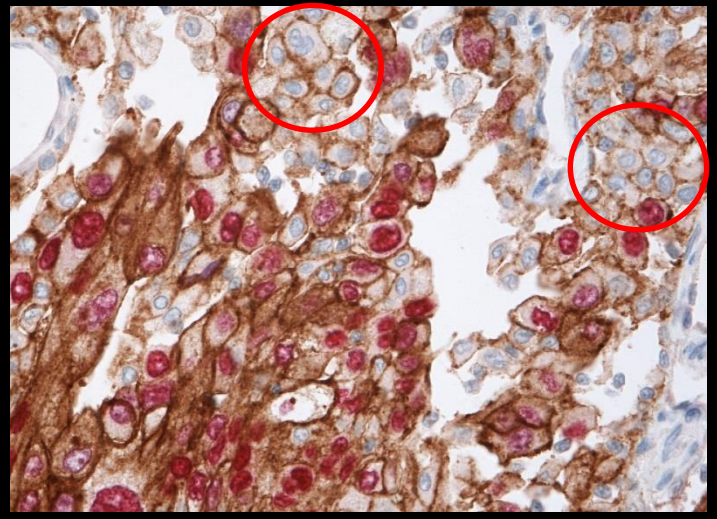






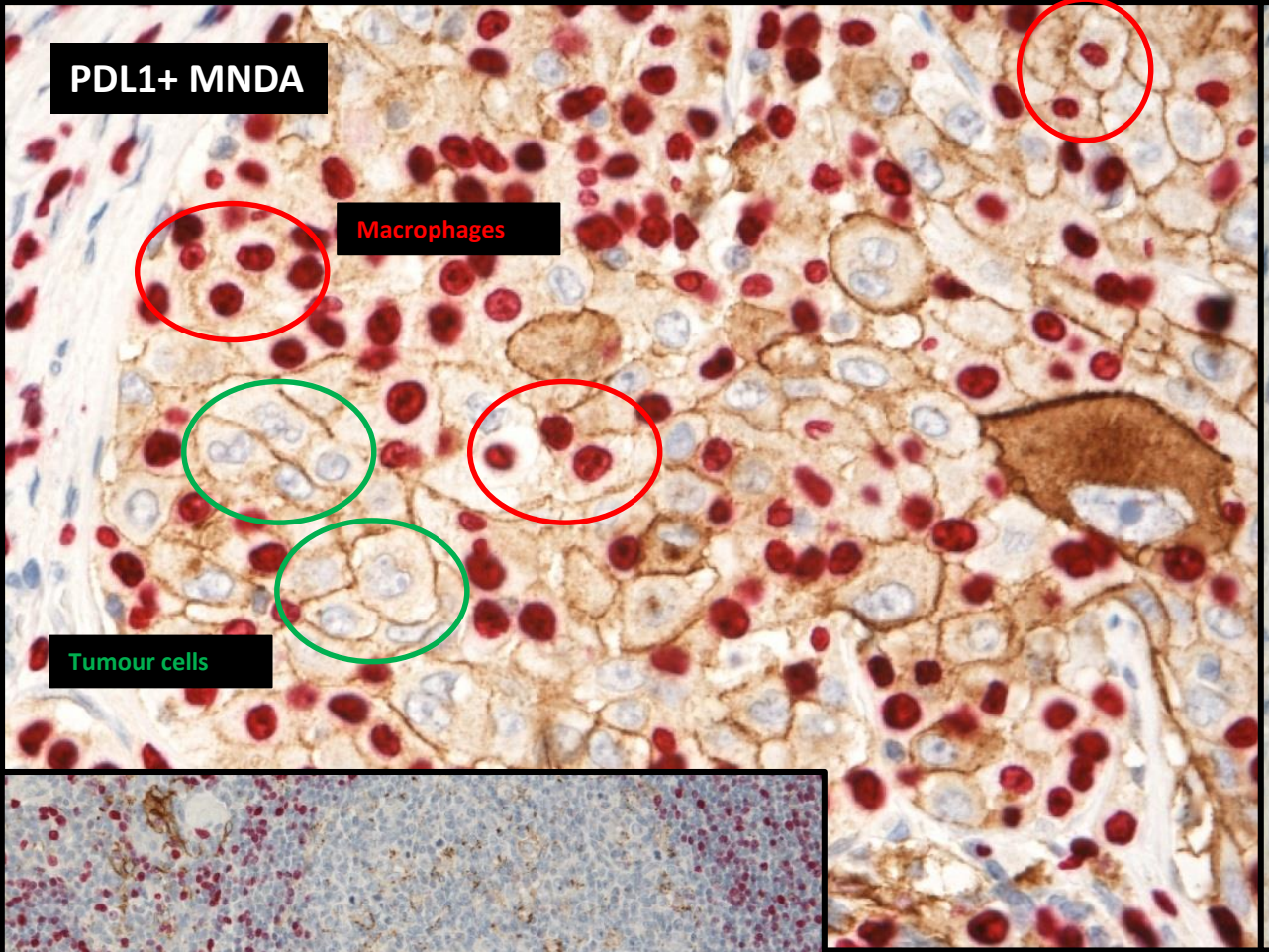
Omnis: PD-L1, 22C3 (1:20) + TTF1, SPT24 (1:200) / HIER Low 40` (mod. Flex+ 40-10-40 & Histo-AP 30-10-20)

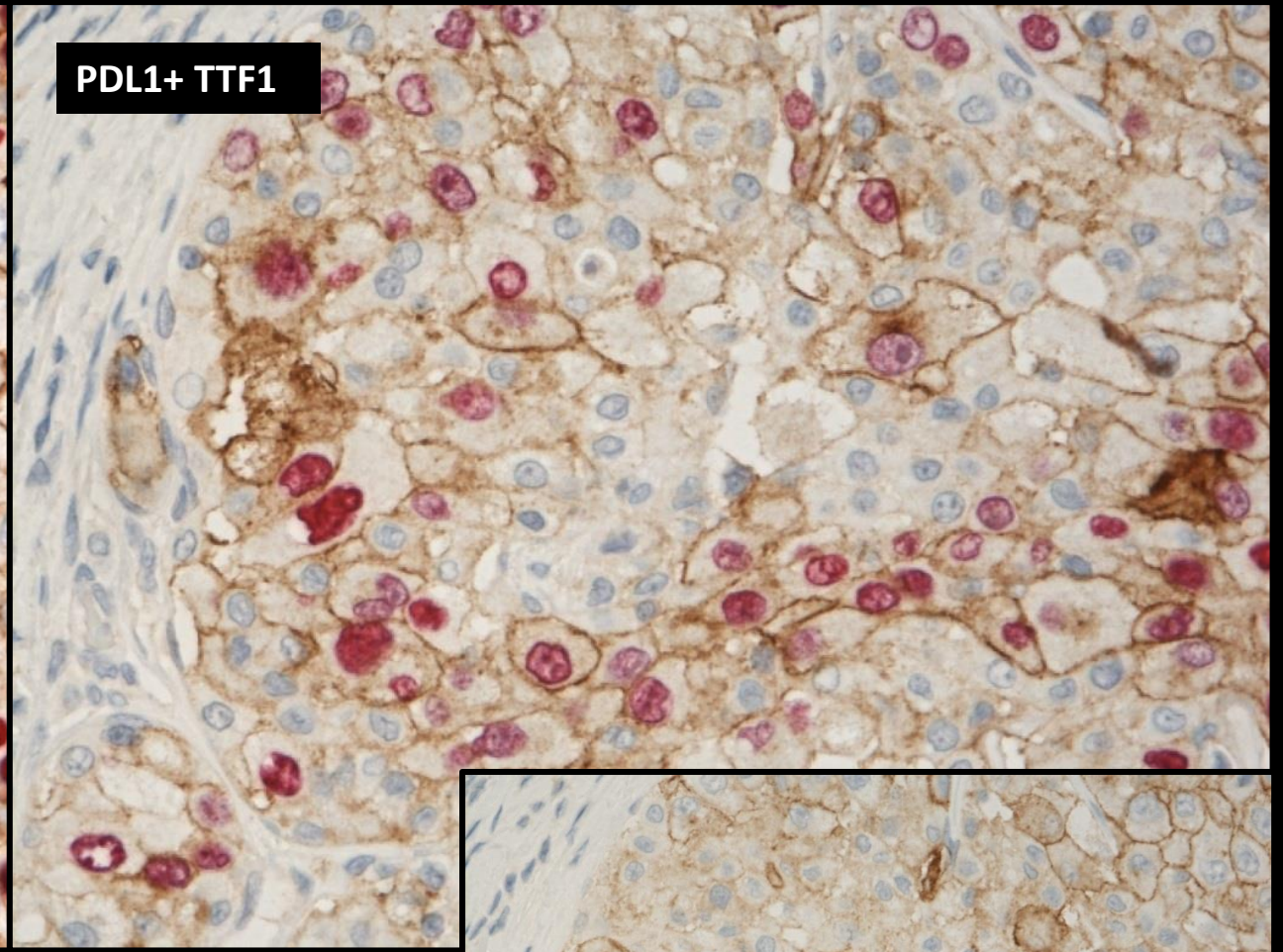
Lung adenocarcinoma

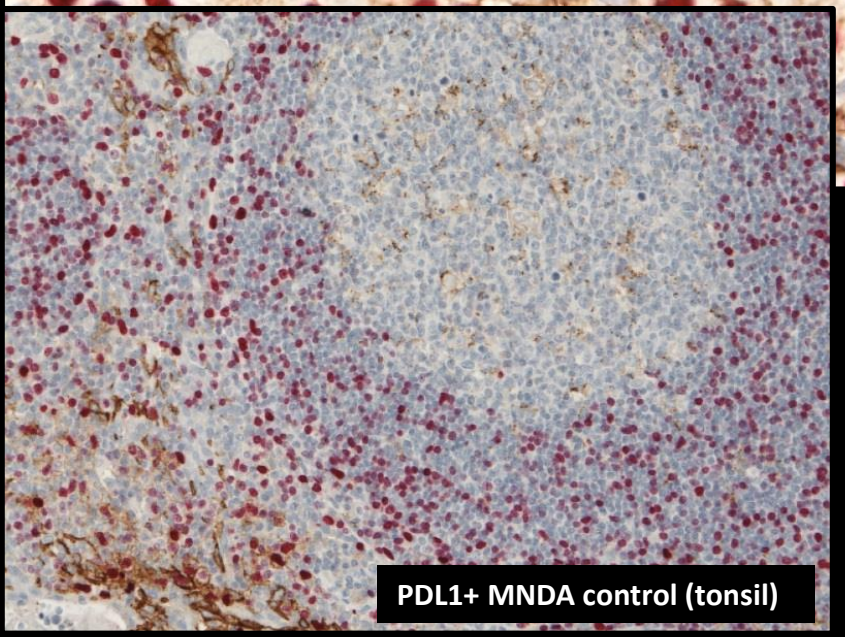


Macrophages ?

Tumour cells ?







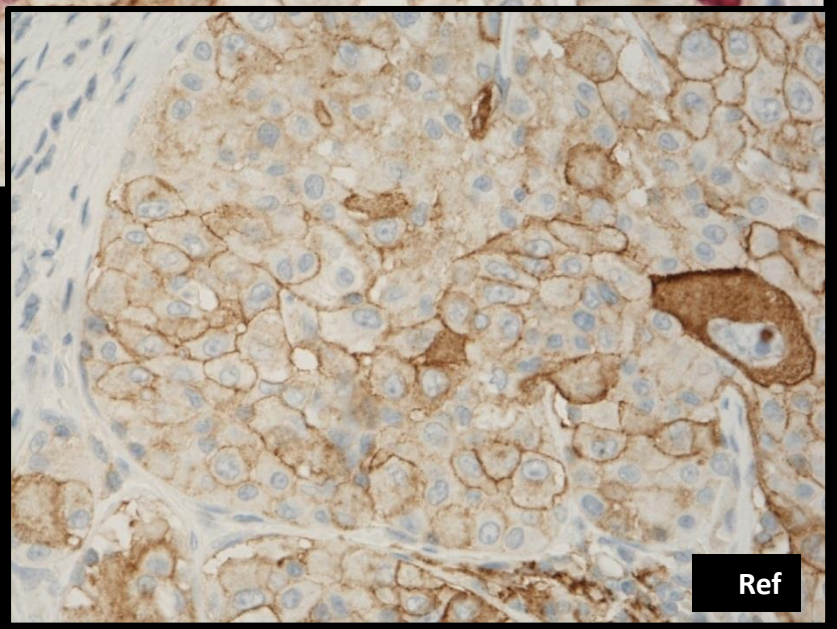
Lung adenocarcinoma

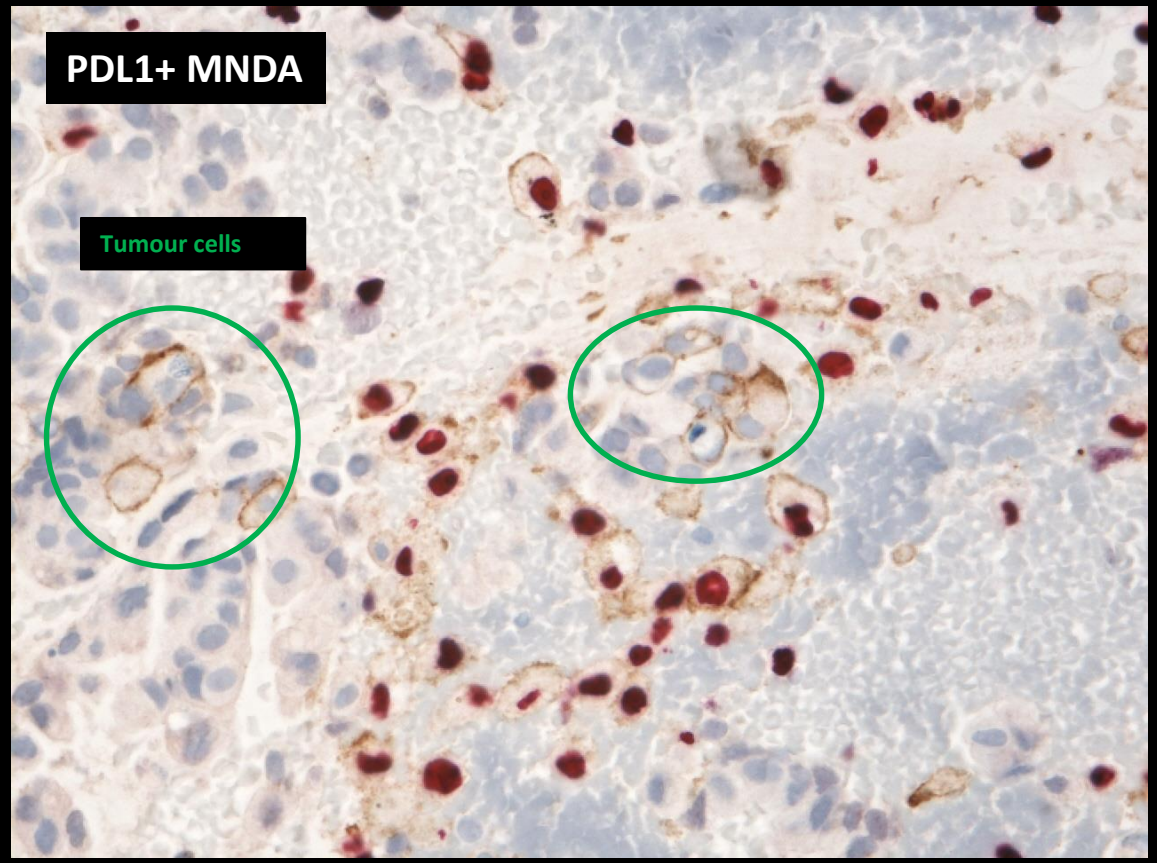
Omnis: HIER Low pH 40`

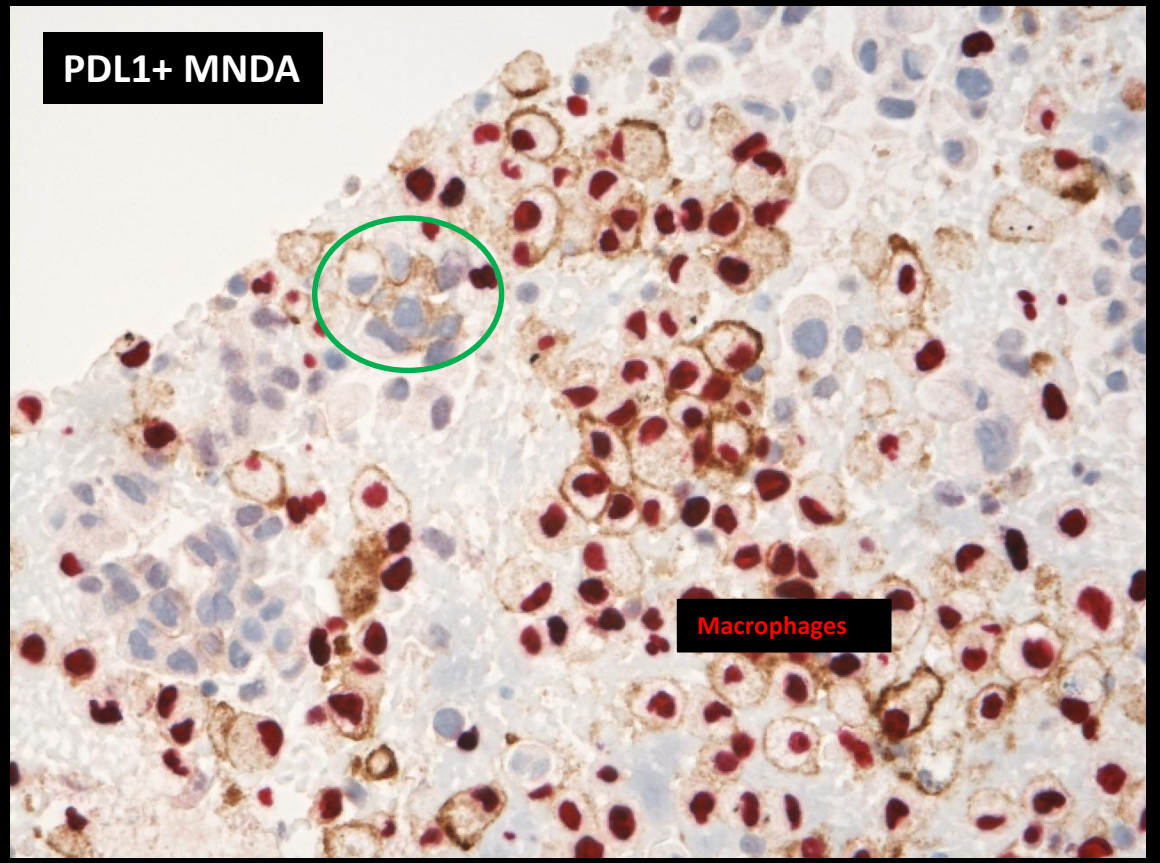
PD-L1, 22C3 (1:20) /Flex+ 40-10-40

1. MNDA, 253A (1:80) / Histo-AP 30-10-20

2. TTF1, SPT24 (1:200) / Histo-AP 30-10-20





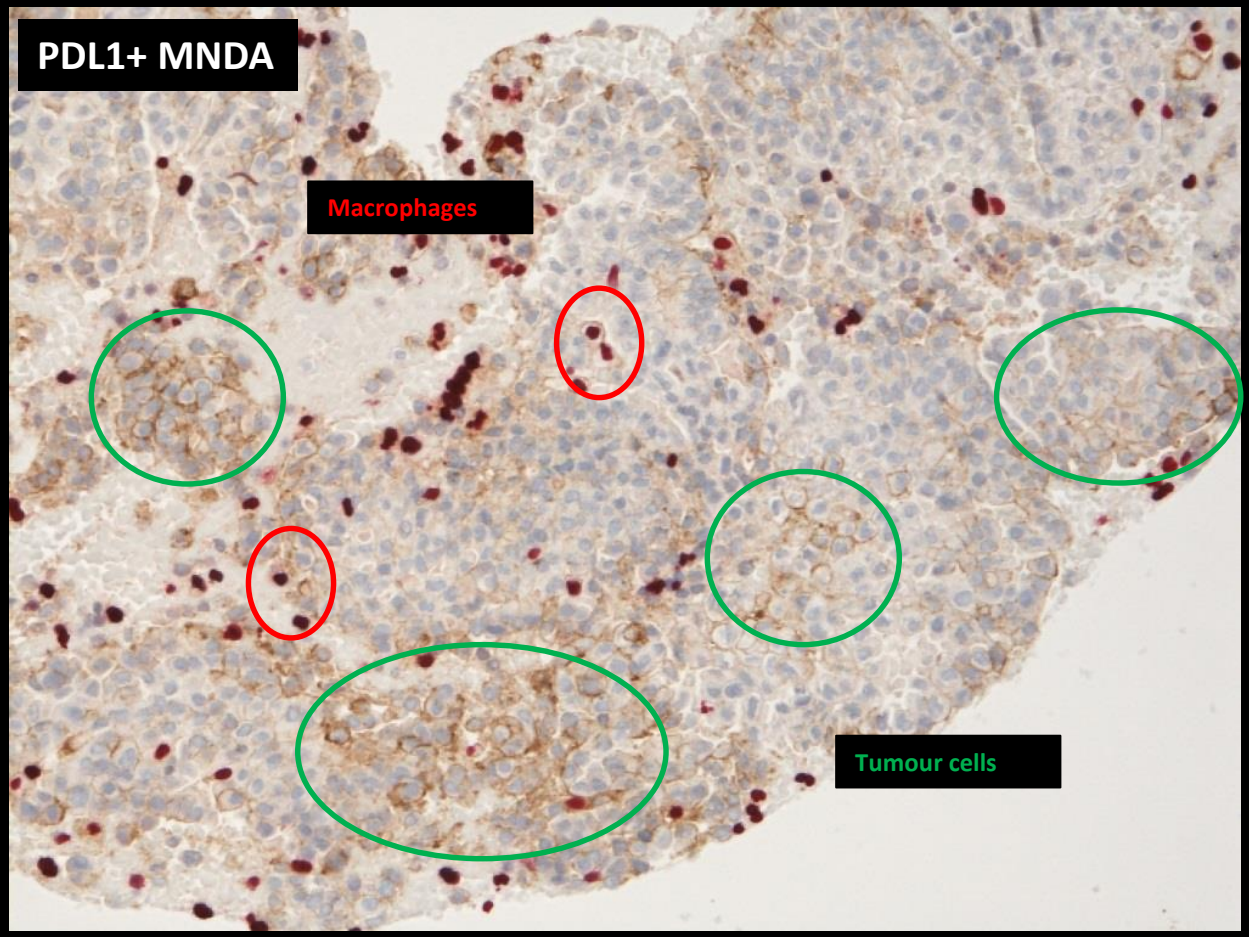


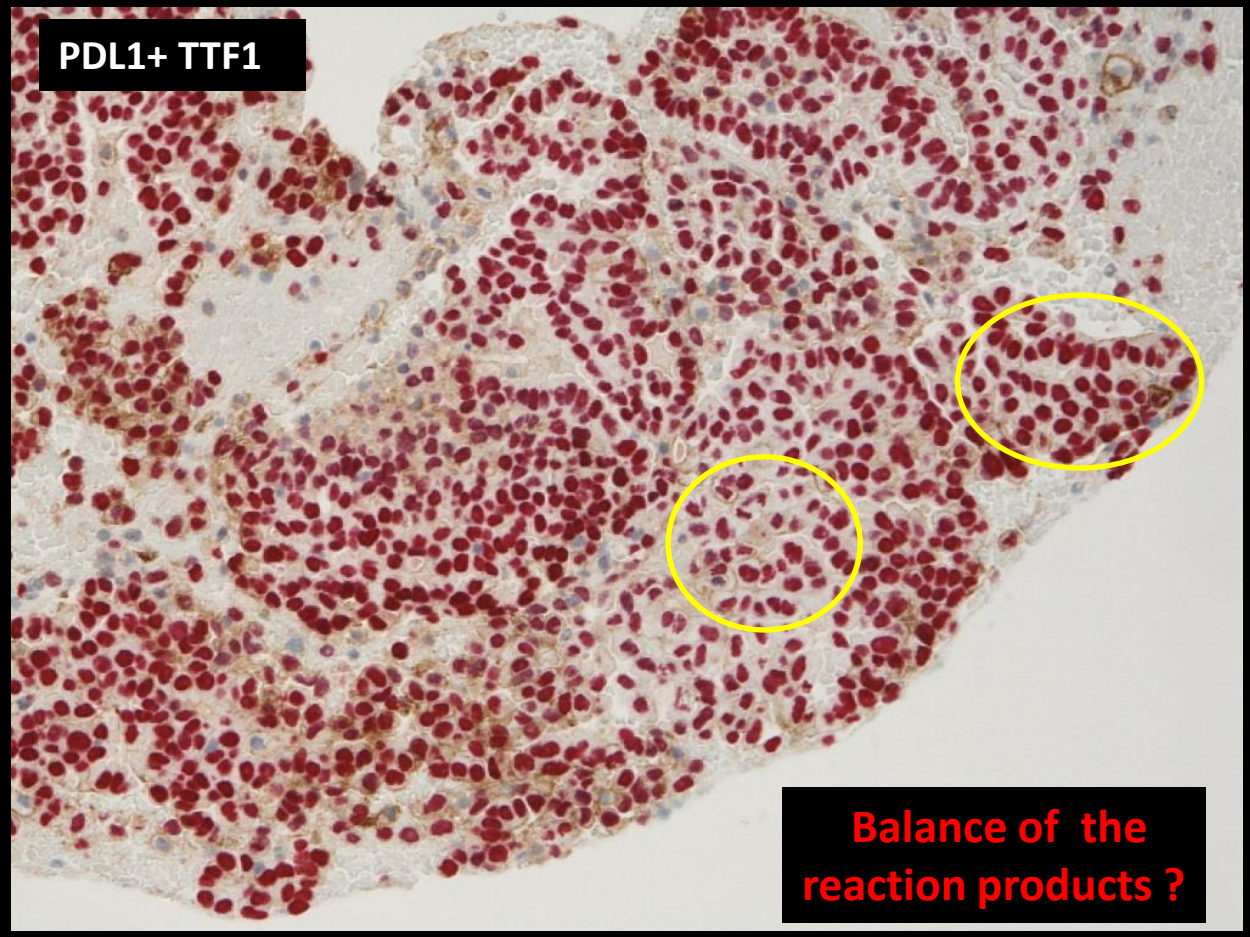
Lung adenocarcinoma

Omnis: HIER Low pH 40`

PD-L1, 22C3 (1:20) /Flex+ 40-10-40

MNDA, 253A (1:80) /Histo-AP 30-10-20



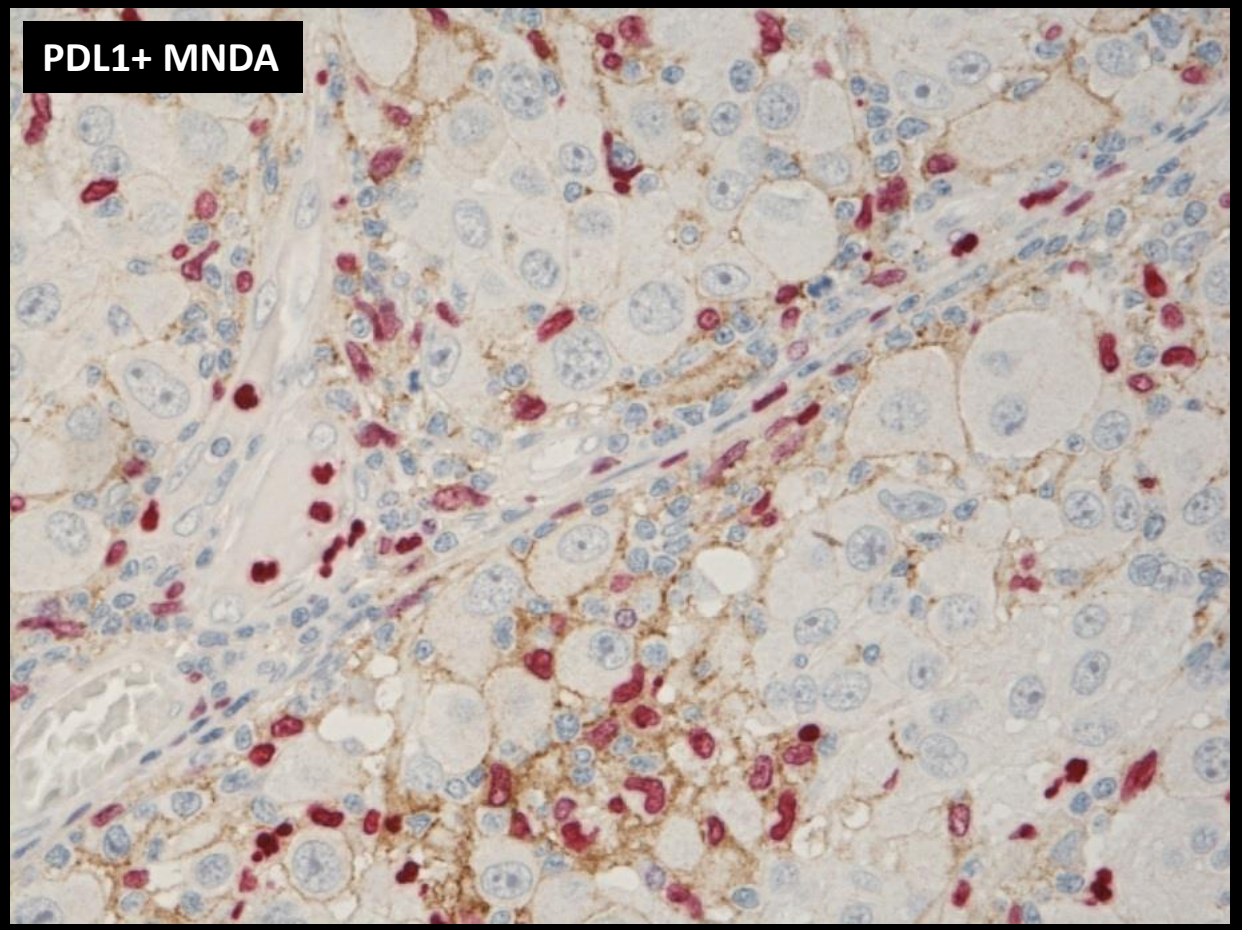


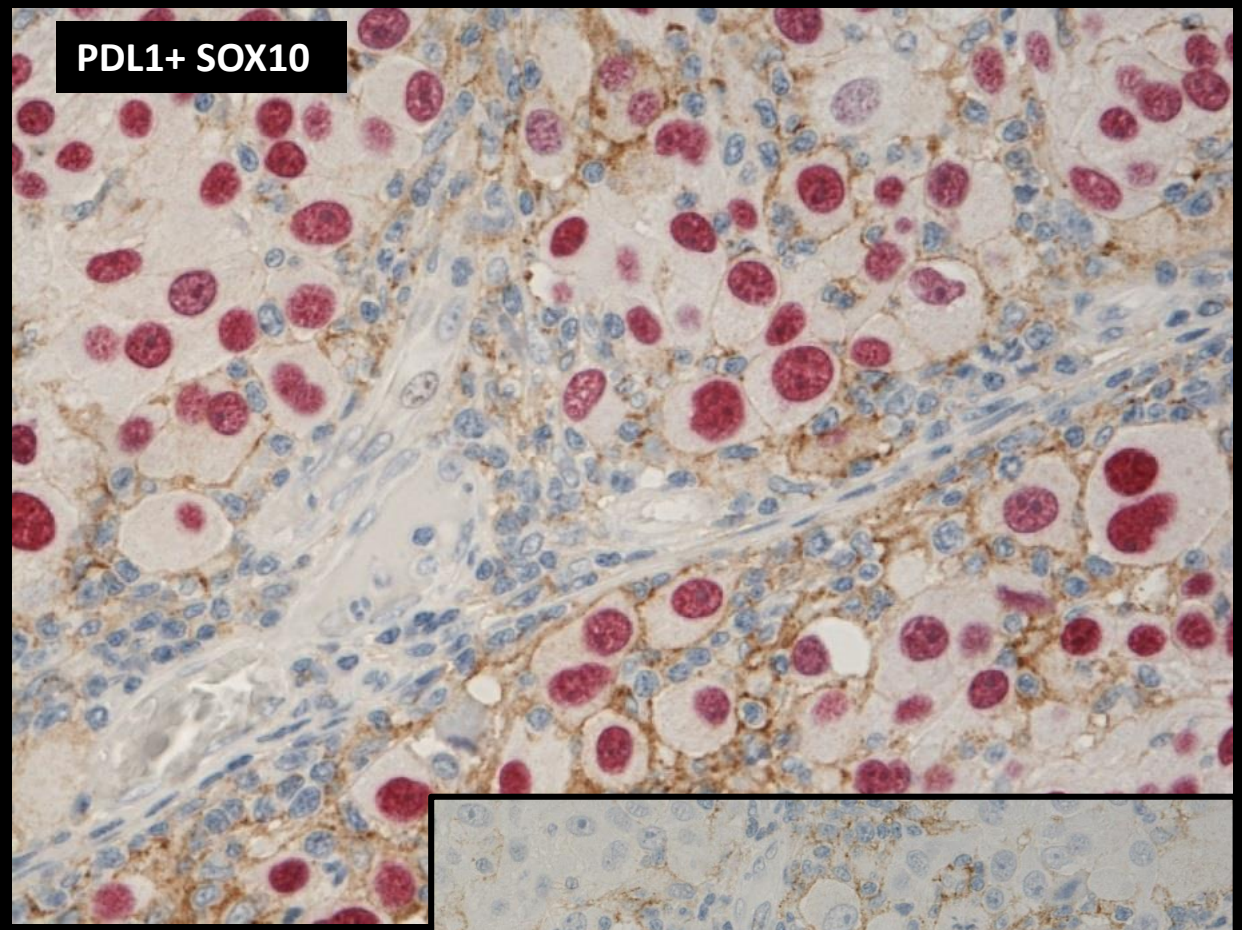
Lung adenocarcinoma

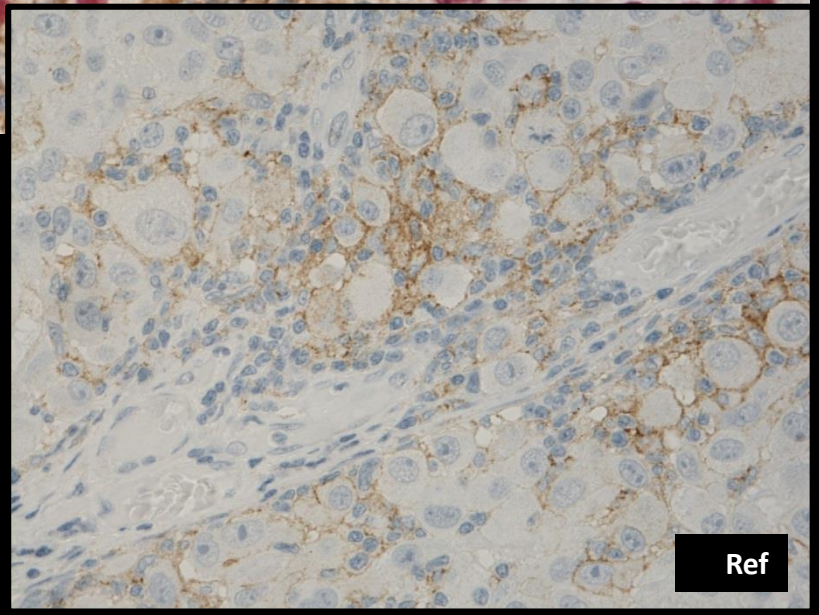
Omnis: HIER Low pH 40`

PD-L1, 22C3 (1:20) /Flex+ 40-10-40

MNDA, 253A (1:80) or TTF1, SPT24 (1:200) /Histo-AP 30-10-20





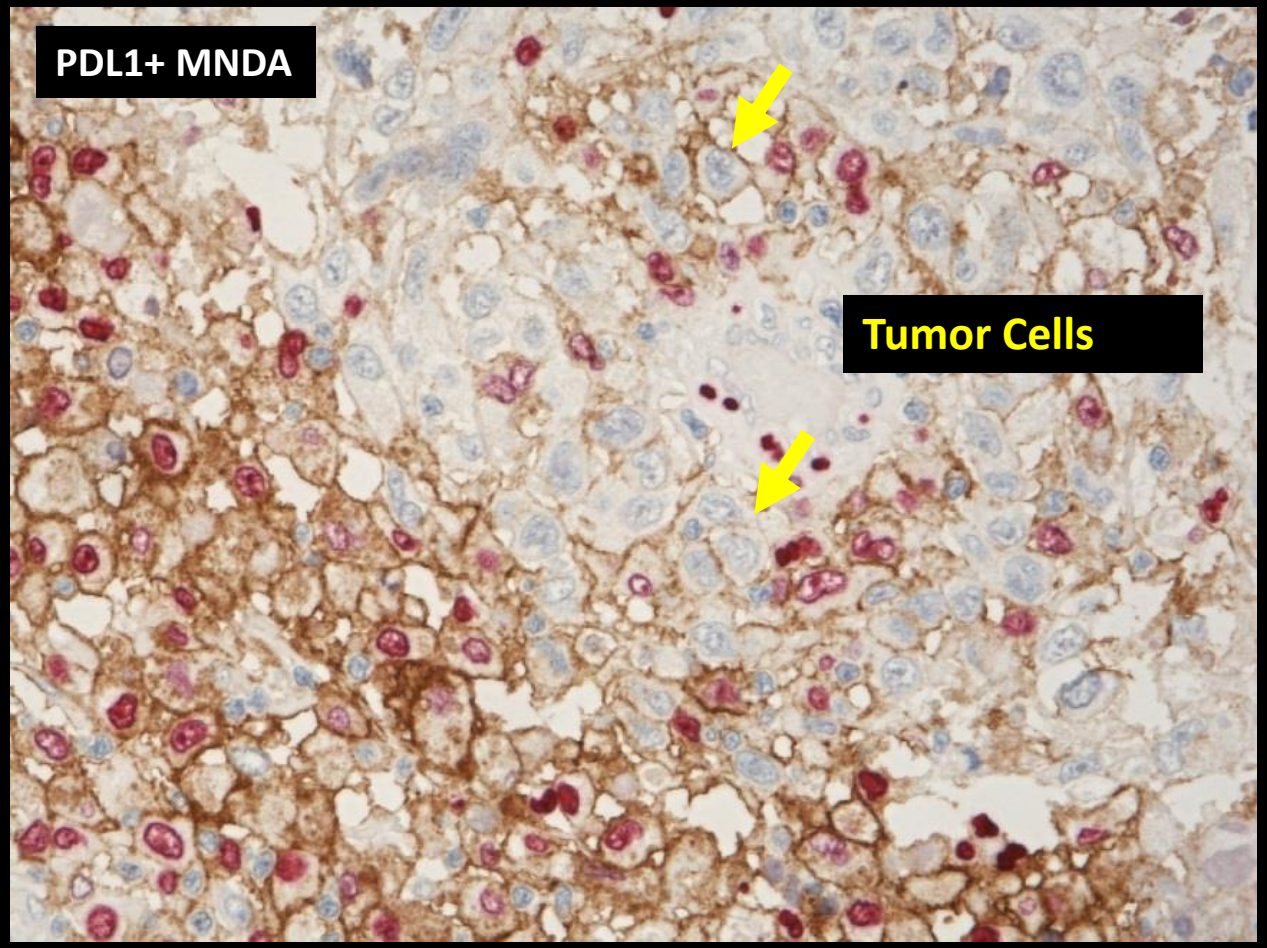


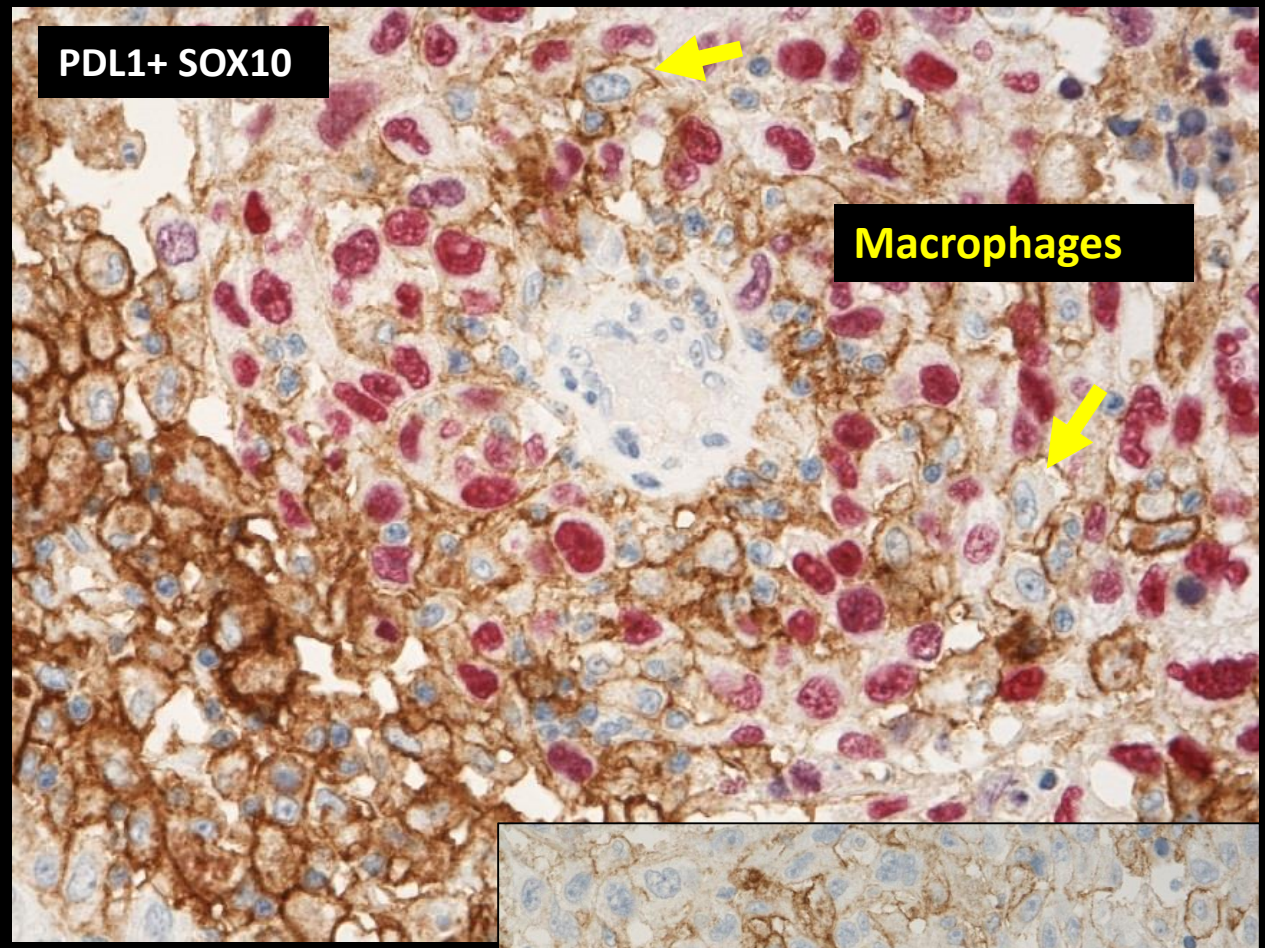
Melanoma

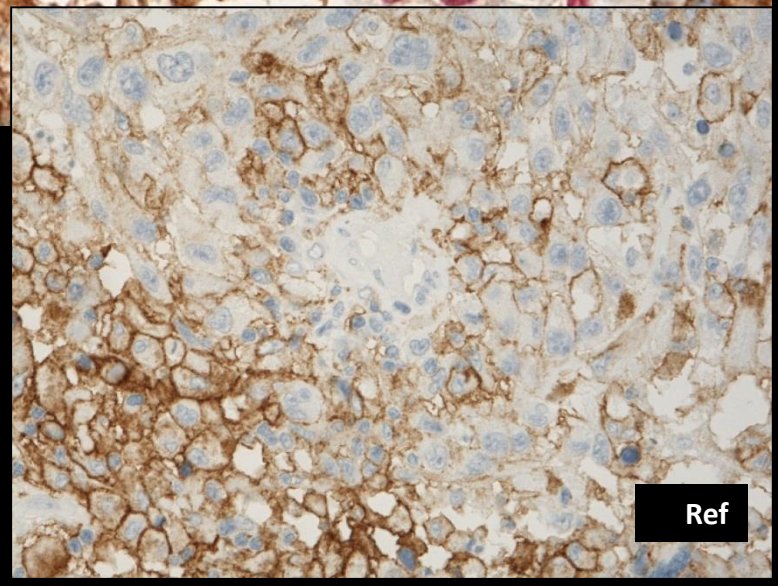
Omnis: HIER Low pH 40`

PD-L1, 22C3 (1:20) /Flex+ 40-10-40

MNDA, 253A (1:80) or SOX10, BS7 (1:200) /Histo-AP 30-10-20







Melanoma

Omnis: HIER Low pH 40`

PD-L1, 22C3 (1:20) /Flex+ 40-10-40

MNDA, 253A (1:80) or SOX10, BS7 (1:200) /Histo-AP 30-10-20

Double staining using sequential technique (Immuno-enzymatic)

The order of primary antibodies

In general:

- Nuclear markers before cytoplasmic or membranous markers
- Membranous markers before cytoplasmic

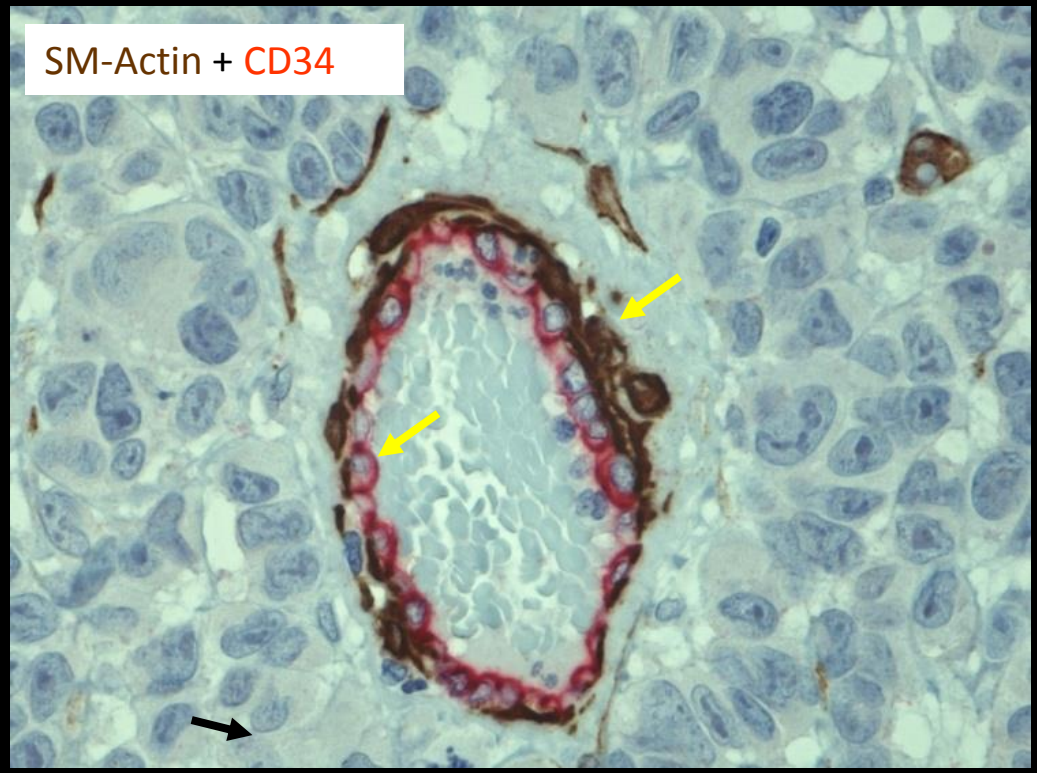
A reversed applications of the primary antibodies may un-ravel that :

DAB deposit shields for the second antigen of interest - first and second antigen are in close proximity with each other (false negative result)

Co-localized signals is present due to expression of the two antigens of interest in the same cellular compartment

Double staining using sequential technique (Immuno-enzymatic)

CD34 (QBEND 10) + SM-Actin (1A4)

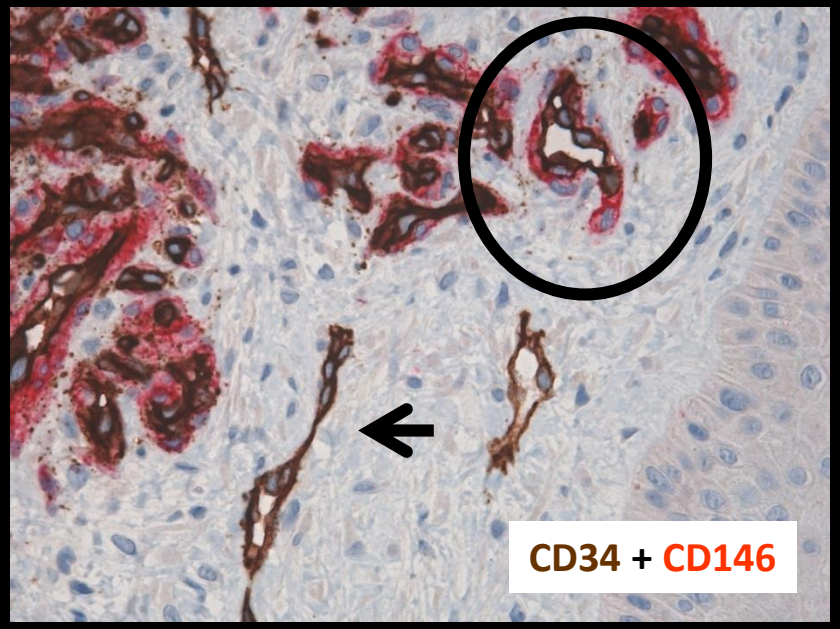


Note: No co-localization of either endothelium or smooth muscles (arrows)

Melanoma

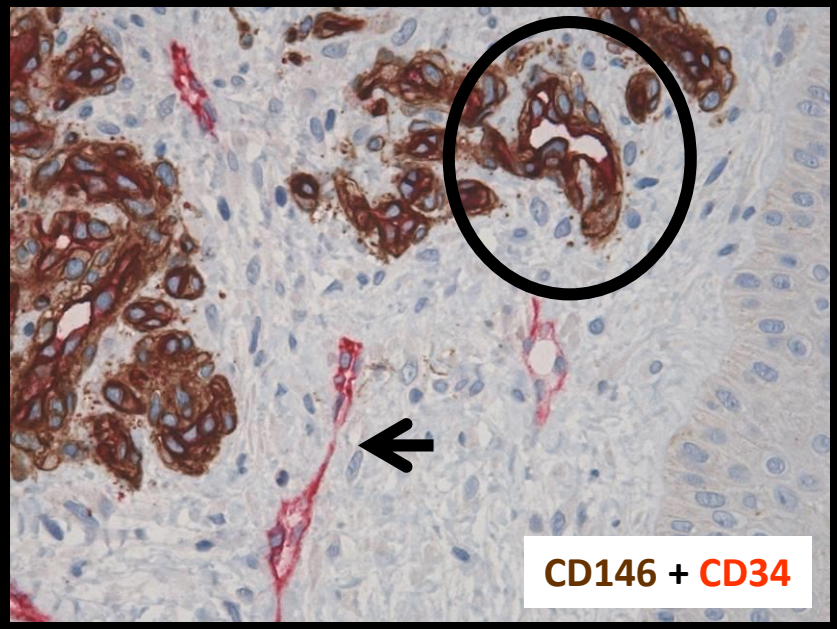
Double Immuno-staining – reversal stainings

CD34 (QBEND 10) + CD146 (EPR3208)



The order of primary antibodies

The brown deposit (DAB) from the first set of immuno-reagents hinder the second set of immuno-reagents (the red subsequent staining – compare the two images).

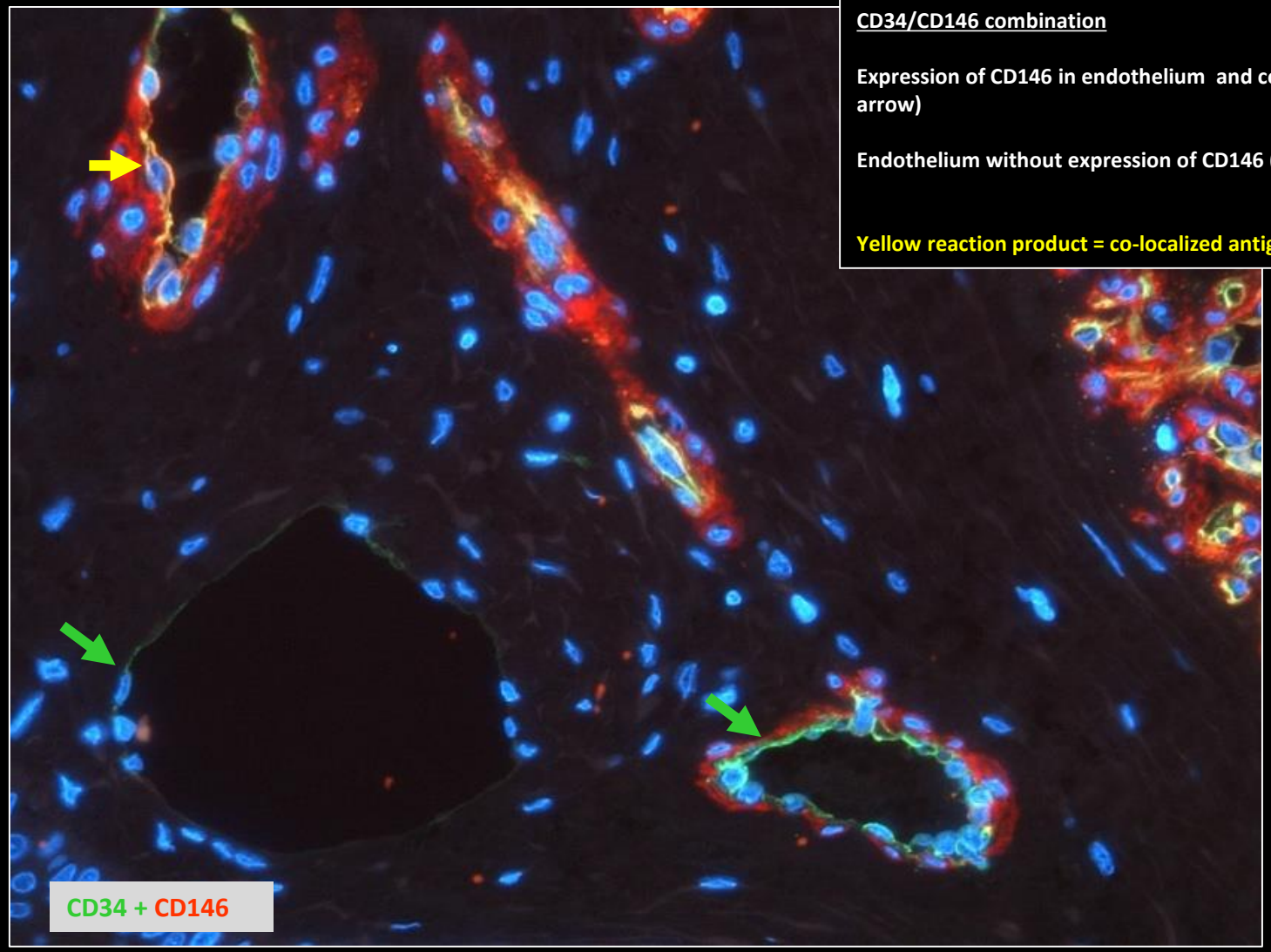


Endothelia cells are "double brown positive" /co-localization

Non of the combinations are useful ?

Hemangioma

Double immunofluorescence staining of vascular structures



CD34/CD146 combination

Expression of CD146 in endothelium and co-localization with CD34 (yellow arrow)

Endothelium without expression of CD146 (green arrow)

Yellow reaction product = co-localized antigens

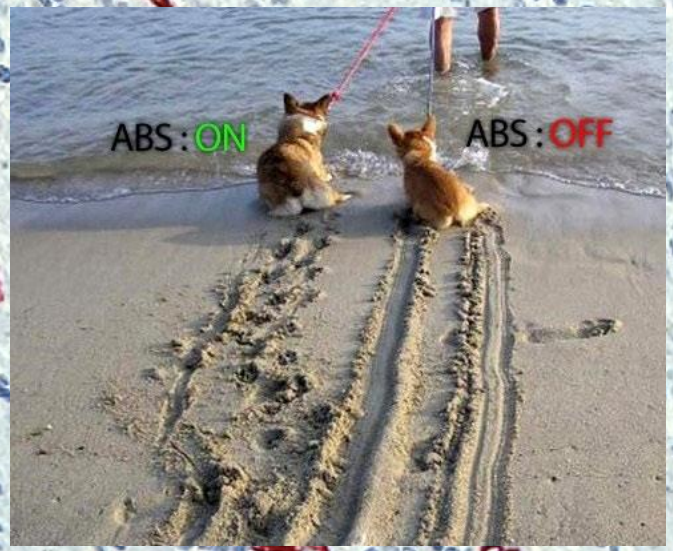
Hemangioma

CDX-2 (DAK-CDX2) + CK 8/18 (5D3)

Problems ?

The DAB deposit may cause problems as it may block for the next set of immuno-reagents - arrows.

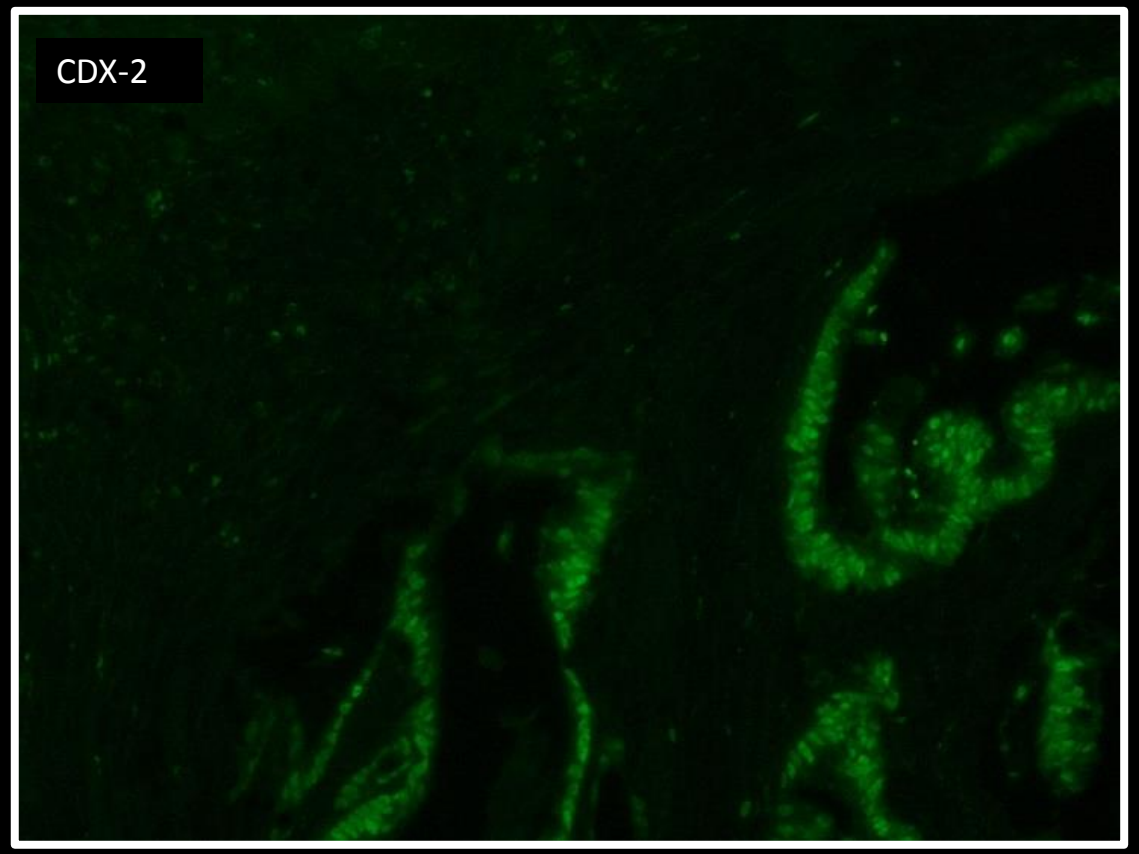
Tumor cells with infiltrative growth pattern (buddings) show expression of CK 8/18 due to downregulation of CDX2 – arrowheads.

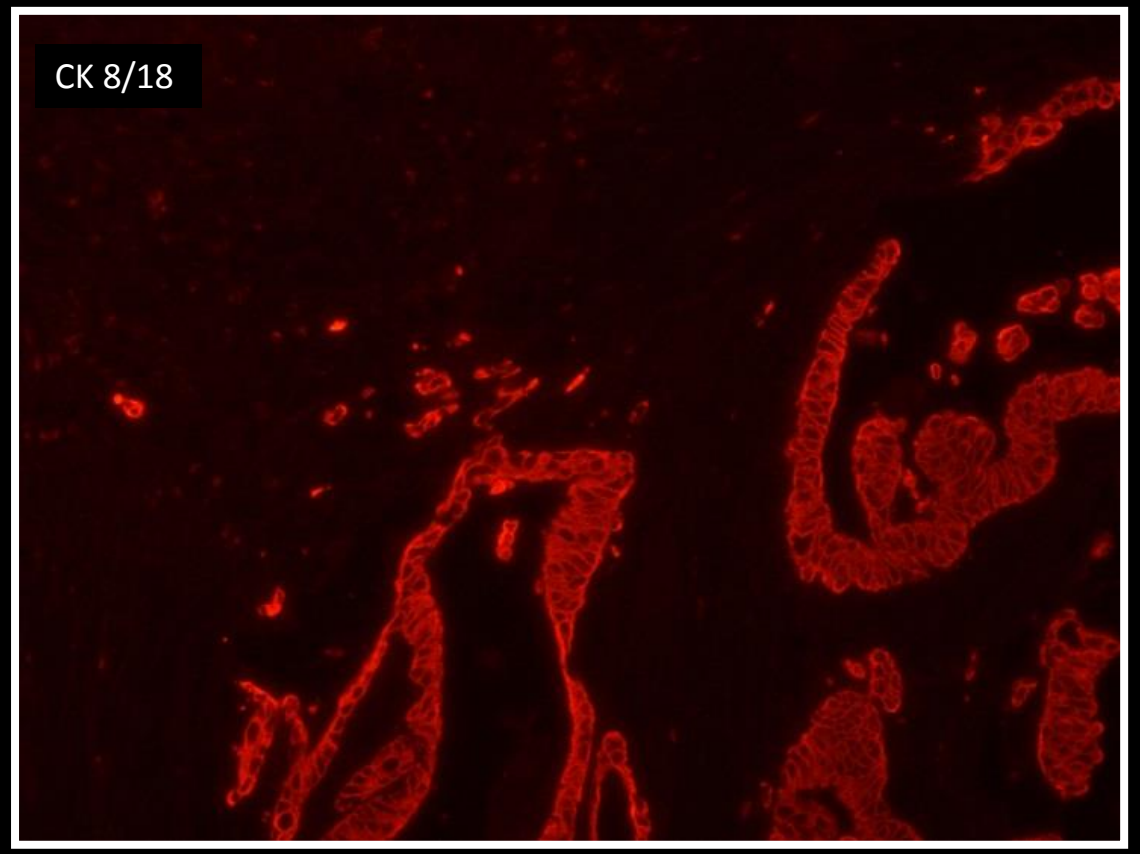


Colon Adenocarcinoma

CDX-2 (EP25) + CK 8/18 (5D3)

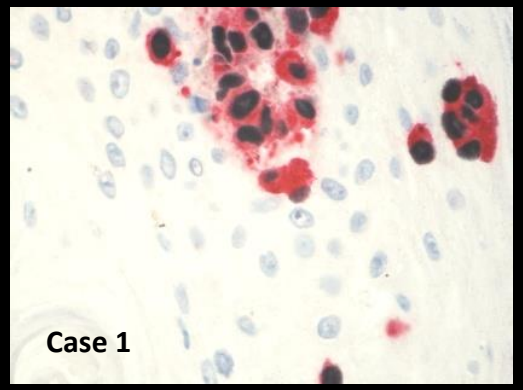
Double Staining-IF (simultaneous technique)





Note expression of CK 8/18 in all tumor cells

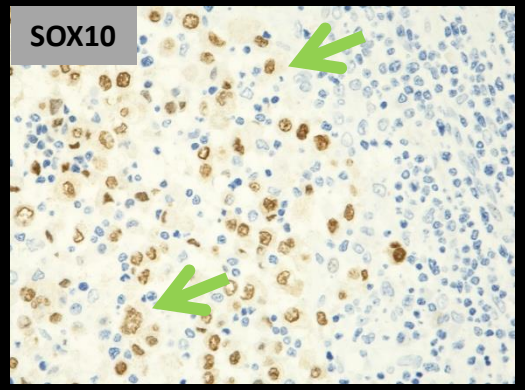
Colon Adenocarcinoma

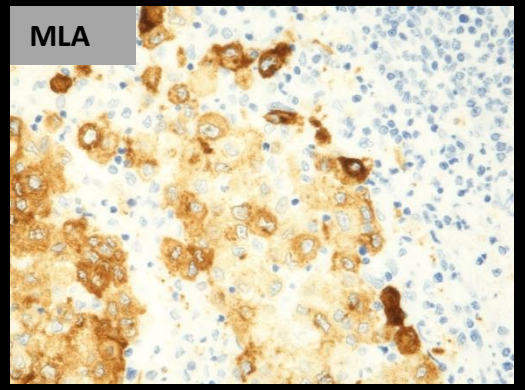


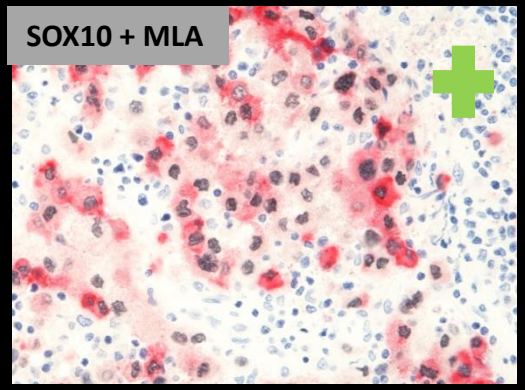
Sequential double immunostaining: Sox-10, BC34 (1:20) + MLA, A103 (1:25)

Melanomas

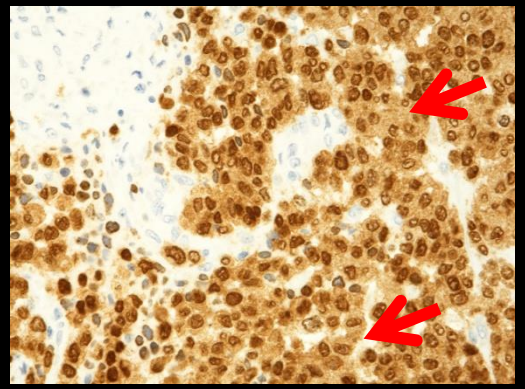
Case 2

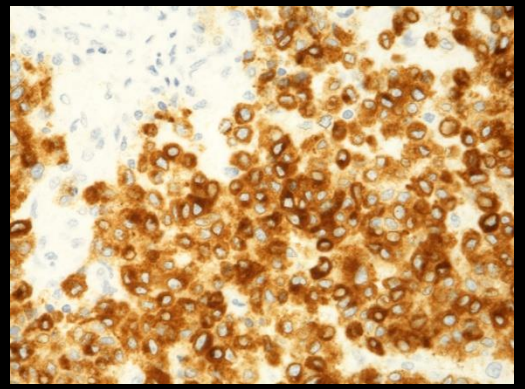


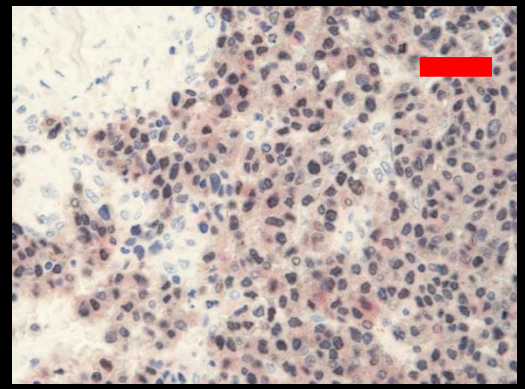




Case 3







Problems ?

DAB/DAB based chromogens shields for second set of immuno-reagents (red arrows showing moderate-strong "un-specific" cytoplasmic staining reaction with SOX-10 in melanoma case 3)

Double/Multiple staining using sequential technique (Immuno-enzymatic)

Now, what if unexpected color mixing occur due to cross reactivity with the 1th set of reagents ?

Mainly a problem related to other than DAB or DAB based chromogens

Inactivation of 1th set of immuno-reagents :

- Elution methods (High salt, extreme pH values and strong oxidizing agents)
- HIER using Citrate pH6 (10 min)

Applied between the 1th and 2nd set of immuno-reagents

Double staining using sequential technique (Immuno-enzymatic)

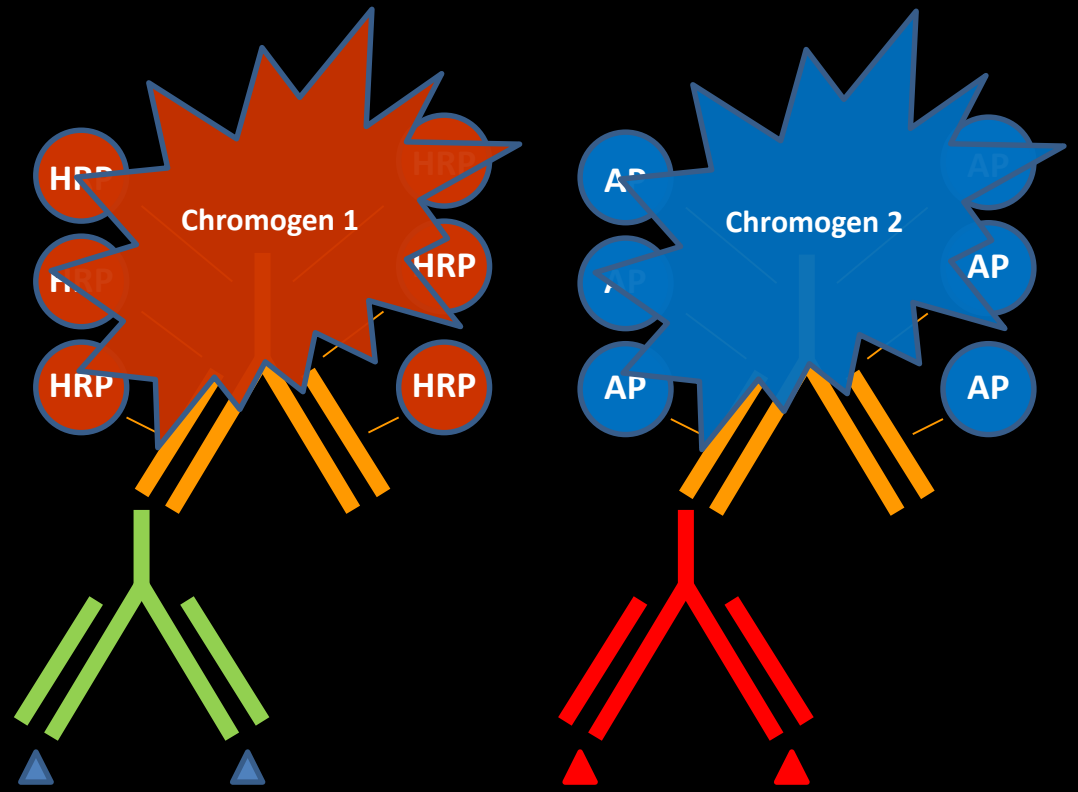
Inactivation of the first set of antibody reagents

Elution step

Glycine-HCL pH 2.2 (Nakane PK, 1968)

HCL pH 2 (Nakane PK, 1968)
$KMnO_4$ (Tramu G,1978)
Glycine-SDS pH2 (Pirici D, 2009)

And many more



Limitations: High affinity antibodies are difficult to elute

Double staining using sequential technique (Immuno-enzymatic)

Inactivation of the first set of antibody reagents

Van der Loos CM et al. J Histotechnol; 31: 119-127

A Generally Applicable Sequential Alkaline Phosphatase Immunohistochemical Double Staining

Table 3. Sequential Double AP Immunohistochemical Staining on FFPE Tissue Sections Using SMA and CD68 as Primary Antibodies: Different Orders of AP Chromogens, with and without HIER, and Controls (*Experiment 1*)

First primary	*First detection*	*First chrom.*	*HIER step*	*Second primary*	*Second detection*	*Second chrom.*	*Figure*
SMA	Anti-Ms polymer/AP	LPRed	+	CD68	Anti-Ms polymer/AP	VBlue	5
SMA	—	LPRed	+	—	Anti-Ms polymer/AP	VBlue	6
SMA	Anti-Ms polymer/AP	LPRed	–	CD68	Anti-Ms polymer/AP	VBlue	7
SMA	—	LPRed	–	—	Anti-Ms polymer/AP	VBlue	8
SMA	Anti-Ms polymer/AP	VBlue	+	CD68	Anti-Ms polymer/AP	LPRed	1
SMA	—	VBlue	+	—	Anti-Ms polymer/AP	LPRed	2
SMA	Anti-Ms polymer/AP	VBlue	–	CD68	Anti-Ms polymer/AP	LPRed	3
SMA	—	VBlue	–	—	Anti-Ms polymer/AP	LPRed	4

Blocking of first set of detection with a HIER step - select primary Abs where no co-localization is expected

<u>Inactivation by HIER:</u>

HIER in Ci pH 6, (Lan HY ,1995)

<u>Limitations:</u>

Require Heat stable chromogens - DAB, VBlue, VRed and LPR (Dako)

Always efficient ?

Volume 57(6): 567–575, 2009
Journal of Histochemistry & Cytochemistry
http://www.jhc.org

ARTICLE

Antibody Elution Method for Multiple Immunohistochemistry on Primary Antibodies Raised in the Same Species and of the Same Subtype

Daniel Pirici, Laurentiu Mogoanta, Samir Kumar-Singh, Ionica Pirici, Claudiu Margaritescu, Cristina Simionescu, and Radu Stanescu

Control studies

Table 1 Primary antibodies used in this study

Antigen	IgG isotype, species	Specificity	Working dilution	Antigen retrieval	Source
CD20cy	IgG2a, Ms	B lymphocytes	1:100	10 mM citrate buffer, pH 6	Dako
CD45Ro	IgG2a, Ms	T lymphocytes	1:50	10 mM citrate buffer, pH 6	Dako
CD3	Pab, Rbb	T lymphocytes	1:100	10 mM citrate buffer, pH 6	Dako
CD31	IgG1, Ms	Endothelial cells	1:50	10 mM citrate buffer, pH 6	Dako
CD34	IgG1, Ms	Endothelial cells	1:50	10 mM citrate buffer, pH 6	Dako
CD105	Pab, Rbb	Endothelial cells	Ready to use	10 mM citrate buffer, pH 6	Abcam
CD105	IgG1, Ms	Endothelial cells	1:1000	–	Dako
Collagen IV	IgG1, Ms	Basal membranes	1:25	10 mM citrate buffer, pH 6	Dako
F VIII	IgG1, Ms	Endothelial cells	1:50	10 mM citrate buffer, pH 6	Dako
CD68	IgG1, Ms	Macrophages	1:100	10 mM citrate buffer, pH 6	Dako
S100	Pab, Rbb	Antigen presenting cells	1:2000	10 mM citrate buffer, pH 6	Dako
PCNA	IgG2a, Ms	Cell proliferation marker	1:50	10 mM citrate buffer, pH 6	Dako
Ki67	Pab, Rbb	Cell proliferation marker	1:250	10 mM citrate buffer, pH 6	Abcam
Ki67	IgG1, Ms	Cell proliferation marker	1:100	10 mM citrate buffer, pH 6	Dako

Abcam; Cheminkpress, Craiova, Romania.

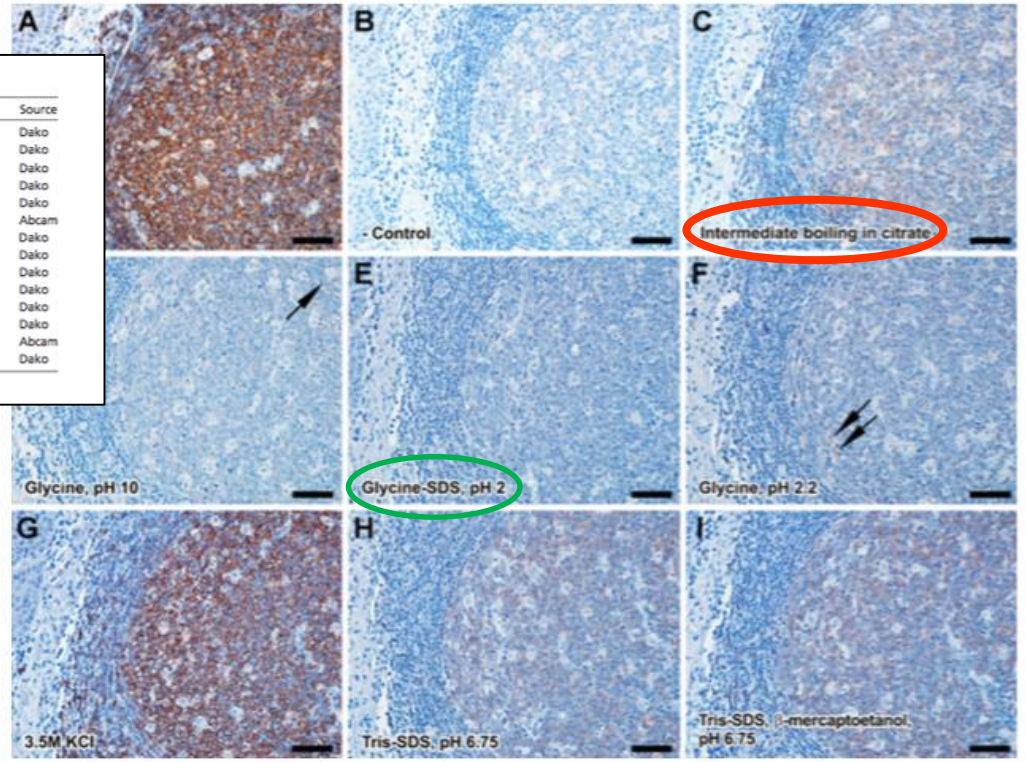


Figure 1 Choosing the optimum antibody-elution protocol. The procedure involved incubation with a primary antibody (follicular B-cell marker CD20cy here), applying the elution procedure, and detecting the remaining primary antibody. Positive and negative controls for this reaction were obtained by skipping the elution step (A) or not adding the primary antibody (B). Boiling in citrate buffer (C), incubating in glycine pH 10 (D), glycine-HCl, pH 2.2 (F), 3.5 M KCl (G), Tris-SDS, pH 6.75 (H), and Tris-SDS β-mercaptoethanol, pH 6.75 (I) showed insufficient signal reduction, whereas the glycine-SDS pH 2 protocol (E) showed a complete antibody elution. All elutions involved a 30-min incubation under agitation at 50C. Arrows indicate sites with faint remnant signal. Bar = 50 μm.

Demonstrated that:

Elution, using a glycine SDS pH 2 solution, of the antibodies after the first round of immunolabelling was superior in regard of eliminate cross reactivity with the second set of immuno-reagents compared to other methods tested .

This also includes an intermediate HIER step using Citrate pH6

Double enzymatic staining using simultaneous technique

- Primary antibody cocktail is applied to the tissue at the same time (simultaneously)

- Primary antibodies must be of different host (e.g. mouse and rabbit) or at least different Ig-types, subclass or one primary Ab with a conjugate (e.g. biotin).

- Reactions are detected with a mix of secondary antibodies conjugated with two different enzymes (e.g. HRP and AP) and applied to the tissue at the same time (simultaneously).

  To prevent cross-reaction between secondary antibodies raised against different species, it is recommended to apply second-step antibodies raised in the same host – if not possible, use pre-absorbed secondary antibodies.

- Each antibody: antigen reaction will yield a specific color of staining that can be easily identified.

Double enzymatic staining using simultaneous technique

Pre-treatment (Antigen Retrieval)

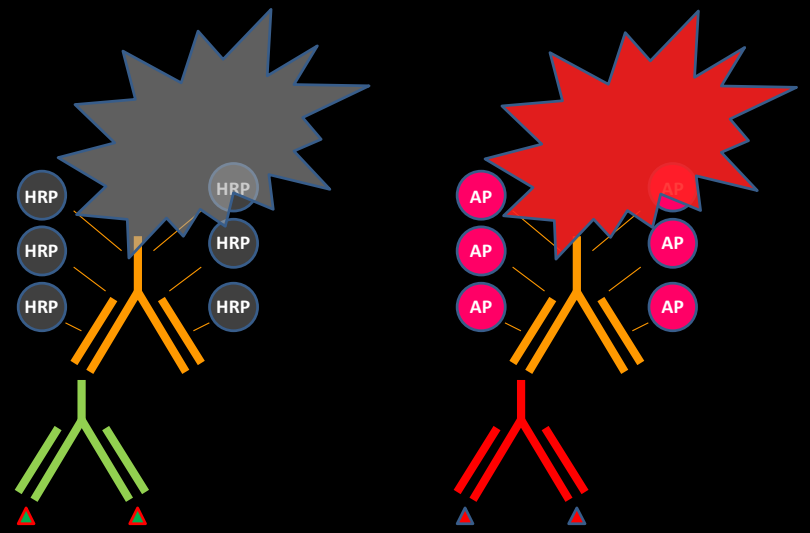
Incubation with mix of primary Abs (Rab+Mab)

Incubation with polymer/multimer mix (anti -Mab/HRP + anti -Rab/AP)

Incubation with HRP substrate (e.g. DAB or DSB)

Incubation with AP substrate (e.g. Fast Red or Warp Red)

Counter stain, mounting and microscopy



Commercial kits (Naestved Lab):

Lab Vision™ MultiVision Polymer Detection System: anti-Mouse-AP and anti-Rabbit-HRP (TL-012-MARH)

Lab Vision™ MultiVision Polymer Detection System: anti-Mouse-HRP and (TL-012-MHRA)

Biocare MACH2 Double Stain 1: anti-Mouse-AP and anti-Rabbit-HRP (MRCT523)

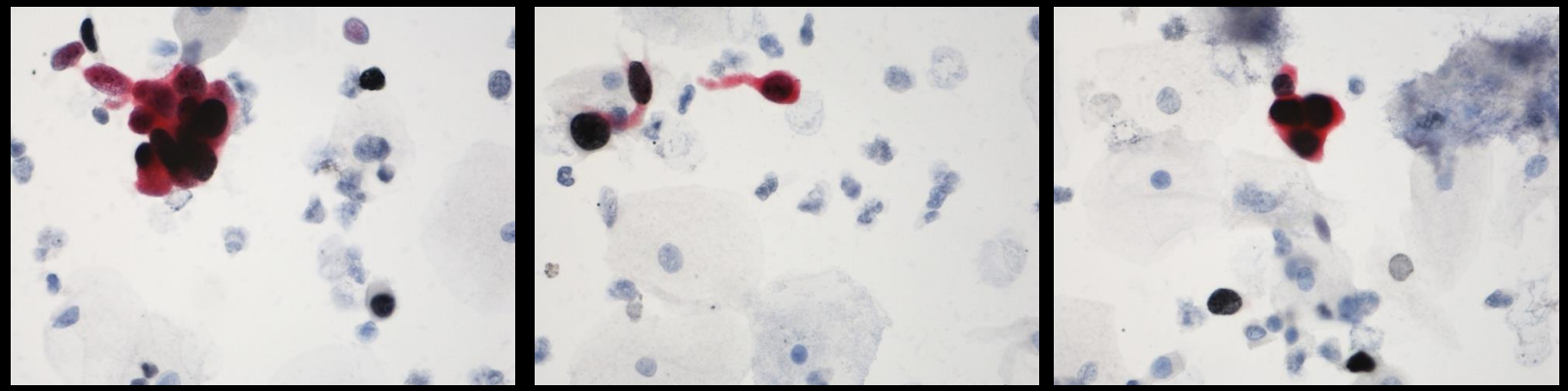
Biocare MACH2 Double Stain 2: anti-Mouse-HRP and anti-Rabbit-AP (MRCT525)

MACH2 Double Staining : Ki-67, SP6 (1:25) + P16, E6H4 (RTU, Ventana)

Dysplasia / Cervix (Cytology)

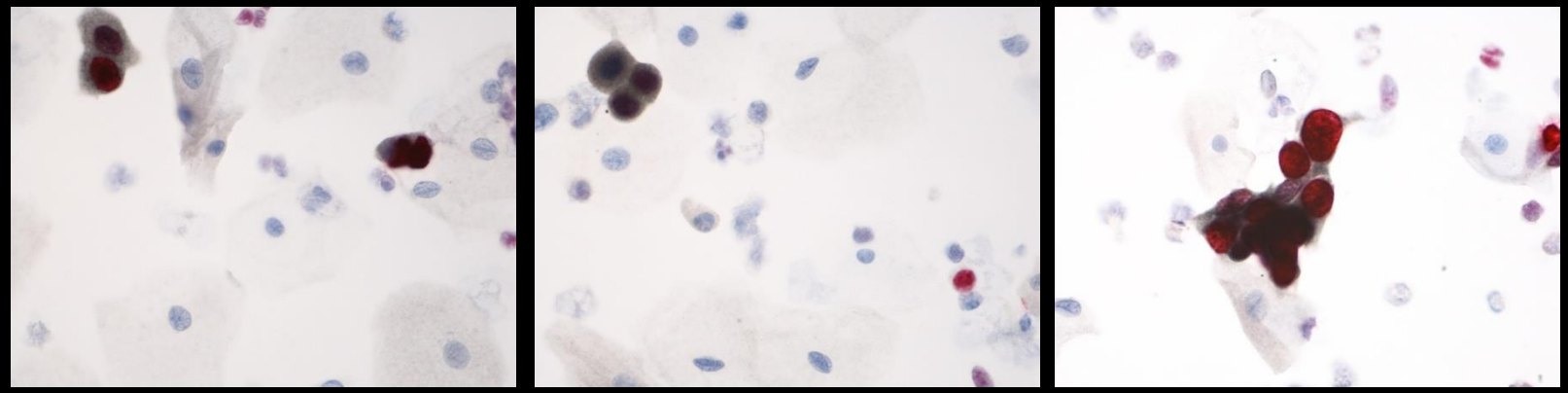
Double Stain 1 (Biocare)

Anti-Rab/HRP
Anti-Mab/AP



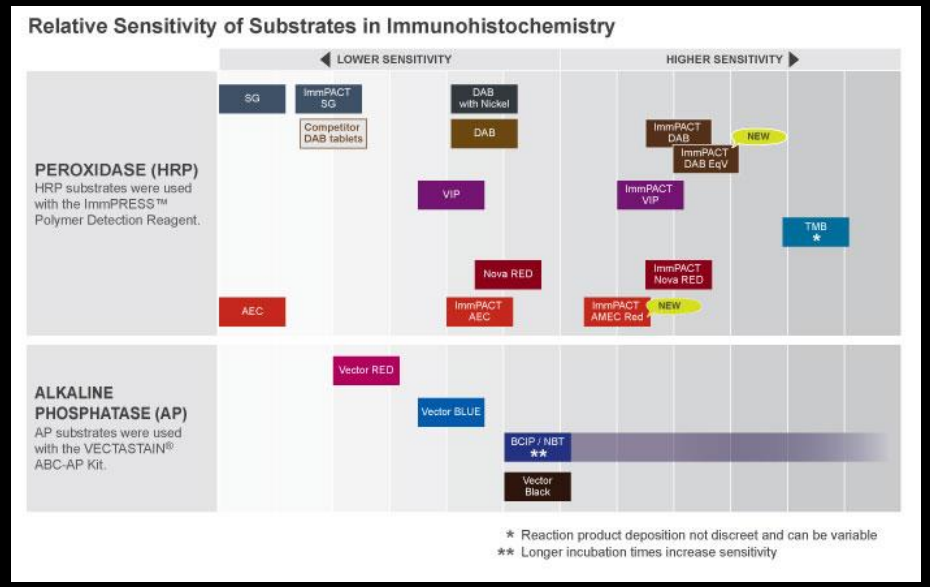
Double Stain 2 (Biocare)

Anti-Rab/AP
Anti-Mab/HRP



Cytological specimens fixed in NBF 30` → 96 alk. 10` → Wash buffer → HIER/TE 20`

Vector LABs



Chromogen compatibility

First Substrate \ Second Substrate	Vector® Red (magenta) SK-5100	Vector® Blue (blue) SK-5300	BCIP/NBT (indigo) SK-5400	VIP/ ImmPACT™ VIP (purple) SK-4605, SK-4600	DAB/ ImmPACT™ DAB (brown) SK-4105, SK-4100	DAB-Ni (gray-black) SK-4100	NovaRED™/ ImmPACT™ NovaRED™ (red) SK-4805, SK-4800	SG/ ImmPACT™ SG (blue-gray) SK-4705, SK-4700	AEC/ ImmPACT™ AEC (red) SK-4205, SK-4200	ImmPACT™ AMEC Red (red) SK-4285
Vector® Red (magenta) Cat. No. SK-5100		–	–	–	+	+	–	+	–	–
Vector® Blue (blue) Cat. No. SK-5300	+		–	+	+	+	+	+	+	+
BCIP/NBT (indigo) Cat. No. SK-5400	+	–		+	+	+	+	+	+	+
VIP/ImmPACT™ VIP (purple) Cat. No. SK-4605, SK-4600	–	+	–		+	+	–	+	–	–
DAB/ImmPACT™ DAB (brown) Cat. No. SK-4105, SK-4100	+	+	+	+		–	–	+	+	+
DAB-Ni (gray-black) Cat. No. SK-4100	+	–	–	+	+		+	–	–	–
NovaRED™/ImmPACT™ NovaRED™ (red) Cat. No. SK-4805, SK-4800	–	+	+	–	+	+		+	–	–
SG/ImmPACT™ SG (blue-gray) Cat. No. SK-4705, SK-4700	+	–	–	+	+	–	–		+	+
AEC/ImmPACT™ AEC (red) Cat. No. SK-4205, SK-4200	–	–	–	–	+	–	–	+		–
ImmPACT™ AMEC Red (red) SK-4285	–	–	–	–	+	–	–	+	–	

Key: Alkaline Phosphatase | Peroxidase + Indicates good contrast – Indicates incompatiblity of substrates for various reasons

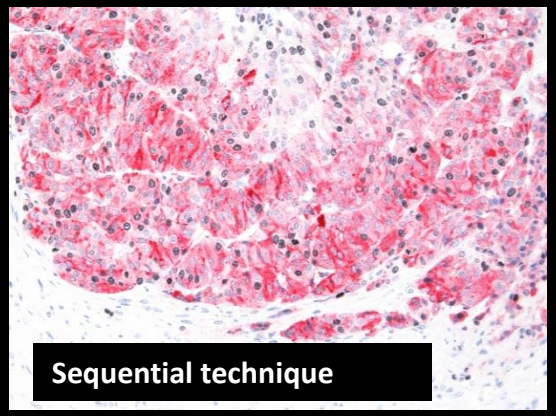
Chromogen reaction products

- ❑ Precise (specific)
- ❑ Sensitive
- ❑ Fast reactions (short incubation time)
- ❑ Compatible with and easy to distinguish from counter staining
- ❑ Stabile and unaffected of the mounting procedure

- ❑ In double immune experiments: High color contrast between chromogens and allowing mixed colors at sites of co-localization

Efficiency depends on:

- ❑ Enzyme conjugate (e.g. HRP and/or AP)
- ❑ Chromogen type (e.g. BCIP/NBT)
- ❑ Incubation time
- ❑ Incubation temperature



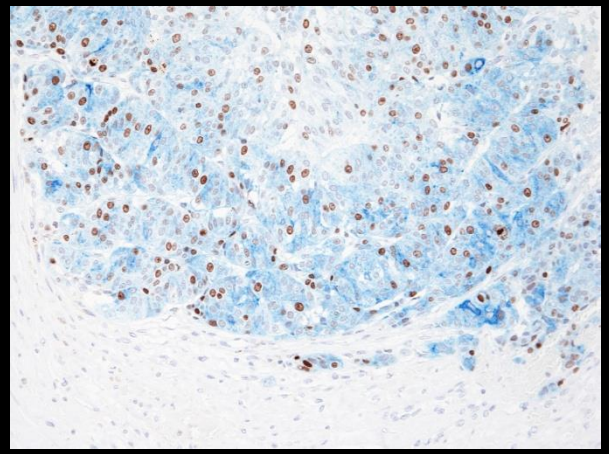
Double enzymatic staining using simultaneous technique

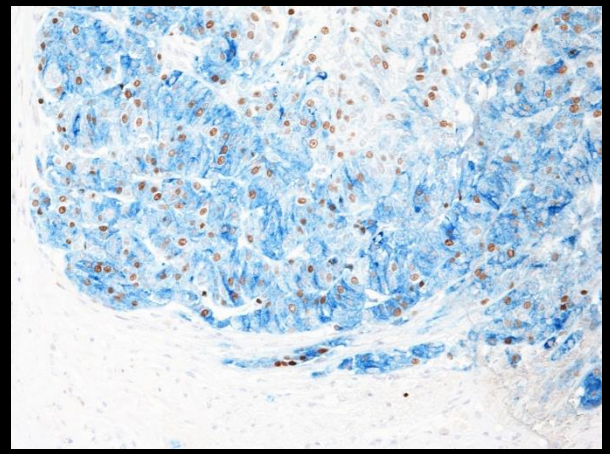
Ki67 (SP6) 1:25 + MLA (A103) 1:25

LVBlue , 10min at RT

LVBlue , 2x10min at RT

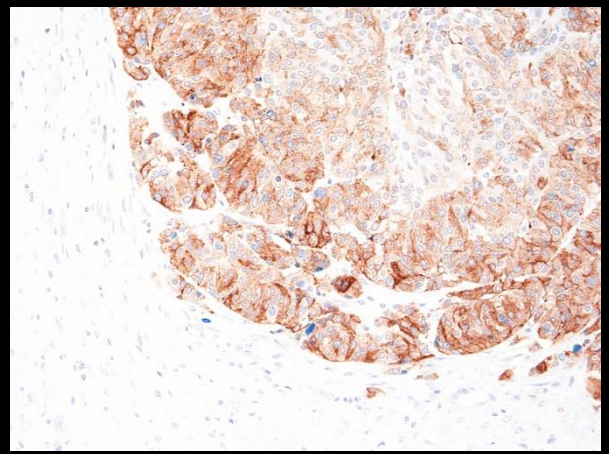
MultiVision 1 / TS (simultaneous)
Rabbit-HRP/Mouse-AP
LVBlue &LVRed

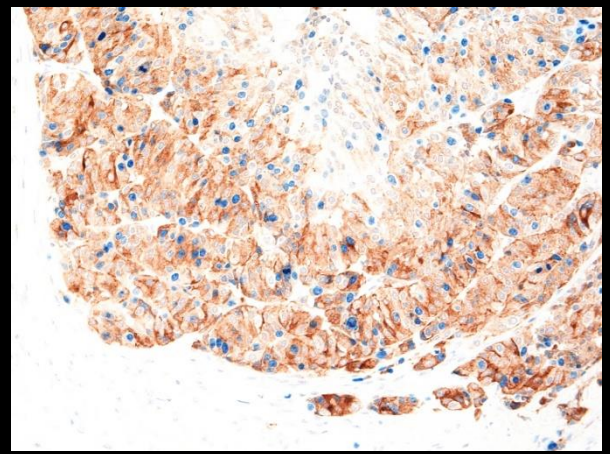




Incubation time with the chromogens ?

MultiVision 2 / TS (simultaneous)
Rabbit-AP/Mouse-HRP
LVBlue &LVRed

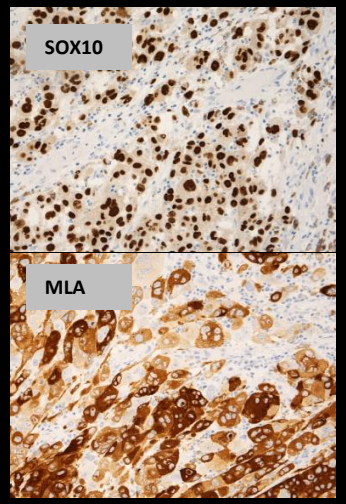


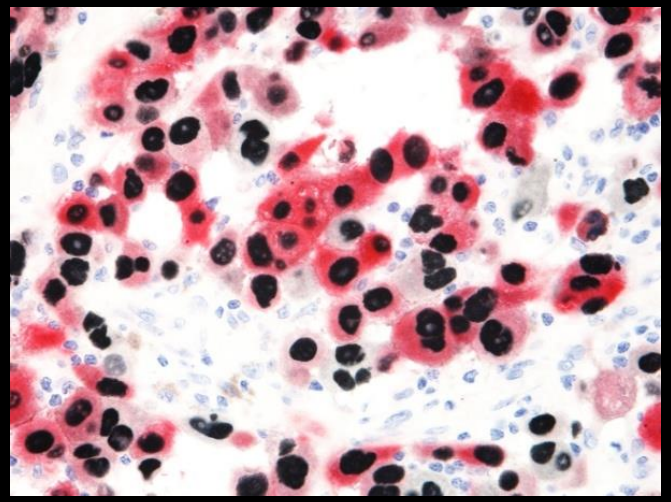
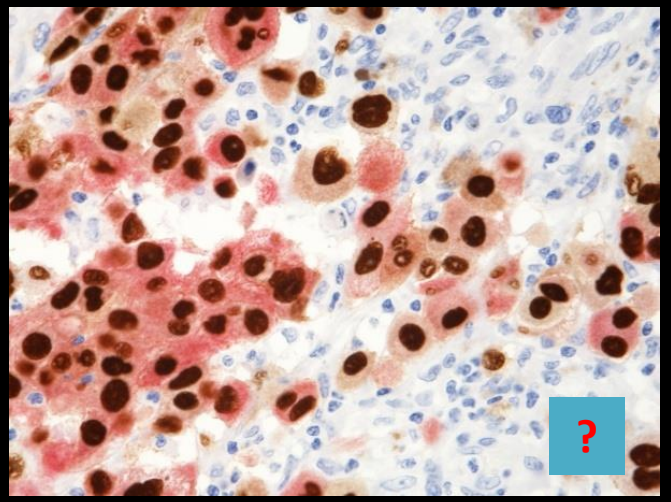
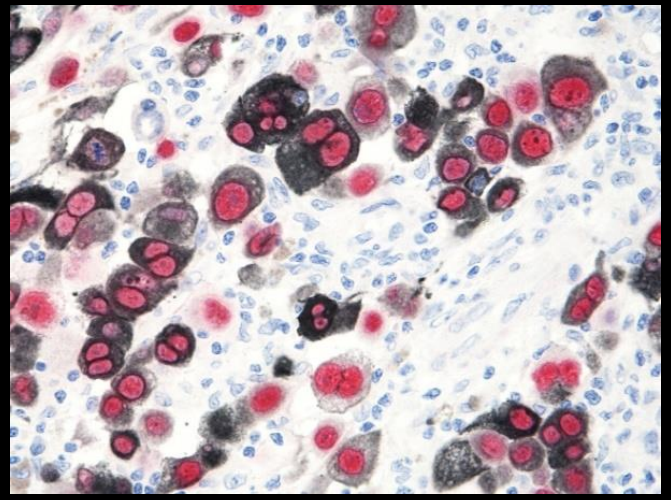
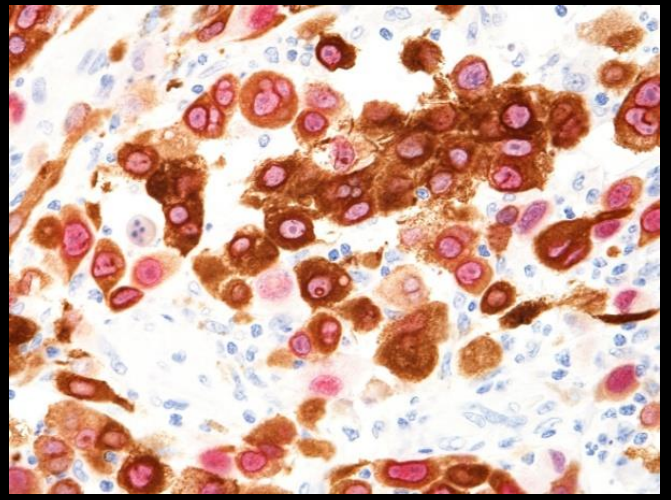


Melanoma

MACH2 Double Staining: Sox-10, EP238 (1:25) + MLA, A103 (1:25)

Melanoma



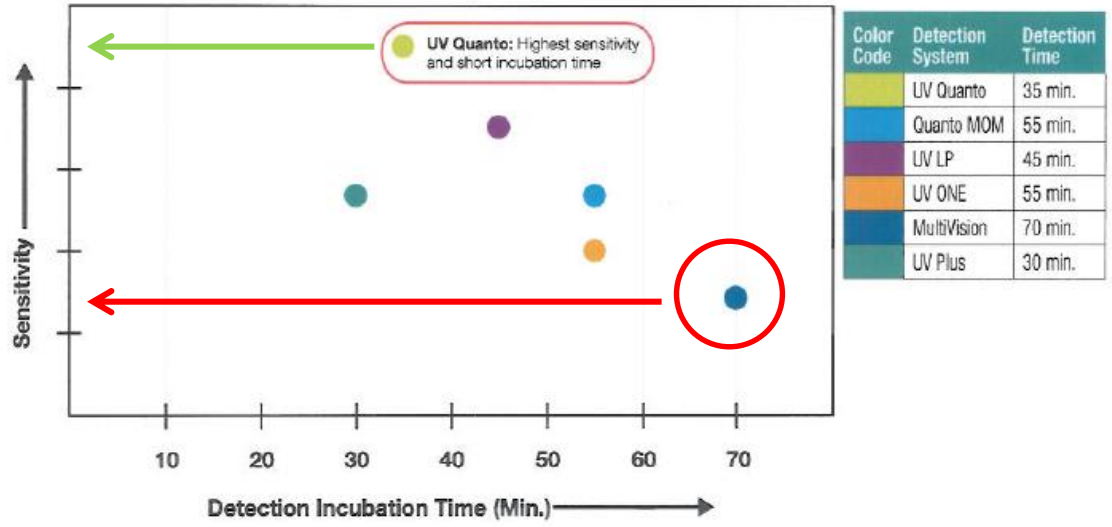
	Deep Space Black 5` + Warp Red 2x8`	DAB (BZ) 5` + Warp Red 7` Recommended protocols (Vendor)
Double stain 1 Anti-Rab/HRP + Anti-Mab/AP		 ?
Double stain 2 Anti-Rab/AP + Anti-Mab/HRP		

Color contrast`s ?

Detection systems and sensitivity

Double (MultiVision), EnVision G/2 Doublestain versus single immuno-staining protocols

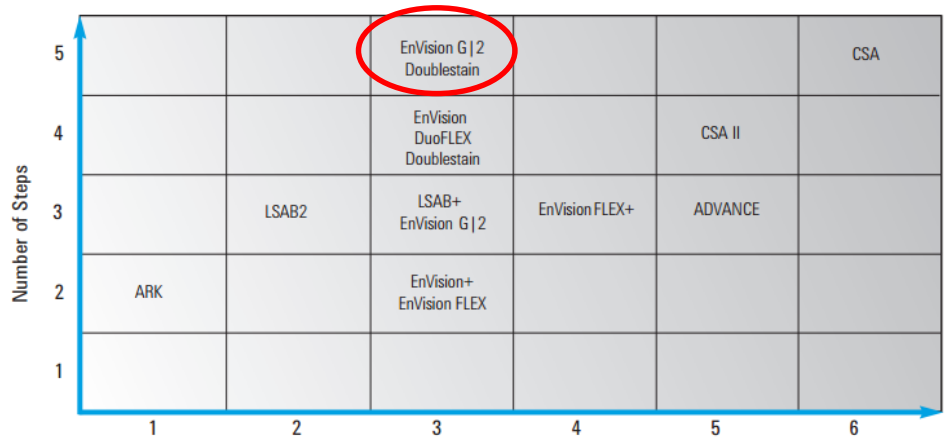
www.thermoscientific.com/labvision



Color Code	Detection System	Detection Time
	UV Quanto	35 min.
	Quanto MOM	55 min.
	UV LP	45 min.
	UV ONE	55 min.
	MultiVision	70 min.
	UV Plus	30 min.

Overview of Dako Visualization Systems

Complexity Versus Sensitivity of Dako Visualization Systems



Relative low sensitivity

<u>Questions using double immuno-staining systems:</u>

Critical Staining Quality Indicators (iCAPs) ?

Challenging primary antibodies – how will they perform ?

G/2 double stain versus In-House develop protocol

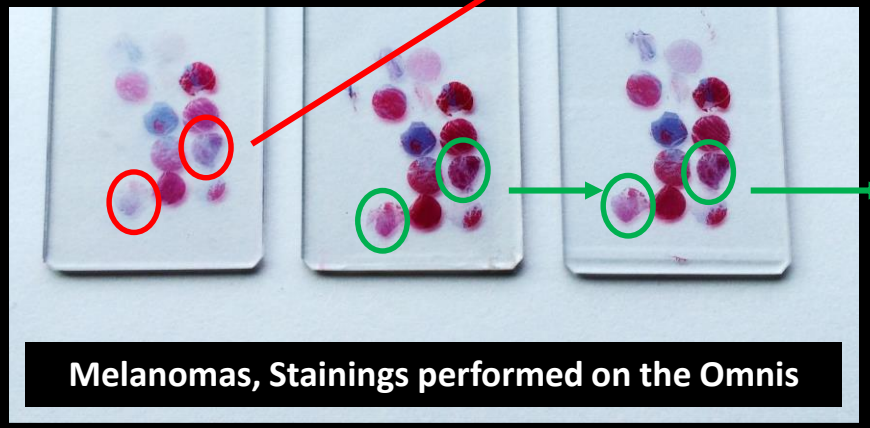
Omission of first primary ab + MART1, EP43 (1:30 RR)

Substitution of the second set of immuno-reagents (Detection system & Chromogen)

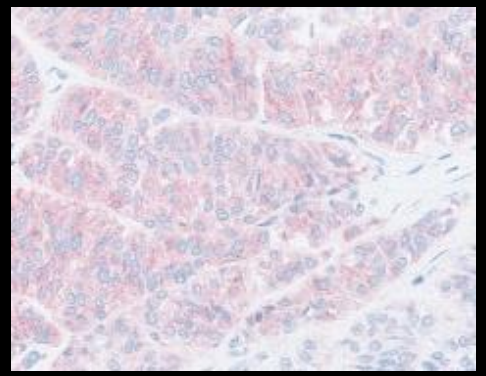
G/2 double stain + PR

HiDEF /AP + PR

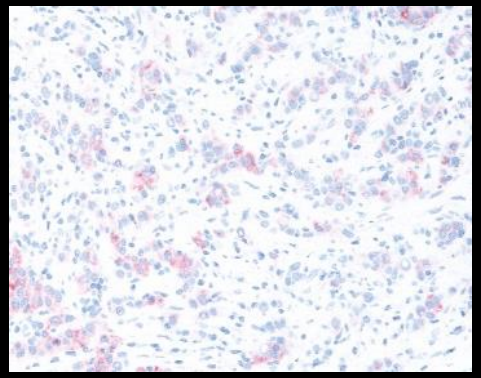
HiDEF /AP + WR



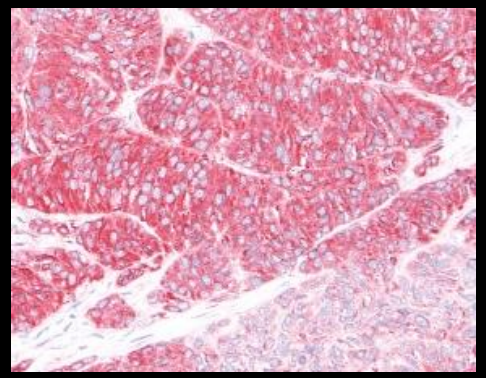
Melanomas, Stainings performed on the Omnis

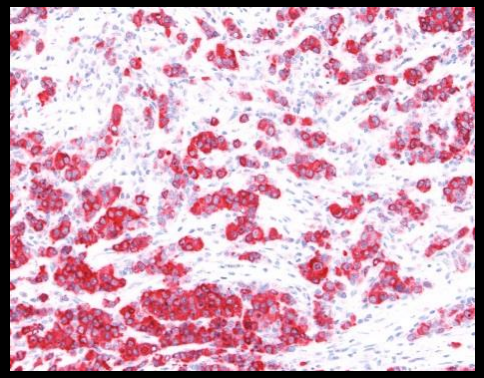


Melanoma 1



Melanoma 2





Multiplex staining techniques (IHC): Co-localized antigens

Are antigens of interest located in the same cellular compartment (e.g. the nuclei`s) ?

NO

Use a DAB based sequential or a simultaneous technique

Enzyme conjugates

Conventional bright field microscopy

Include controls

YES

Double immunofluorescence technique (simultaneous technique)

Double immuno-enzymatic technique (simultaneous technique / sequential technique)

A reversed applications of the primary antibodies (sequential technique)

SIMPLE technique (Sequential Immunoperoxidase Labelling and Erasing Method)

NGFR (Mab, MRQ-21) + CD146 (Rab, EPR3208)

Simultaneous procedure (Immuno-Fluorescence):

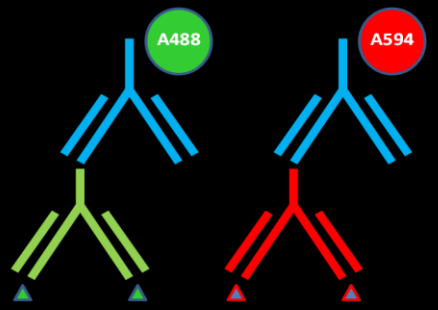
Pre-treatment (Antigen Retrieval)

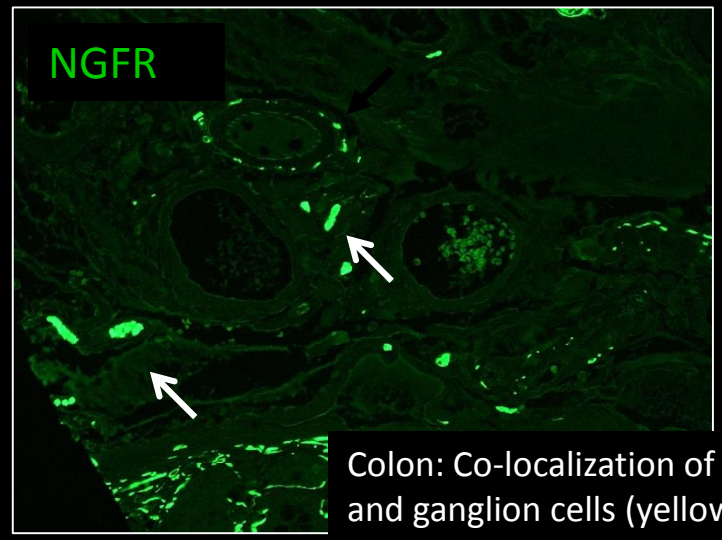
Incubation with Primary Ab mix (e.g different host/ Mab+Rab) (1h).

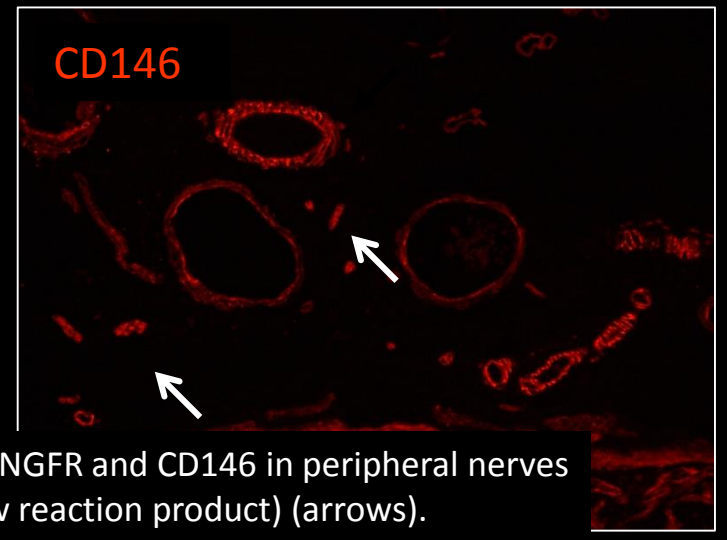
Incubation with Secondary Ab mix (Goat -anti Mab+Rab) (1h).

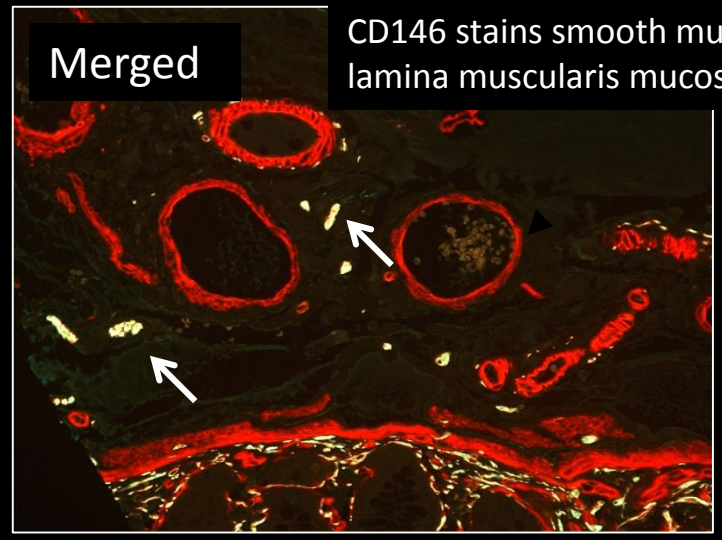
Alexa Fluor 488 anti mouse Ig + Alexa Fluor 594 anti rabbit Ig

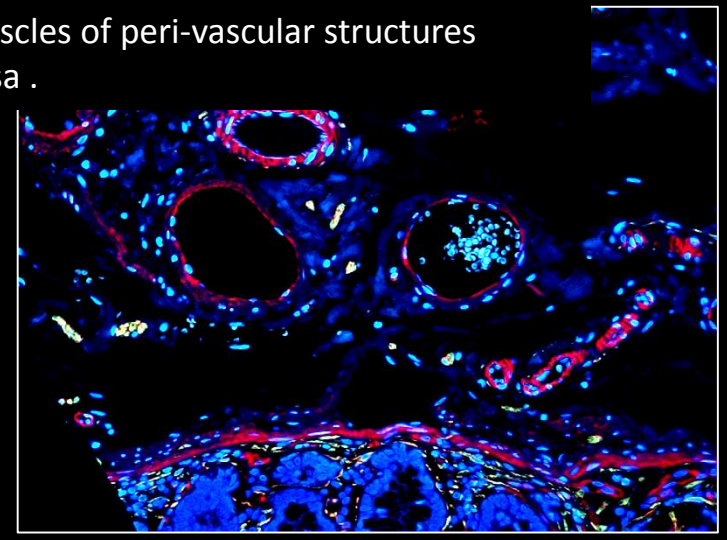
Dehydration + air-drying + coverslipping with Vectashield (+ DAPI)











Colon: Co-localization of NGFR and CD146 in peripheral nerves and ganglion cells (yellow reaction product) (arrows).

CD146 stains smooth muscles of peri-vascular structures lamina muscularis mucosa .

Co-localized signal using double immuno-enzymatic techniques ?

Only a few chromogen combinations fulfill the criteria of a good visual contrast between the basic colors and a good contrasting mixed color at sites of co-localized antigens:

- ❑ Red–blue combination, composed of HRP activity visualized with amino-ethyl carbazole (AEC) and alkaline phosphatase (AP) activity visualized with naphthol- AS-MX-phosphate/Fast Blue BB

- ❑ Vector NovaRed (Vector Laboratories) and Vector Blue (VBlue) for HRP and AP activities, respectively (alternatively - MultiVision kit system for rabbit and mouse primaries including all chromogen reagents by Thermo Fisher Scientific (LabVision))

- ❑ Red–blue combination, composed of alkaline phosphatase (AP) activity visualized with VBlue and AP activity visualized with Liquid Permanent Red (Dako) – sequential technique with intermediary HIER step to block first set of immuno-reagents

- ❑ Red–turquoise color combination composed of AP and beta-galactosidase activities, respectively. (Compared with most HRP and AP reaction products, beta-galactosidase activity visualized by X-gal/ferro-ferri cyanide is relatively insensitive/inefficient and also quite diffusely localized - unprecise)

Only for research ?

Van der Loos CM. The J Histotechnol 33 (1): 31-40, 2010

Van der Loos CM et al. J Histotechnol; 31: 119-127, 2008

Co-localization and balance of the reaction products ?

MultiVision procedure (Labvision)

Pre-treatment (Antigen Retrieval)

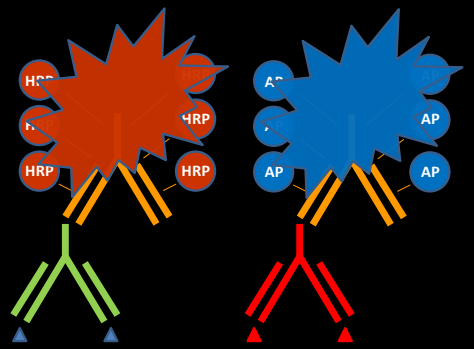
Incubation with mix of primary Abs (Rab+Mab)

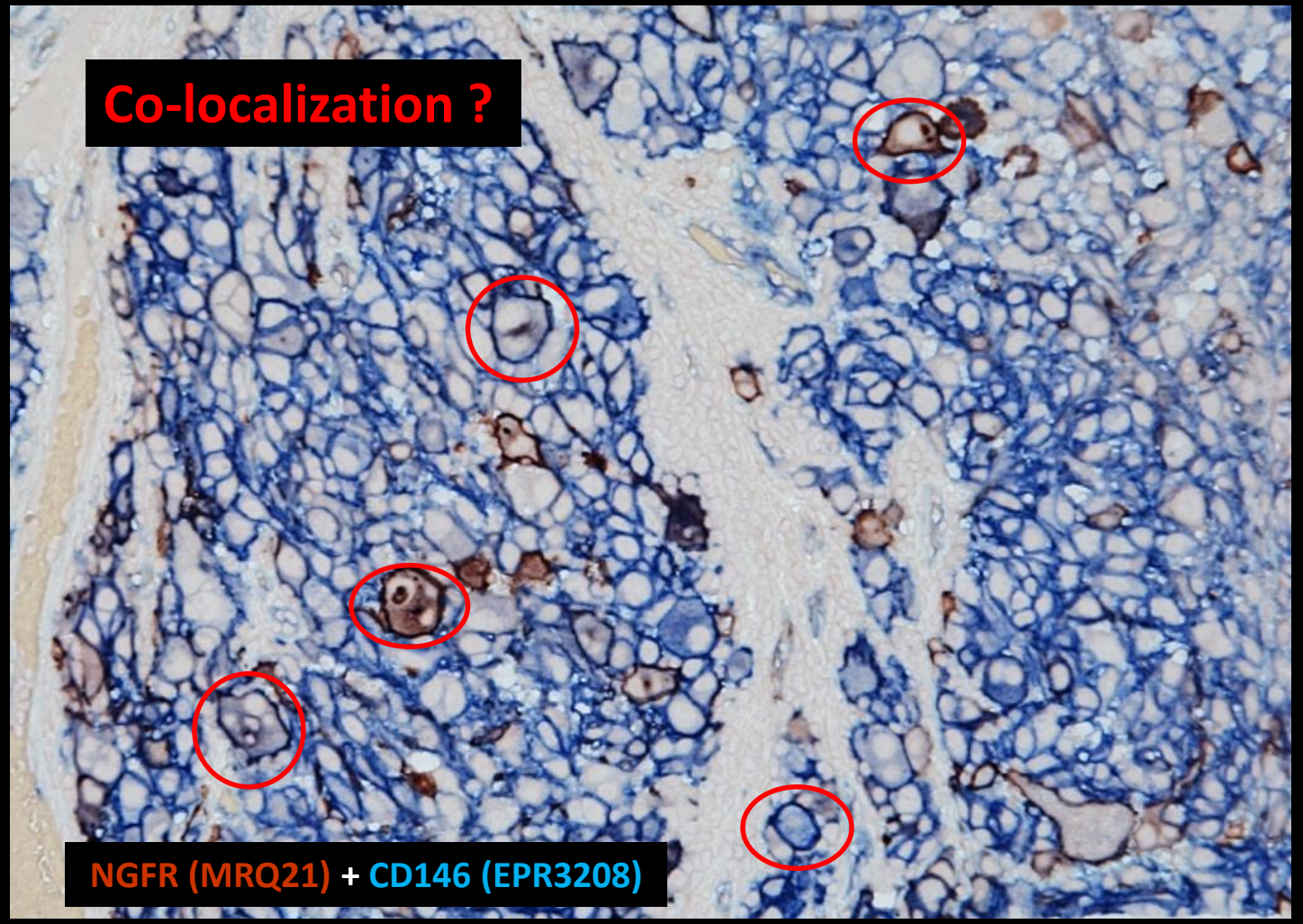
Incubation with Multivision (anti -Mab/HRP + anti -Rab/AP)

Incubation with HRP substrate + Chromogen LVRed

Incubation with AP substrate + Chromogen (LBV Blue)

Counter stain, mounting and Imaging / Interpretation





Melanoma

Volume 57(10): 899–905, 2009
Journal of Histochemistry & Cytochemistry
http://www.jhc.org

ARTICLE

SIMPLE: A Sequential Immunoperoxidase Labeling and Erasing Method

George Glass, Jason A. Papin, and James W. Mandell

Department of Biomedical Engineering, (GG,JAP) and Department of Pathology (Neuropathology) (JWM), University of Virginia, Charlottesville, Virginia

Table 1 Comparison of SIMPLE with existing multiprobe immunolabeling methods

	SIMPLE	Traditional multi-chromagen IHC	Multiplex-immunostain chip	Multicolor IF
Maximum labels per section	5+	2–3	50	3
Use on paraffin-embedded archival tissue	+	+	+	–/+
Ability to overcome autofluorescence/photobleaching	+	+	+	–
Colocalization within a single cellular compartment	+	–	–	+
Compatible with primary antibodies from same species	+	–	+	–

SIMPLE is compared with traditional two- or three-color multichromagen immunohistochemistry (IHC), the multiplex immunostain chip method (Furuya et al. 2004), and multicolor immunofluorescence (IF) methods.

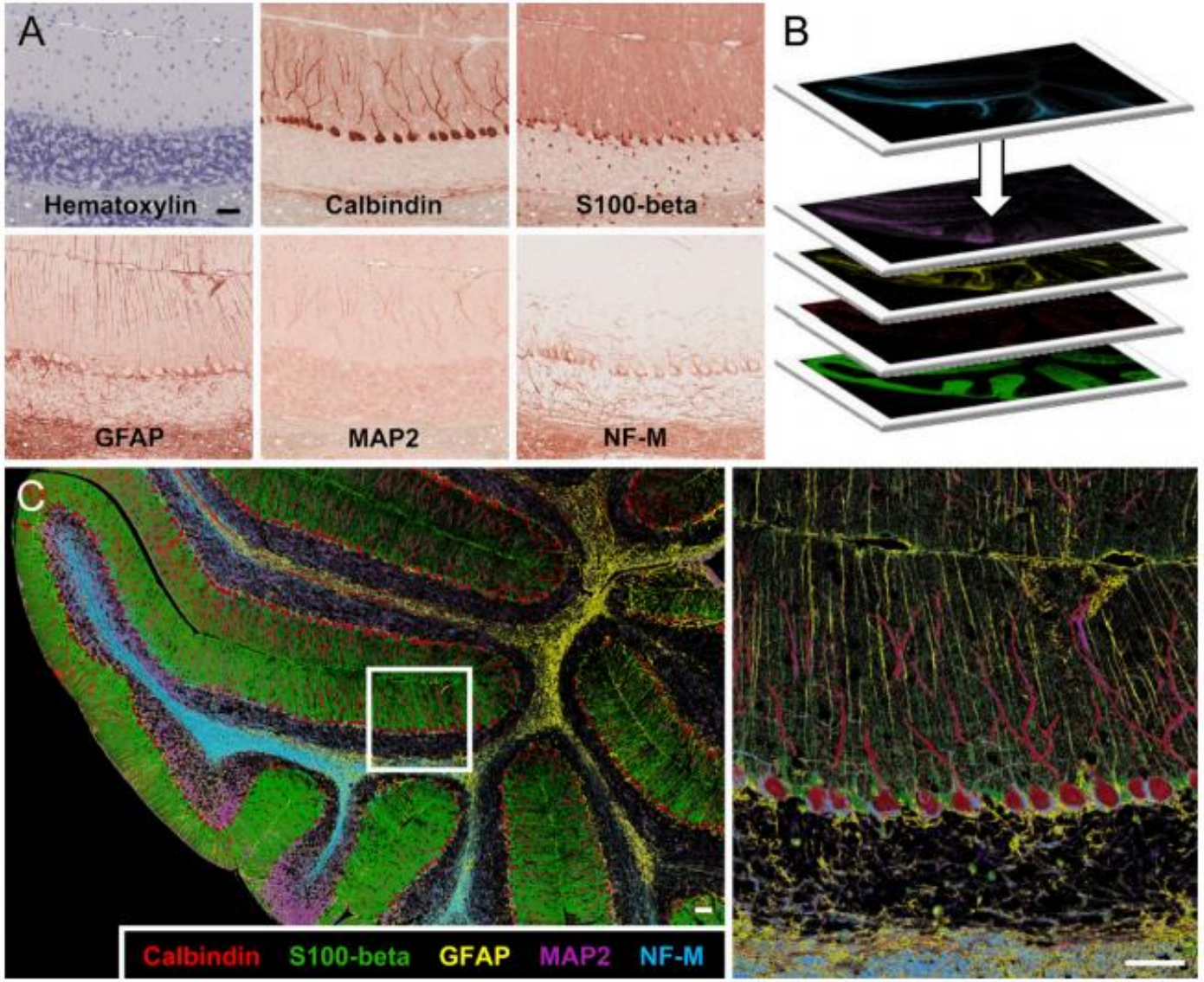


Figure 3 Simultaneous visualization of five antigens in mouse cerebellum. **(A)** Adult mouse brain was counterstained with hemotoxylin, then sequentially probed with polyclonal antibodies to calbindin, S100-β, and GFAP, and monoclonal antibodies to MAP2 (AP18) and neurofilament (NF-M) 2H3. **(B)** The images were individually pseudocolored and overlaid. **(C)** The small boxed area in the left panel is shown magnified at right. The resultant image reveals the morphology of different cell types and fine details of interactions of Purkinje cells, Bergmann glia, astrocytes, and basket cell terminals that would not be obvious with single or dual labeling. Bar = 50 μm.

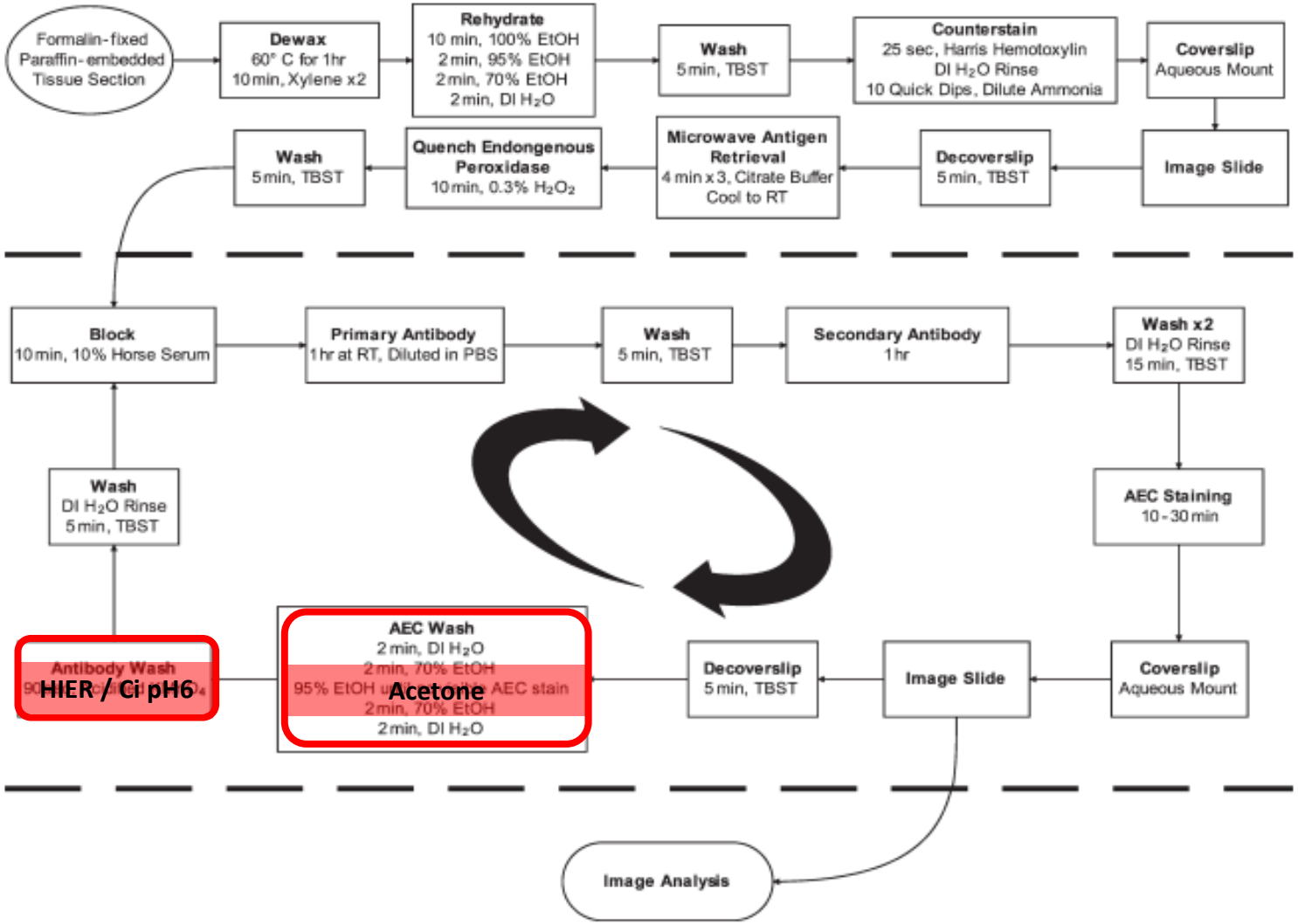
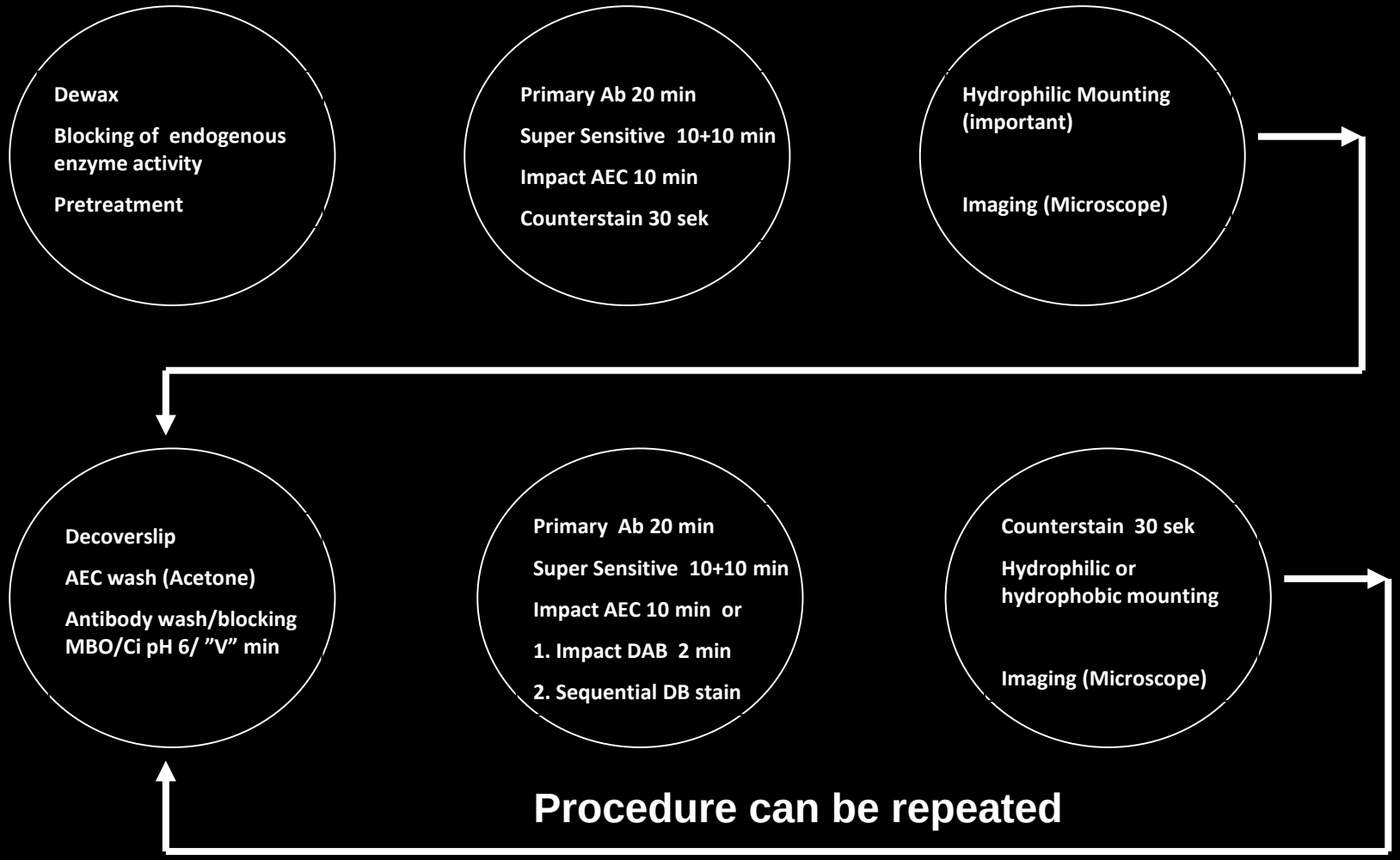


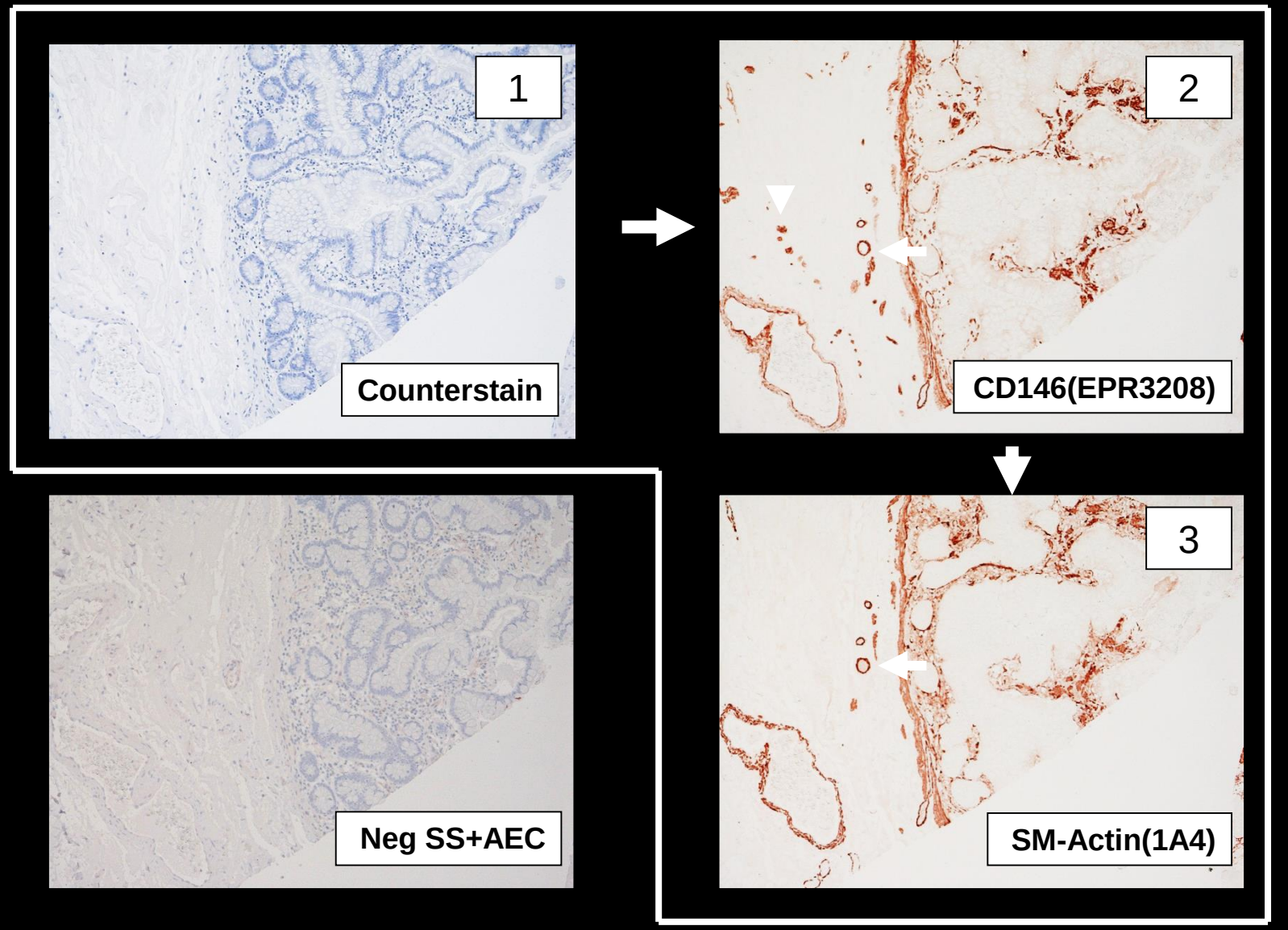
Figure 1 SIMPLE strategy. Formalin-fixed, paraffin-embedded sections are dewaxed, rehydrated, and counterstained before initial probing. Tissue is imaged and then subjected to antigen retrieval, removing the counterstain. Each staining round is conducted using standard immunohistochemical protocols with the alcohol-soluble red peroxidase substrate 3-amino-9-ethylcarbazole (AEC). After each round of staining, the tissue is imaged and then stripped of AEC precipitate in ethanol. Antibody is then eluted in acidified permanganate, and the tissue is subjected to the next round of staining.

Modified Simple Technique



SIMPLE-technique (Pilot study)

Blocking first set of immuno-reagents: MBO/Citrate pH 6/10 min



Co-localization and balance of the reaction products ?

MultiVision procedure (Labvision)

Pre-treatment (Antigen Retrieval)

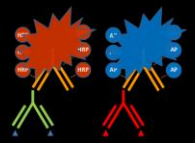
Incubation with mix of primary Abs (Rab+Mab)

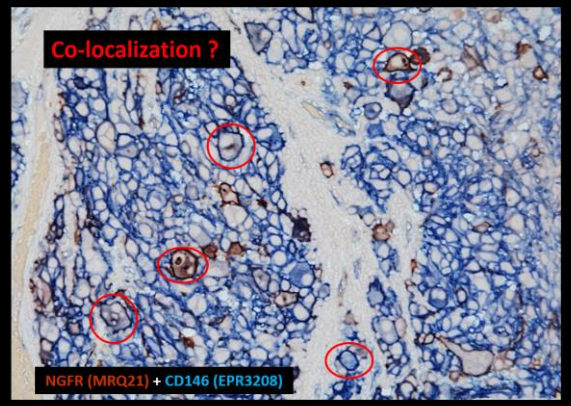
Incubation with Multivision (anti -Mab/HRP + anti -Rab/AP)

Incubation with HRP substrate + Chromogen LVRed

Incubation with AP substrate + Chromogen (LBV Blue)

Counter stain, mounting and Imaging / Interpretation



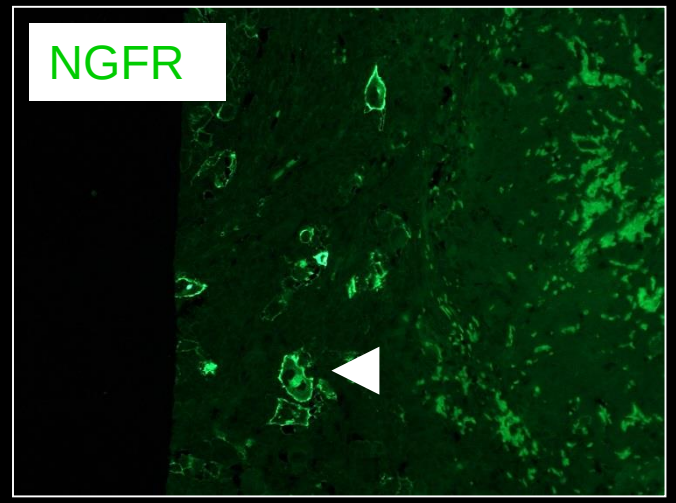


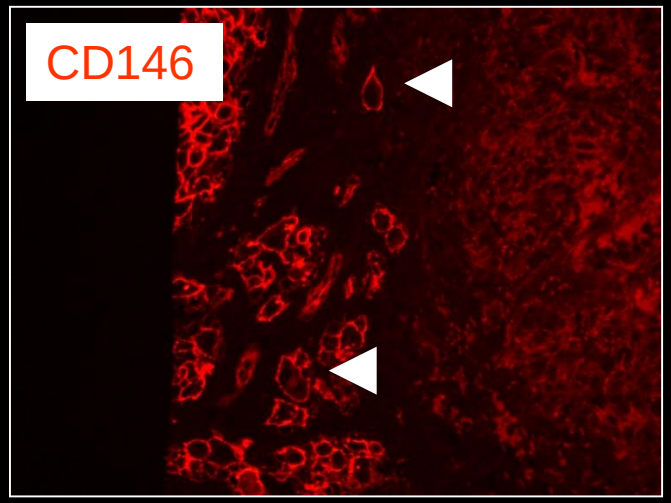
Melanoma

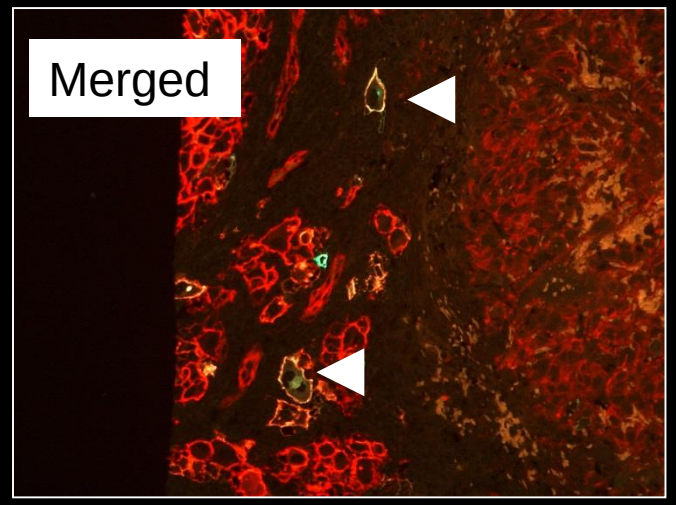
Co-localized signals (yellow reaction product) - arrowhead

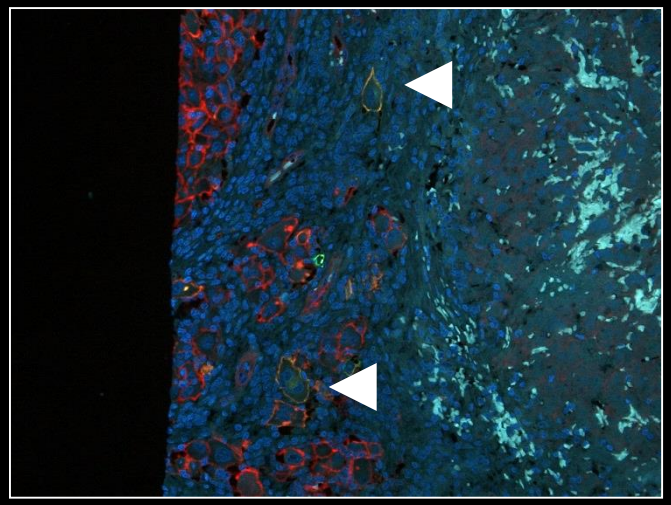
NGFR (MRQ21) + CD146 (EPR3208)

Melanoma

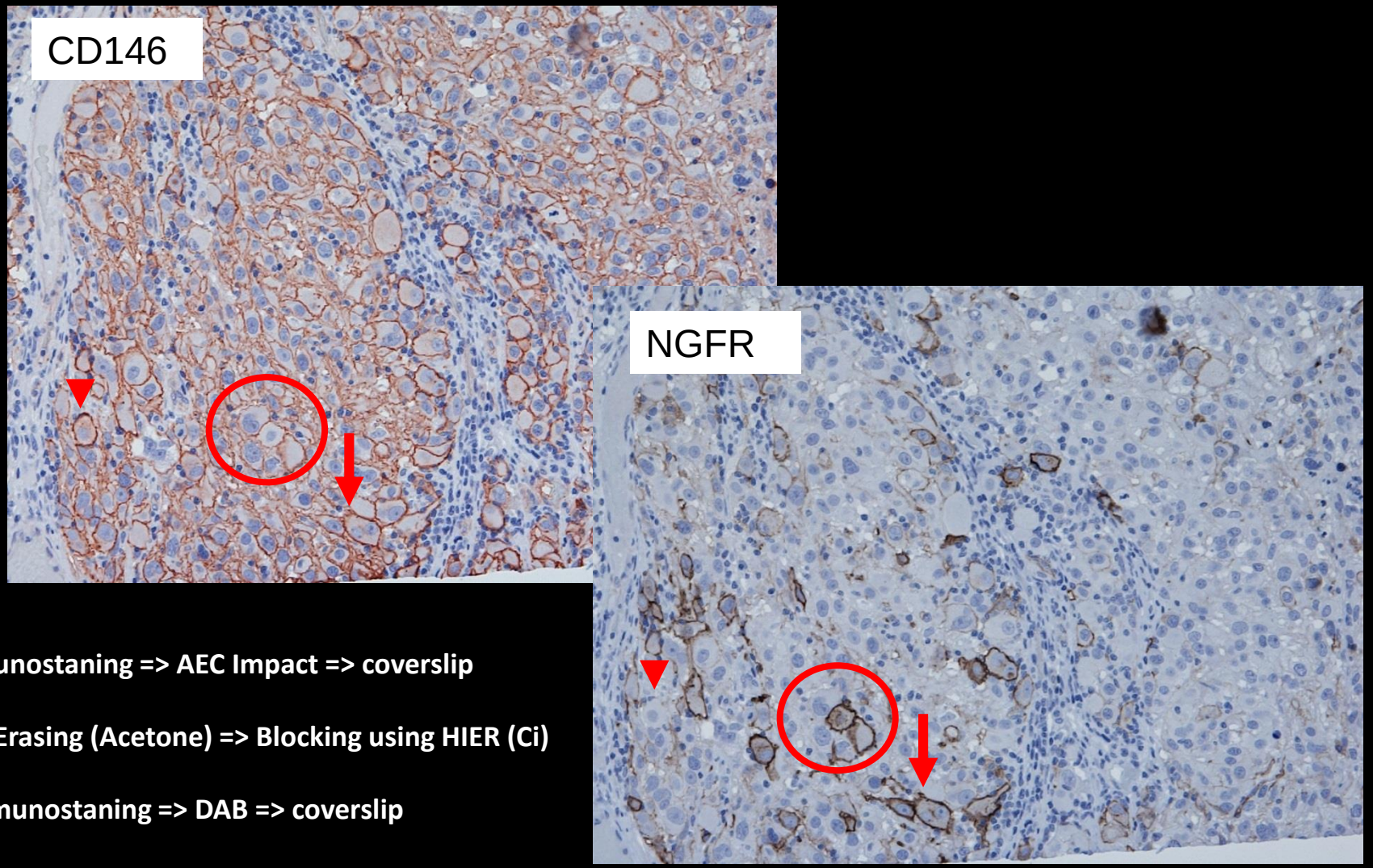








SIMPLE technique: CD146 (EPR3208) + NGFR (MRQ21)



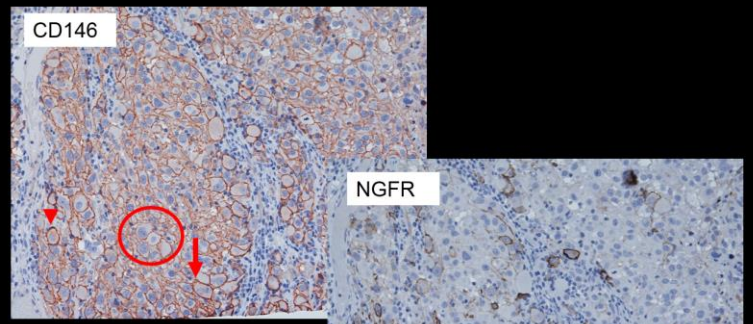
First sequence: CD146 immunostaning => AEC Impact => coverslip

Imaging => de- coverslip => Erasing (Acetone) => Blocking using HIER (Ci)

Second sequence: NGFR immunostaning => DAB => coverslip

Melanoma

SIMPLE technique: CD146 (EPR3208) + NGFR (MRQ21)



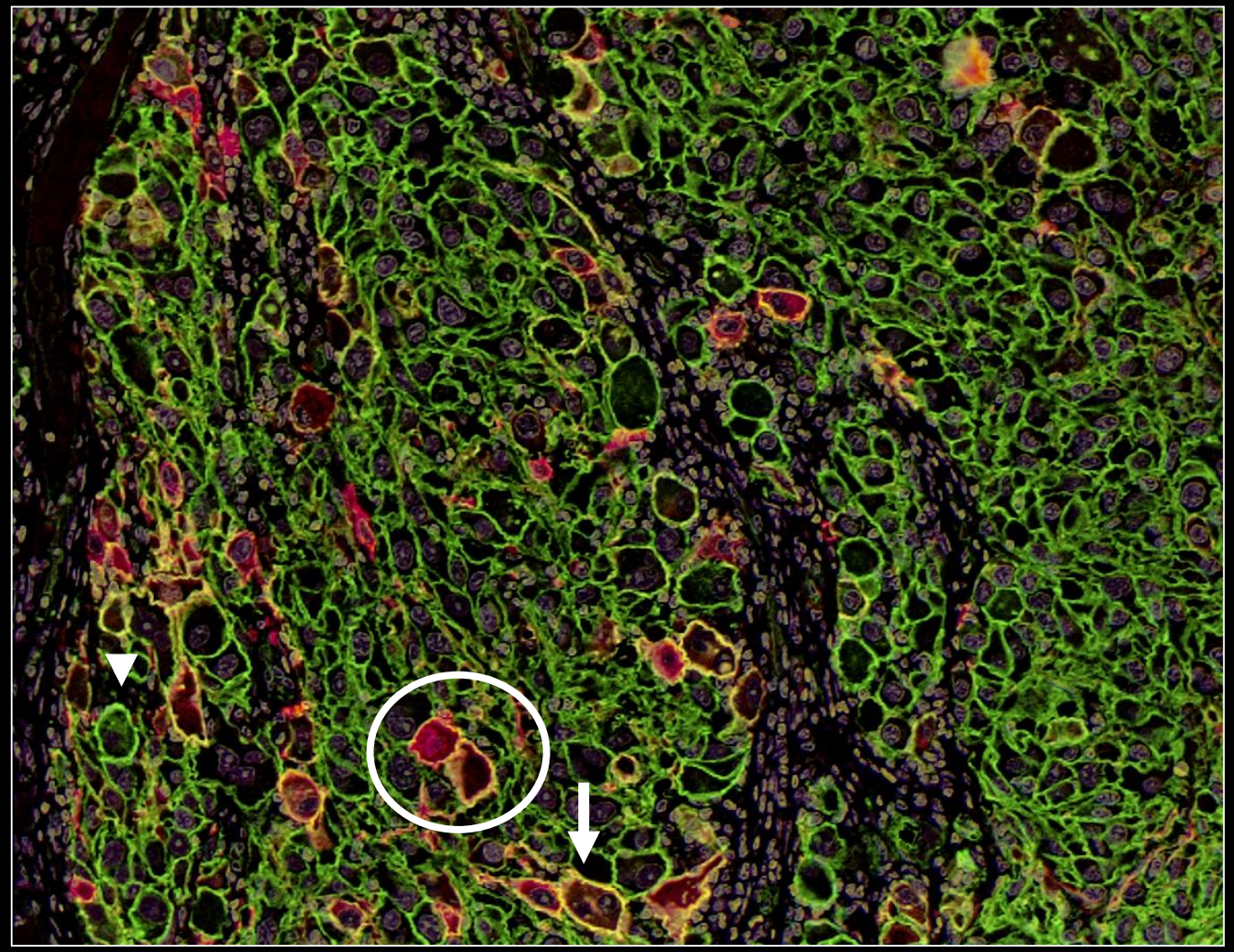
First sequence: CD146 immunostaning => AEC Impact => coverslip

Imaging => de- coverslip => Erasing (Acetone) => Blocking using HIER (Ci)

Second sequence: NGFR immunostaning => DAB => coverslip

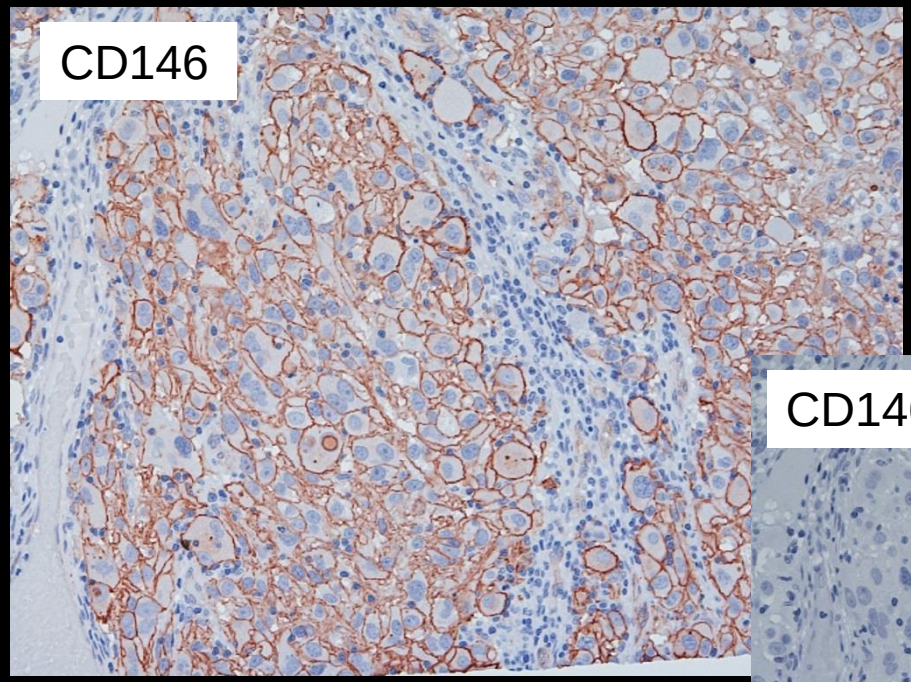
Melanoma

Photo Shop manipulated

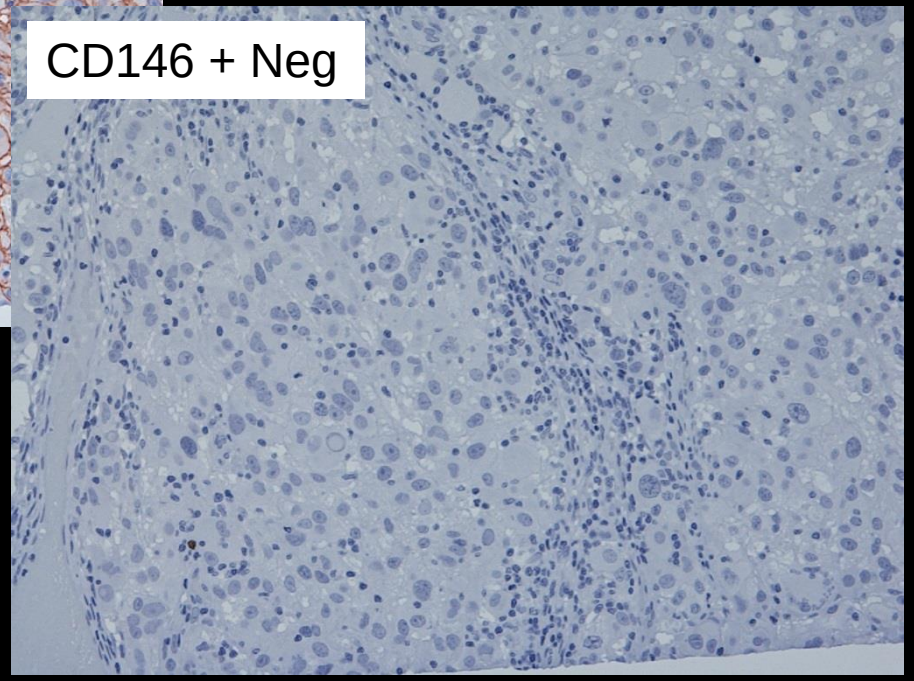


CD146 NGFR Co-exp

SIMPLE technique: CD146 (EPR3208) + Neg



Control



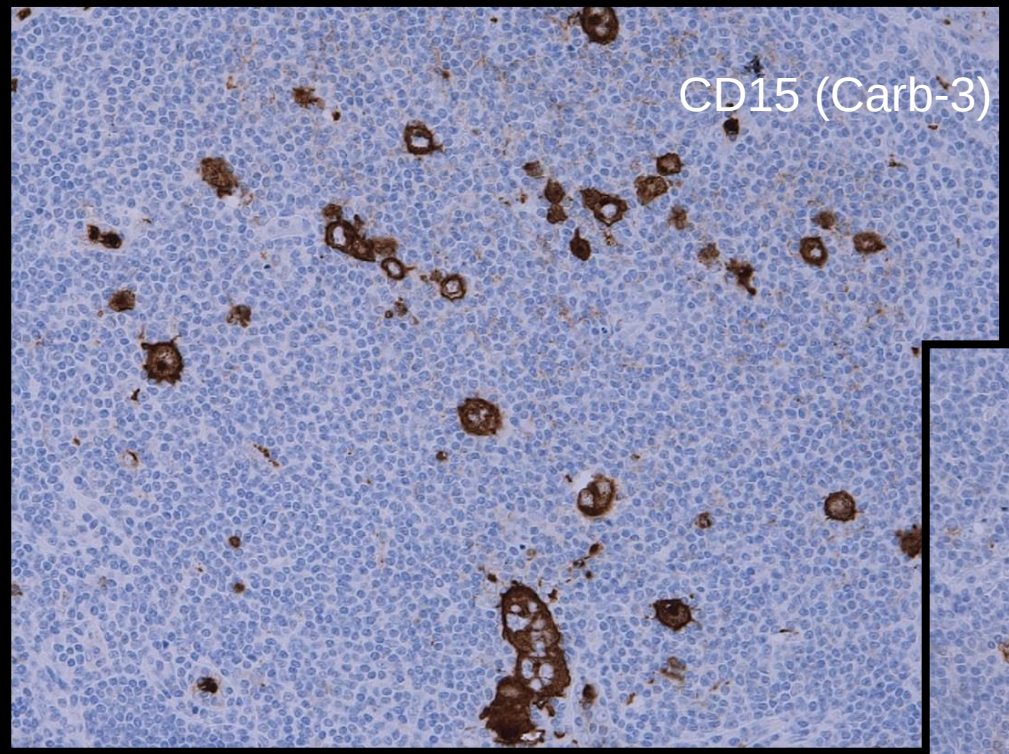
First sequence: CD146 immunostaning => AEC Impact => coverslip

Imaging => de- coverslip => Erasing (Acetone) => Blocking using HIER (Ci)

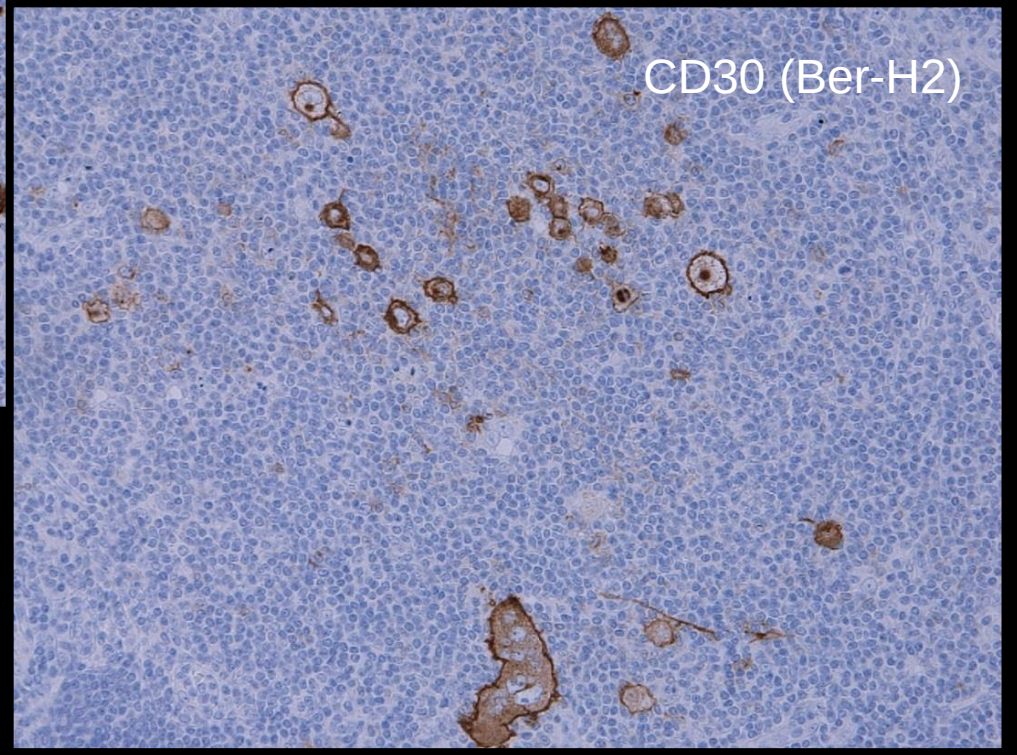
Second sequence: Omission of primary Ab => immunostaning => DAB => coverslip

Melanoma

Hodgkin Lymphoma: CD30 (Ber-H2) and CD15 (Carb-3)



Single immuno-stainings



Mouse Abs

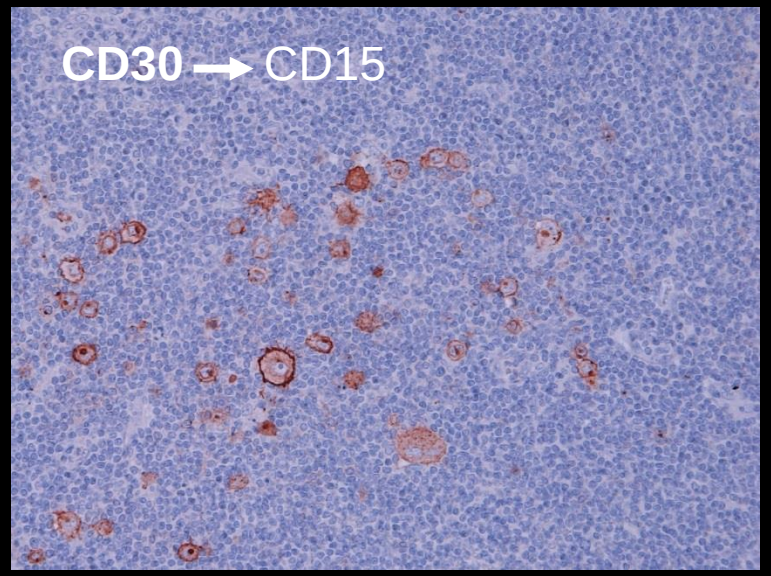
Isotype IgM (CD15)

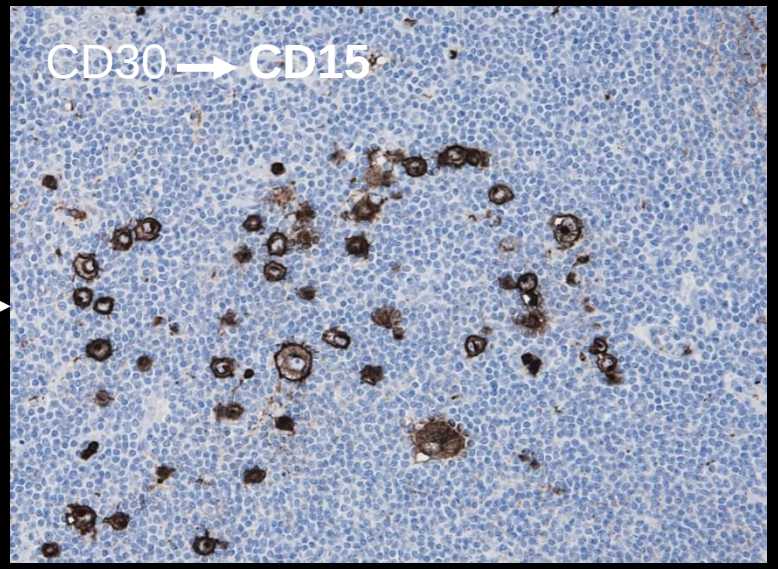
Isotype IgG (CD30)

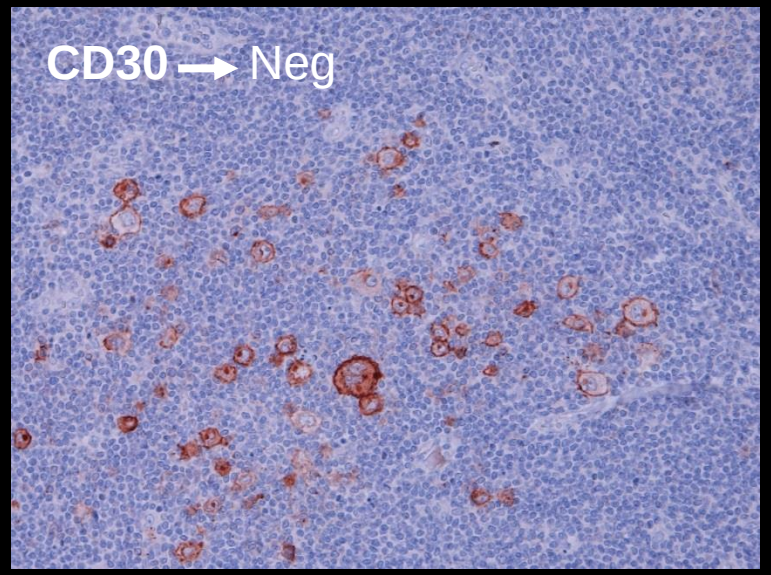
SIMPLE technique: CD30 (Ber-H2) + CD15 (Carb-3)

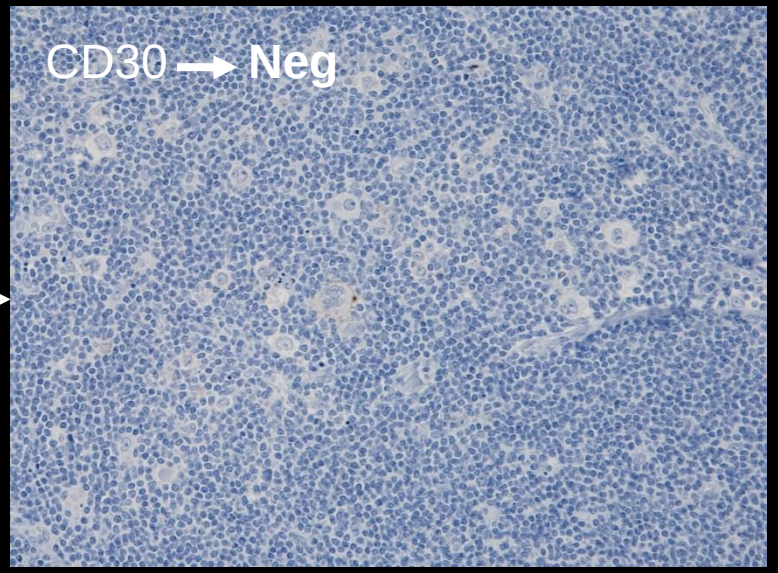
Blocking first set of immuno-reagents

MBO/Citrate pH 6/30 min





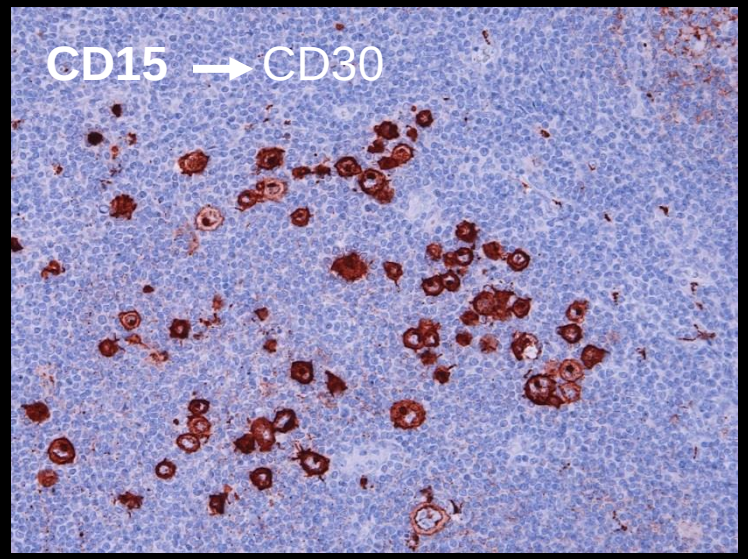


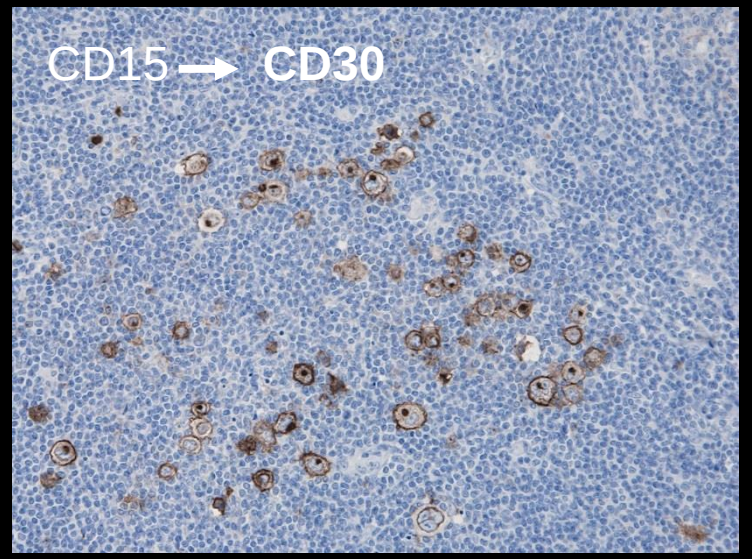


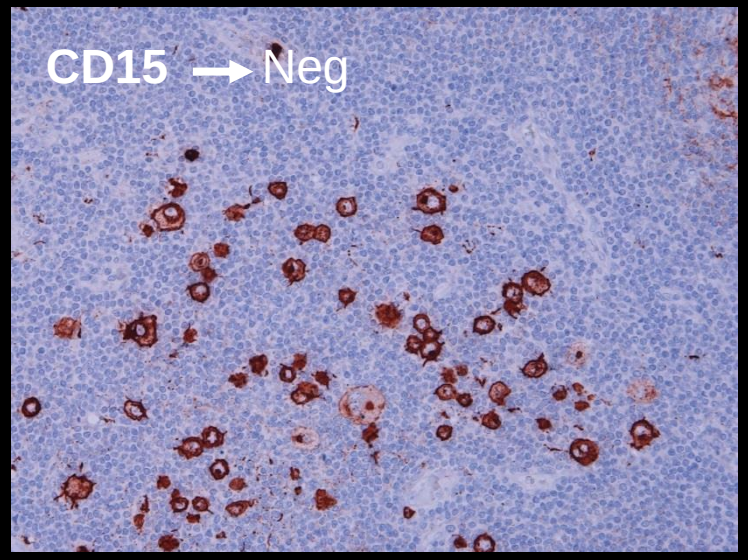
SIMPLE technique: CD15 (Carb-3) + CD30 (Ber-H2)

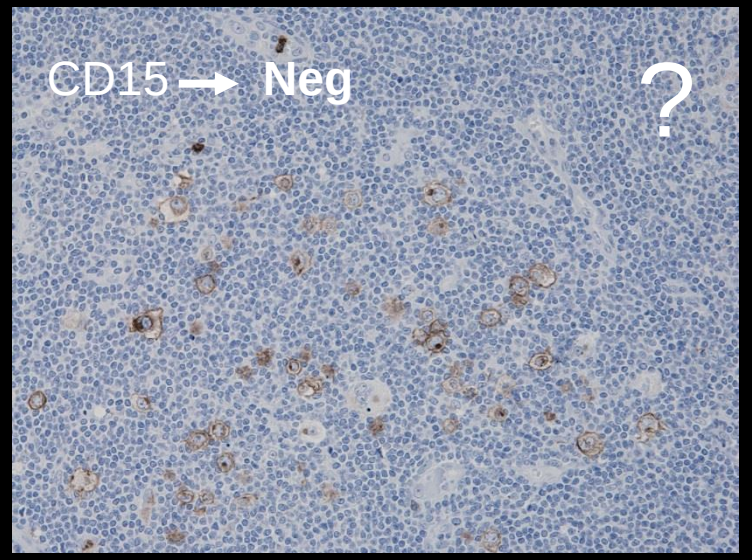
Blocking first set of immuno-reagents

MBO/Citrate pH 6/30 min









SIMPLE technique: Unsuccessful blocking of first set of immuno-reagents

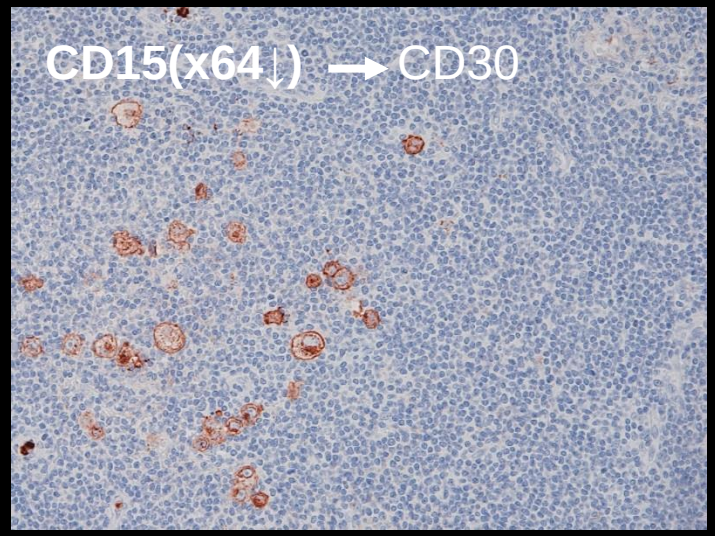
- Antigen density ?
- Antigen-Antibody affinity ?
- Primary antibody structure ?
- Other causes ?

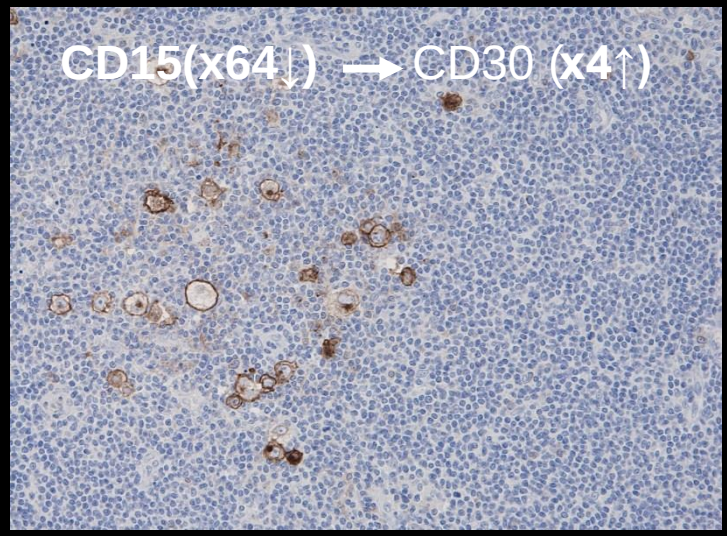
SIMPLE technique: CD15 (Carb-3) + CD30 (Ber-H2)

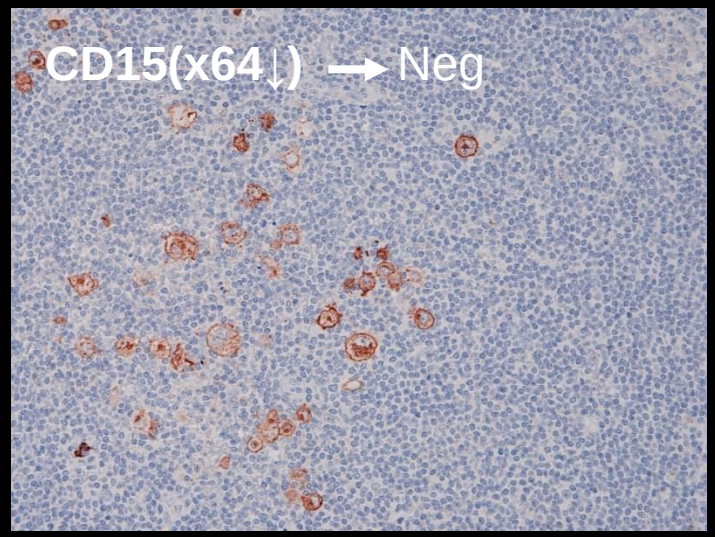
Blocking first set of immuno-reagents

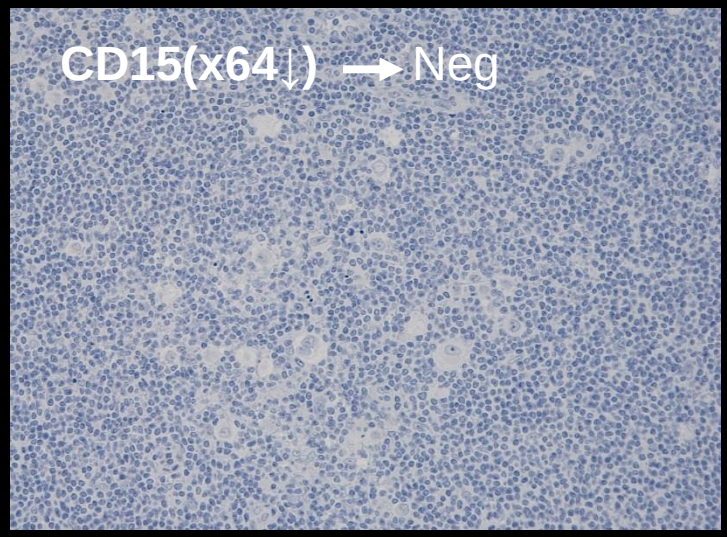
MBO/Citrate pH 6/30 min

CD15 dilution factor (x64)







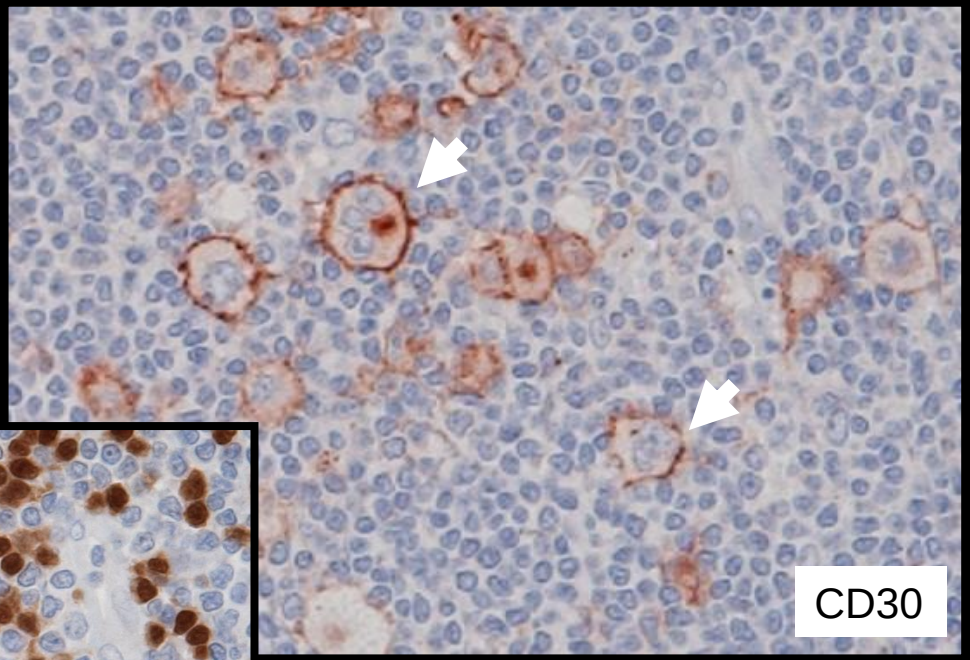


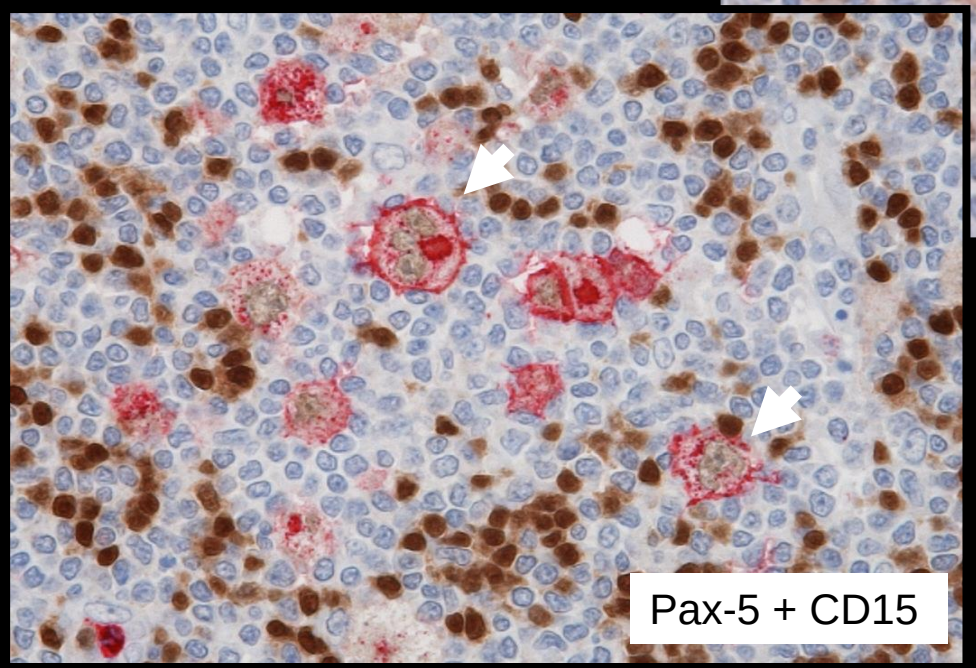
Combining SIMPLE technique with sequential double immune enzymatic method

CD30 (BER-H2) / IgG1

Pax-5 (24) / IgG1

CD15 (Carb-3) /IgM

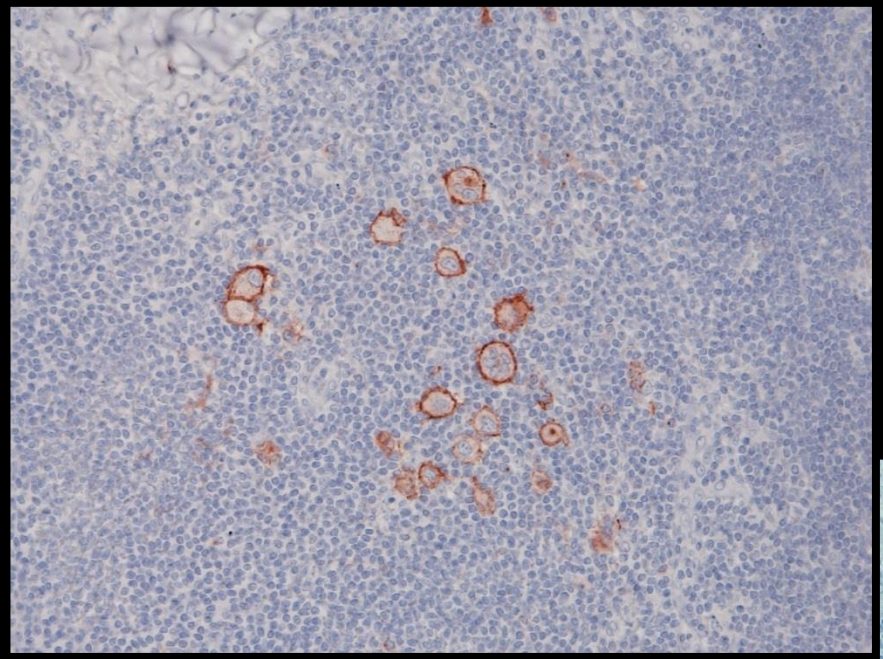




Combined technique

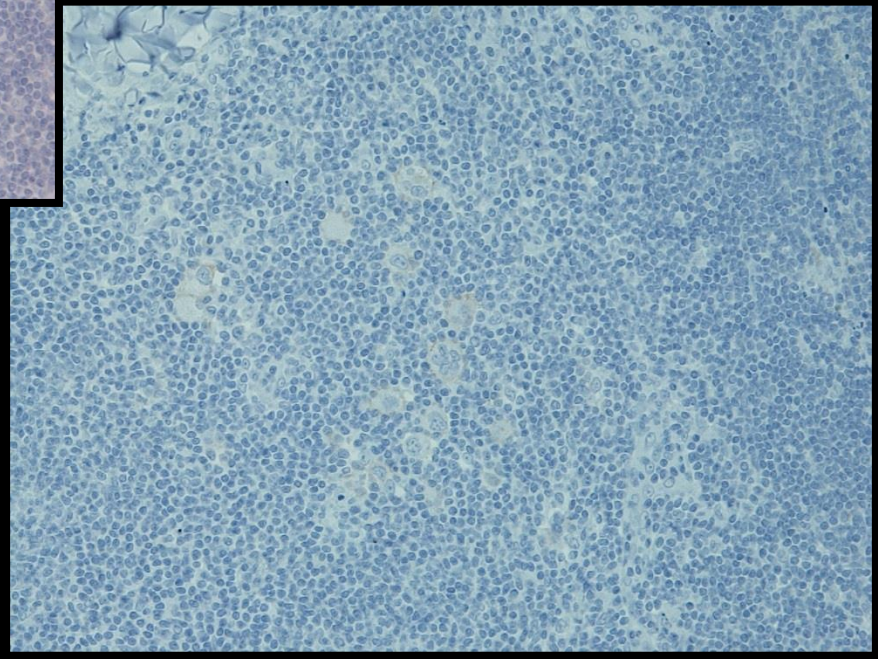
Erasing & blocking first set of immune reagents (HIER) followed by “normal” sequential technique

Combining SIMPLE technique with sequential double immune enzymatic method



CD30 / Neg / Neg

Control of cross reactivity between the individual set of immuno-reagents in the procedure



Hodgkin Lymphoma

Do we have to use a sequential technique ?

Is it possible to avoid the blocking step (HIER in Ci) ?

Simultaneous Immunoperoxidase/phosphatase Labelling and Erasing Method

SIMPLE-Technique

”Poor Mans Virtual Double Staining”

SIMPLE (simultaneous procedure)

Dewax and Pretreatment (Antigen Retrieval)

Incubation with a mix of primary antibody reagents

Rabbit & Mouse monoclonal antibodies

Incubation with Dual-labelling Detection reagents

MultiVision (Mouse-HRP og Rabbit-AP) or MACH2 Double Staining 1 or 2

Incubation with HRP / Chromogen AEC Impact

Hematoxylin (one quick dip) / Mounting (hydrophilic) / Imaging / De-coverslip / Water or buffer

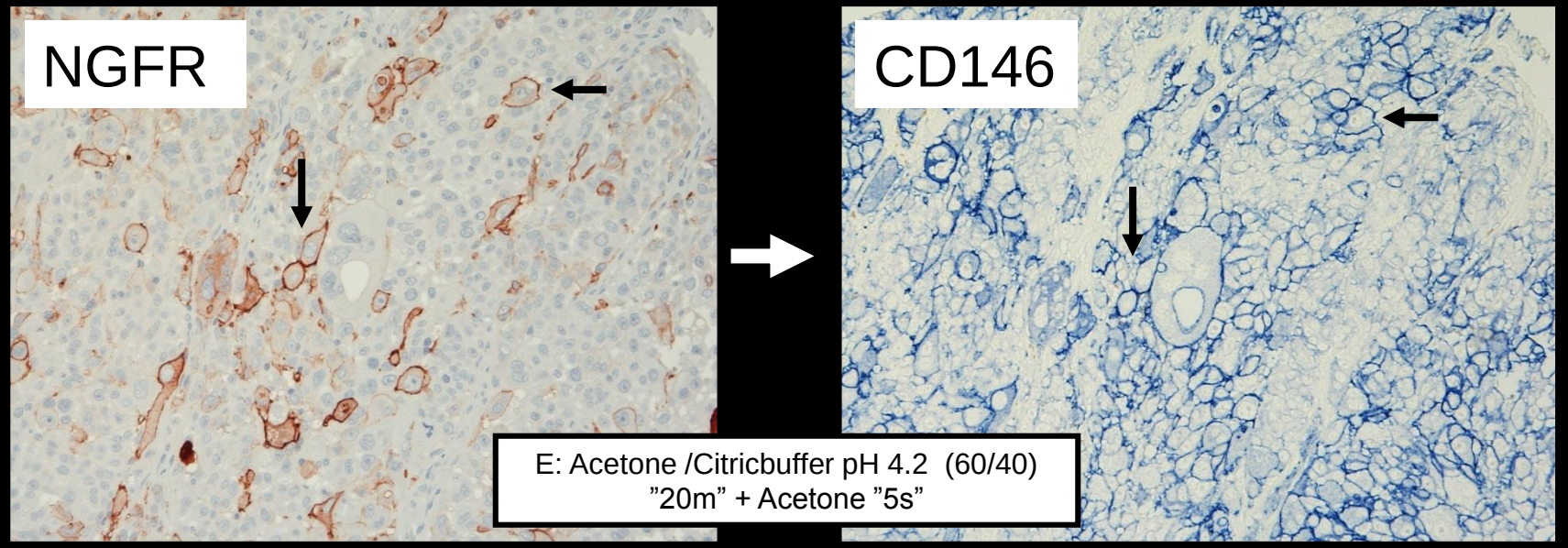
Erasing: Acetone followed by app. buffer

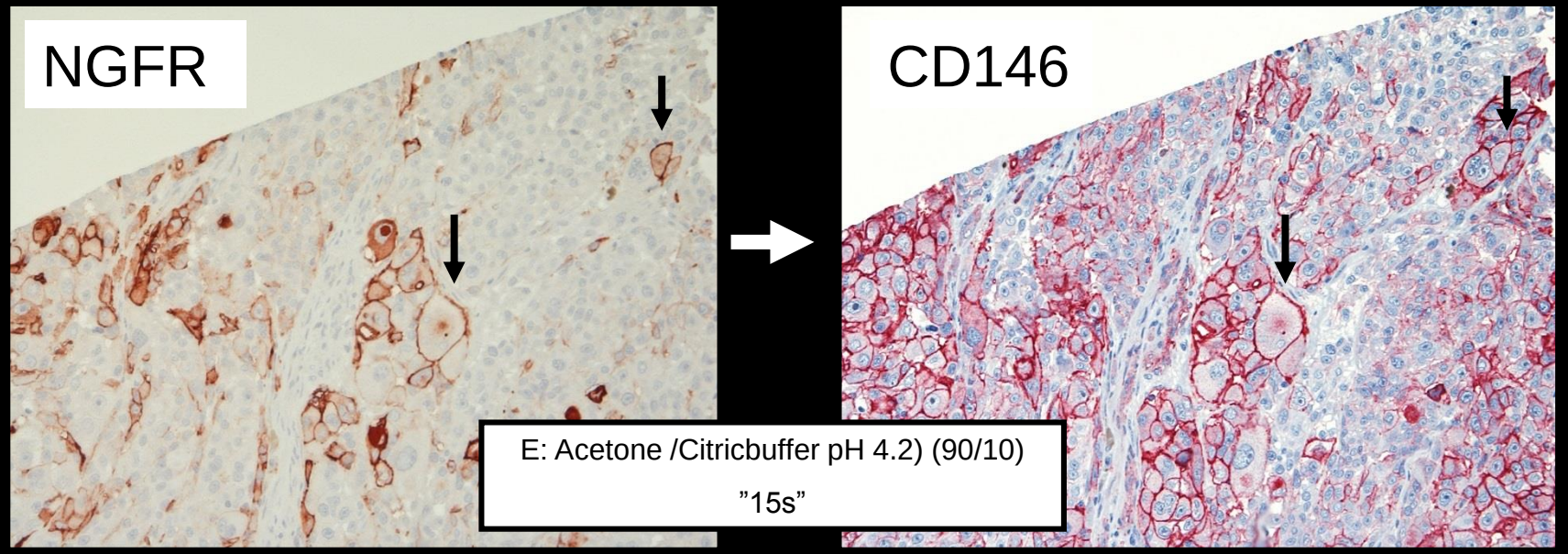
Incubation with AP / Chromogen Permanent Red / LBV-Blue /Warp Red

Mounting (hydrophilic PR or hydrophobic Warp Red / LBV-Blue) / Imaging

NGFR (MRQ21) + CD146 (EPR3208)

SIMPLE-Technique



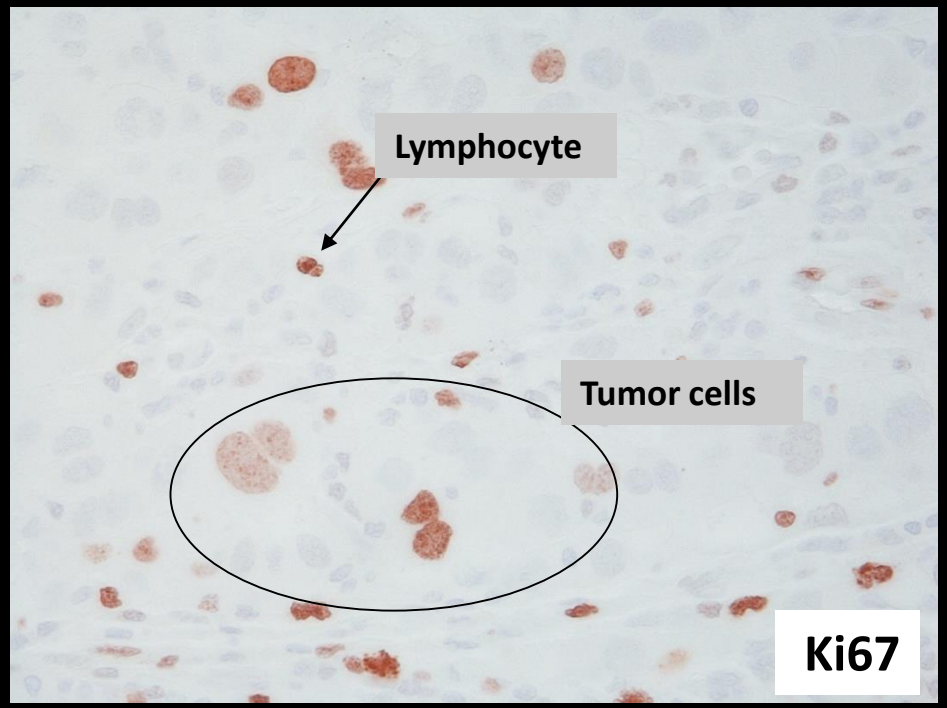


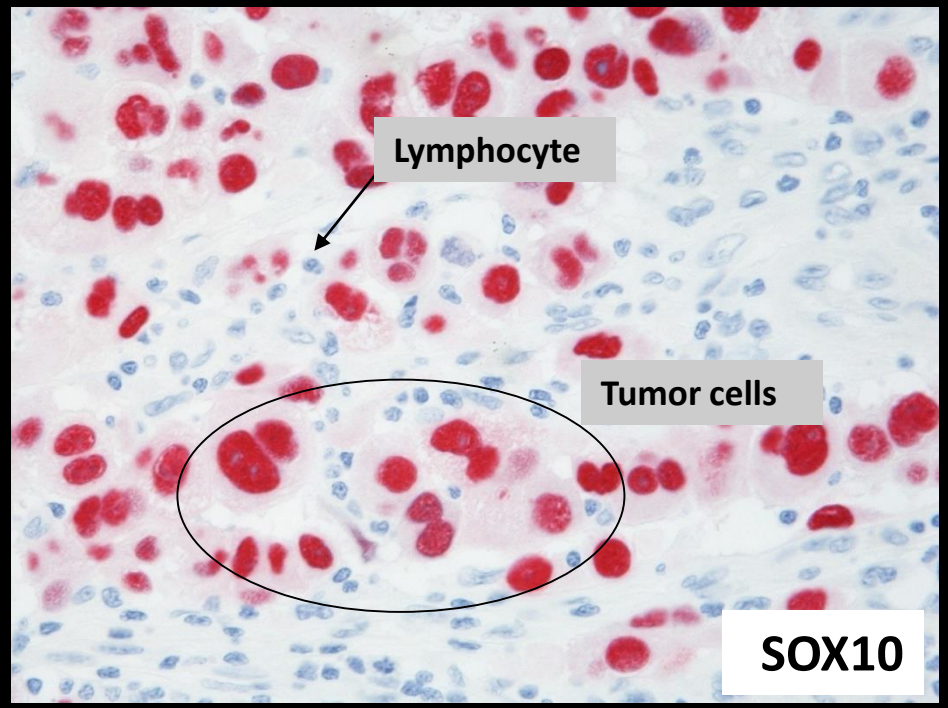
MACH2 Double Staining 1 (SIMPLE technique)

Ki67, SP6 (1:25) + Sox-10, BC34 (1:20)

AEC (Impact) - Erasing (Acetone) - Warp Red

Melanoma



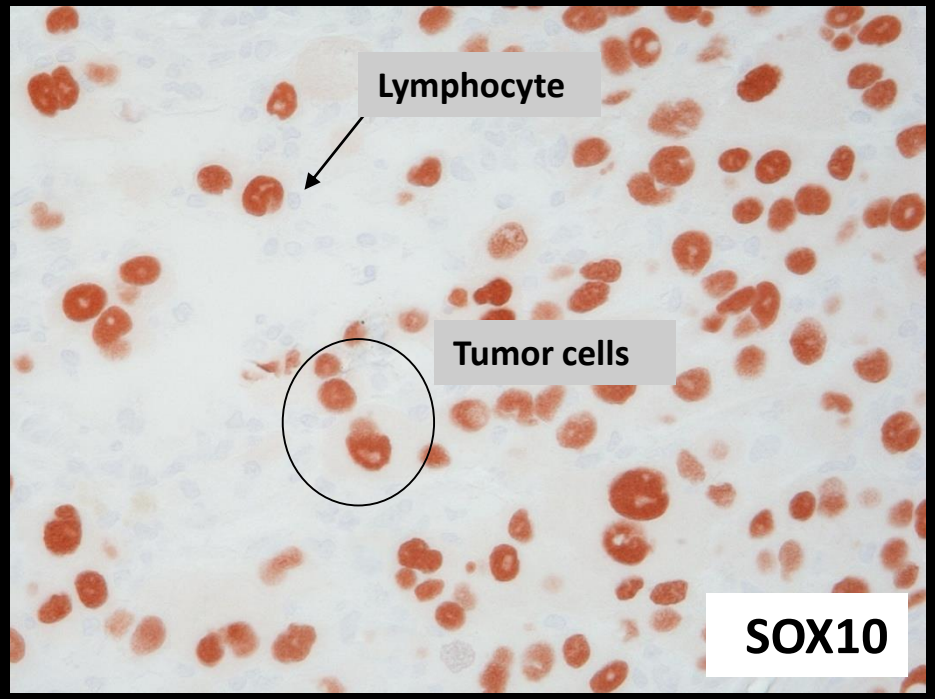


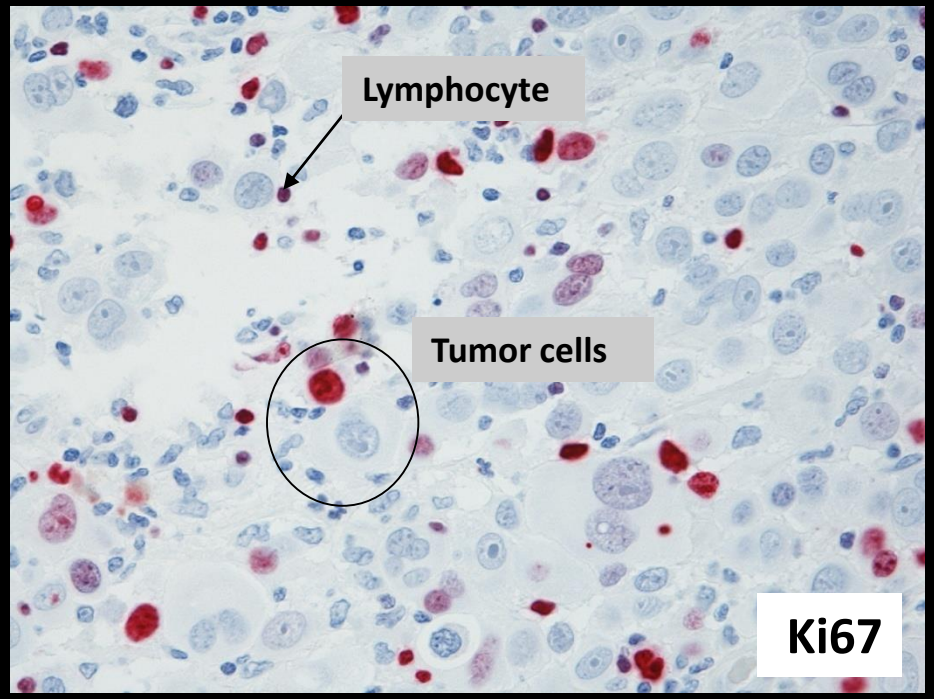
MACH2 Double Staining 2 (SIMPLE technique)

Sox-10, BC34 (1:20) + Ki67, SP6 (1:25)

AEC (Impact) - Erasing (Acetone) - Warp Red

Melanoma





PD-L1

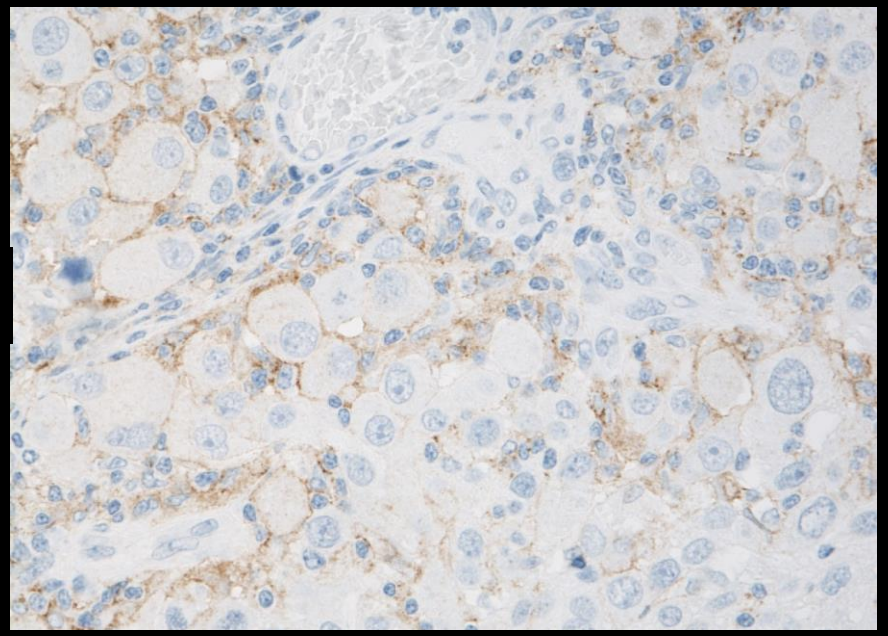
Omnis: HIER Low pH 40` ; PD-L1, 22C3 (1:20) /Flex+ 40-10-40

Removal of coverslip, rehydrated and stained with SOX10

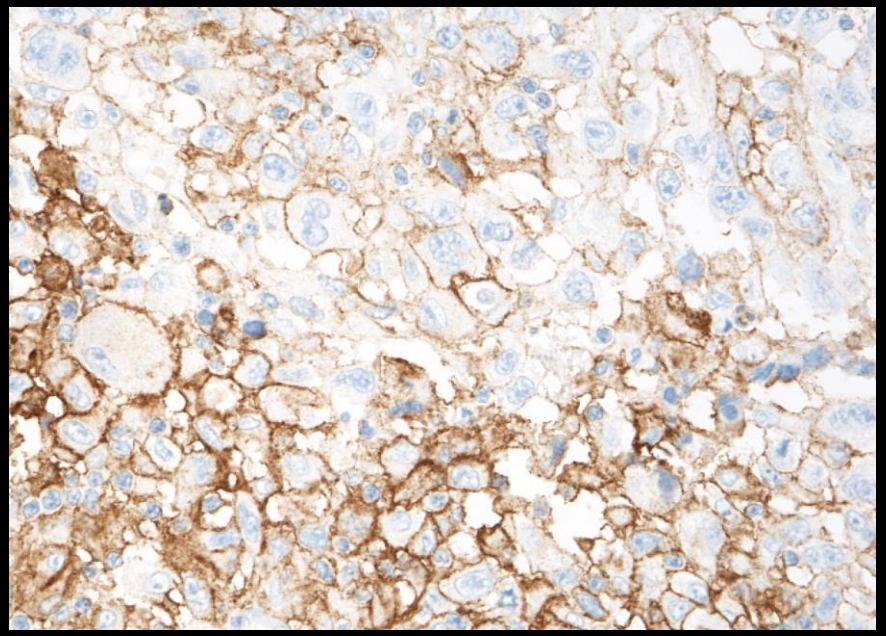
PD-L1 + SOX10

Omnis: HIER low pH 10`; SOX10 (BS7, 1:200 BS) 30`; Histo-AP/PR

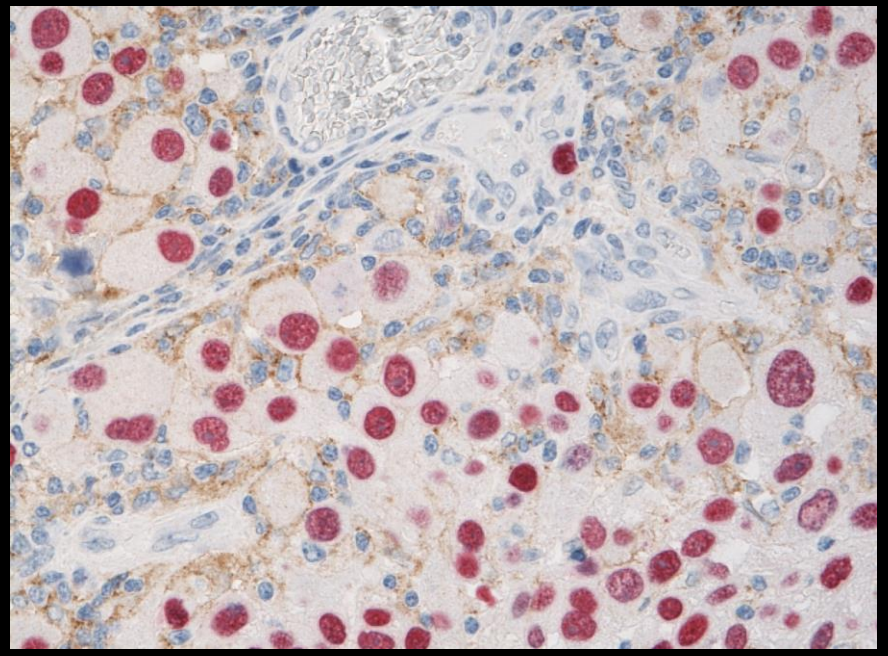
In principal, Flex+-HRP can be used

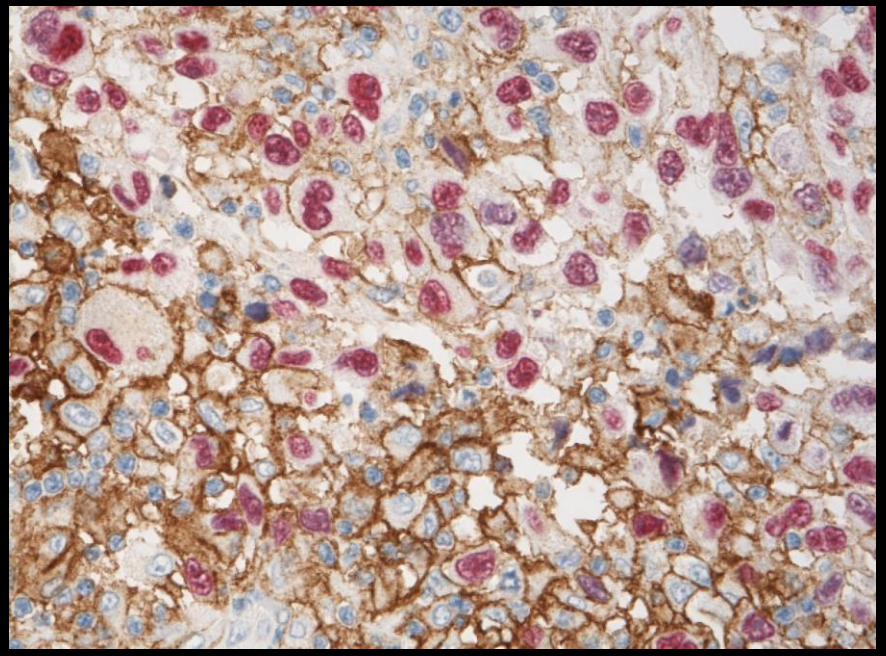


Melanoma (case 1)



Melanoma (case 2)





Conclusion

- Detection of co-localized antigens is possible
- Detection of 3-5 antigens on a single slide
- No considerations in regard of primary Abs (e.g. host, IgG type)

Simultaneous Immunperoxidase/phosphatase Labelling and Erasing Method) applicable to :

- Routine **?**
- Research
- CISH
- Other

Double immuno-staining - The basal fundament for a technical “optimal” performance:

- **Appropriate tissue fixation and processing**
  - Garbage in – Garbage out

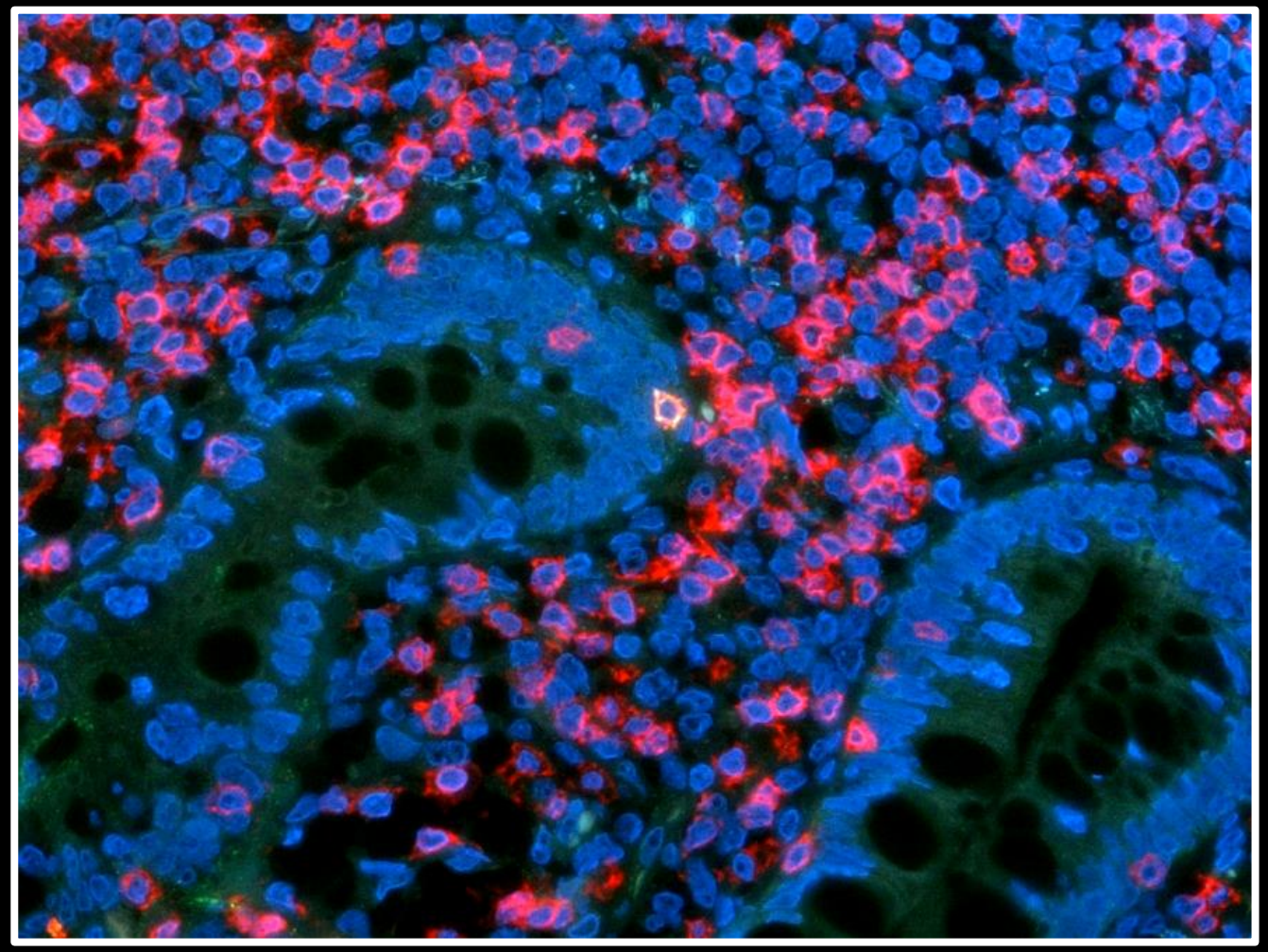
- **Appropriate and efficient epitop retrieval**
  - Do the antigenic epitopes of interest require the same pre-treatment ?

- **Appropriate choice of antibody pairs / clones and dilutions**
  - Do the primary antibody pairs provide app. sensitivity & specificity depending on the chosen platform or detection method ?
  - Is primary antibody pairs available in app. format depending on the chosen detection method ?

- **Robust, specific & sensitive double immuno-staining and visualization systems**
  - Sequential or simultaneous double immuno-staining techniques ?
  - For the routine: Is a double immuno-staining and visualization system (with appropriate sensitivity) always available ?

- **Appropriate choice of control material**
  - Calibrating the primary antibody concentrations carefully according to Critical Staining Quality Indicators (iCAPs)
    - will it work in practice ?

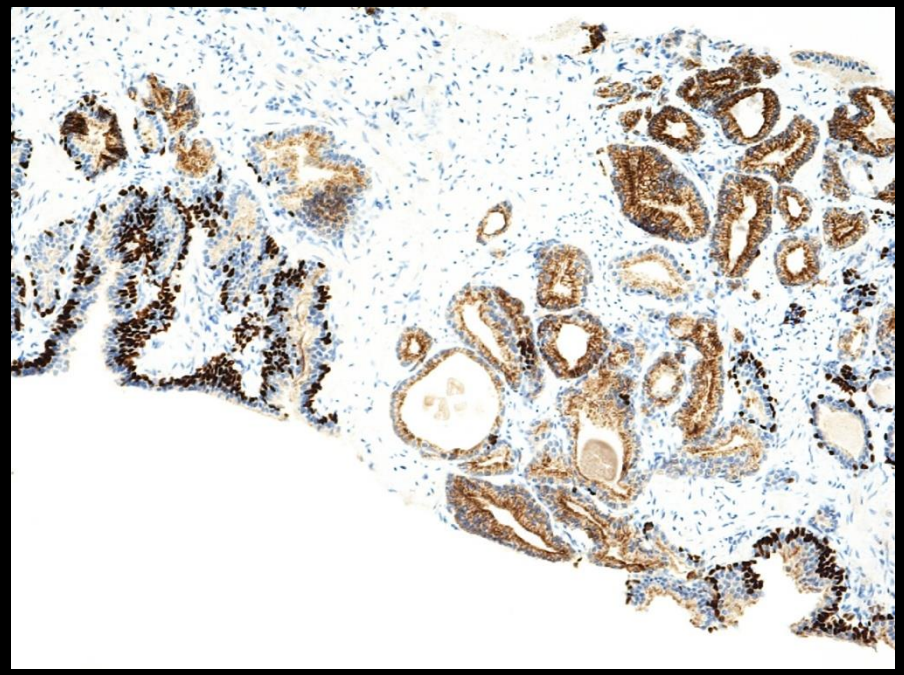
Thank you for your attention



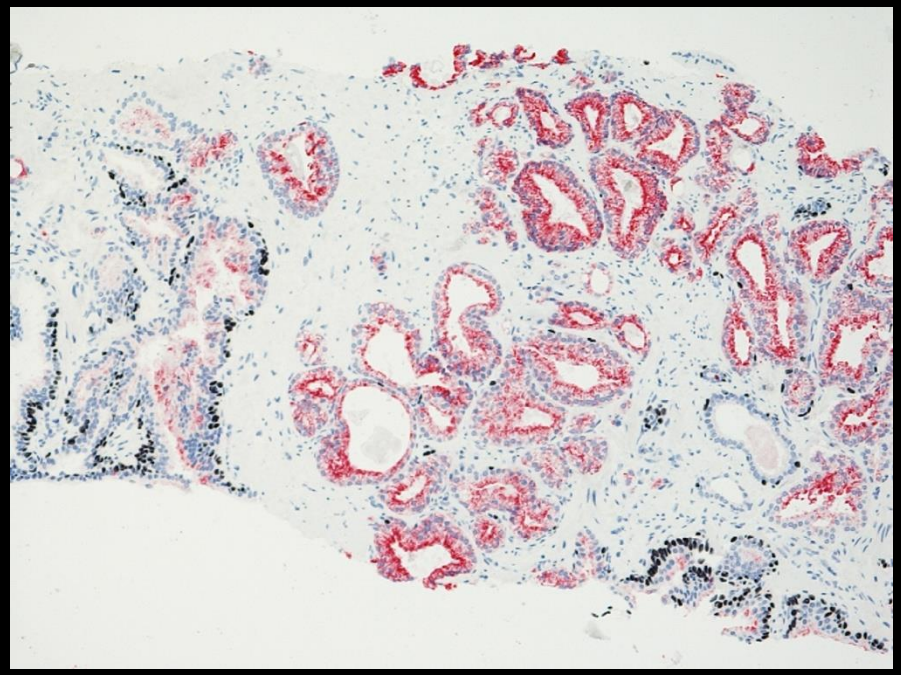
TCR γ (Mab,3.20) /TSA amp. + CD3 (Rab,SP19)

Double staining using sequential technique (Immuno-enzymatic)

PIN [cocktail P63 (4A4) + P504s (13H4)] (Mab+Rab)



PIN [P40 (BC28) + P504s (13H4)] / Sequential staining (Mab+Rab)

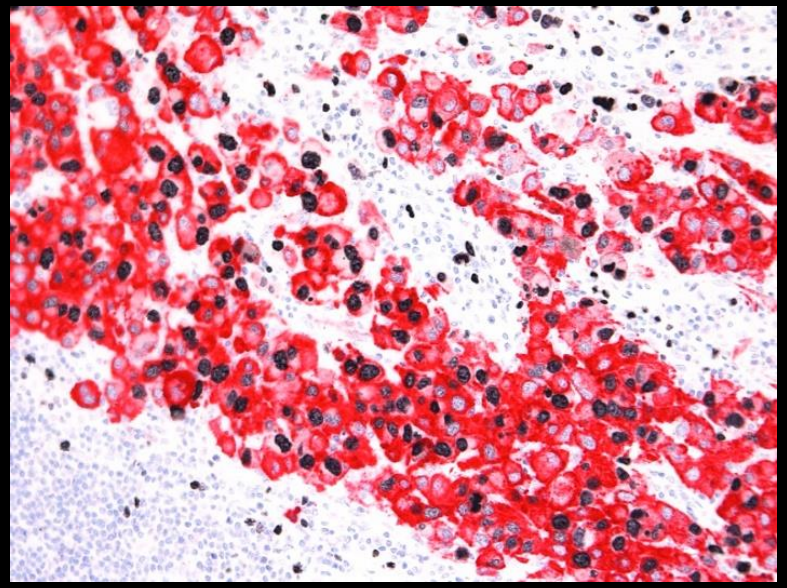


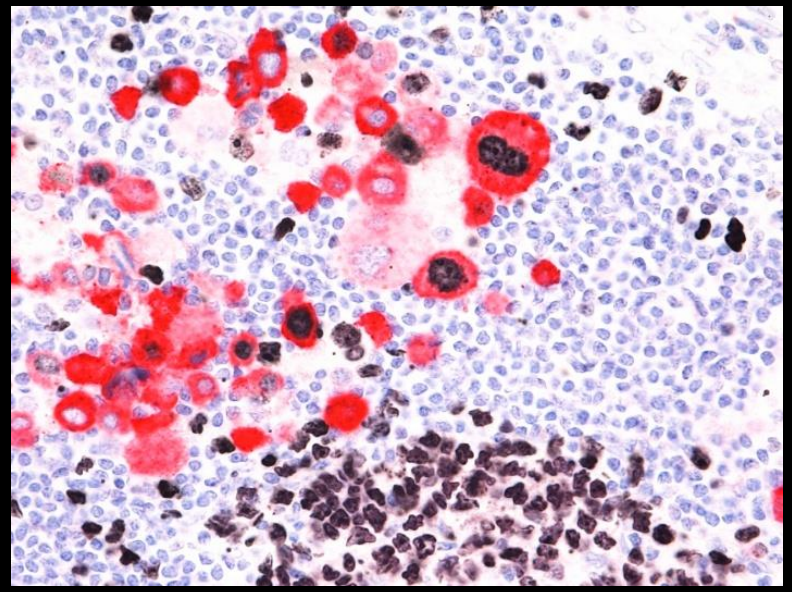
Prostate: Adenocarcinoma

Other useful combinations: : P63 + P504s and/or CK5 (HMw CK) + P504s

Double staining using sequential technique (Immuno-enzymatic)

Melanoma (Lymph node)





Ki67 , SP6 (1:100) + Melan A, A103 (1:100) (Rab+Mab)

Other useful combinations: Sox-10 + MLA and/or Sox-10 + S100

Triple staining using sequential technique (Immuno-enzymatic)

LAB Næstved

Sequential procedure (Immuno-emzymatic):

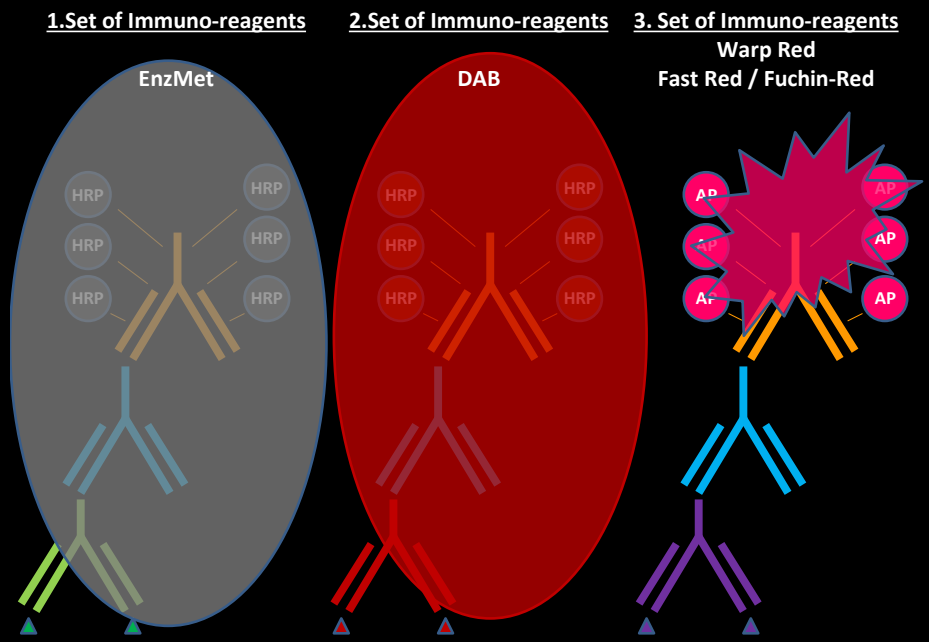
Pre-treatment (Antigen Retrieval)

First primary Ab (same or different host, Ig-type or subclass) (20 min).
Detection with Quanto/HRP (10+10 min).
Visualization with EnZMet (5 min).

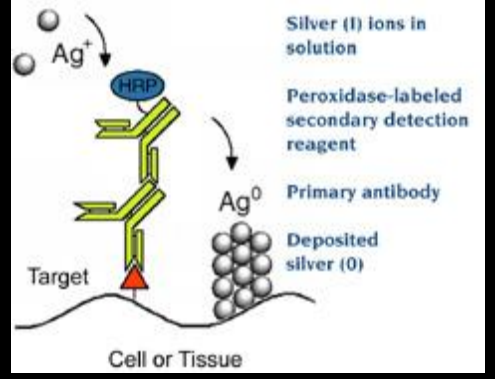
Second primary Ab (same or different host, Ig-type or subclass) (20 min).
Detection with Quanto/HRP (10+10 min).
Visualization with DAB (7min).

Third primary Ab (same or different host, Ig-type or subclass) (20 min).
Detection with Hi-Def /AP (10+10 min).
Visualization with Warp Red (Fuchin-Red) (7min).

Counterstain, dehydration and mounting.



EnzMet (silver) and DAB deposit (after 1. and 2. set of immuno-reagens) shelter / shields for un-specific reaction of the following primary antibodies and/or detection reagents.

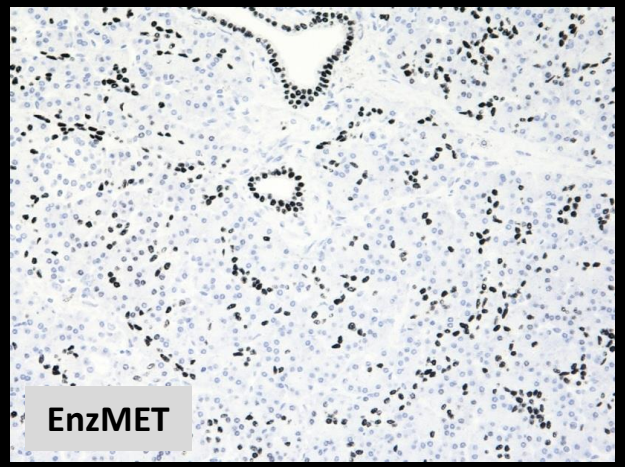


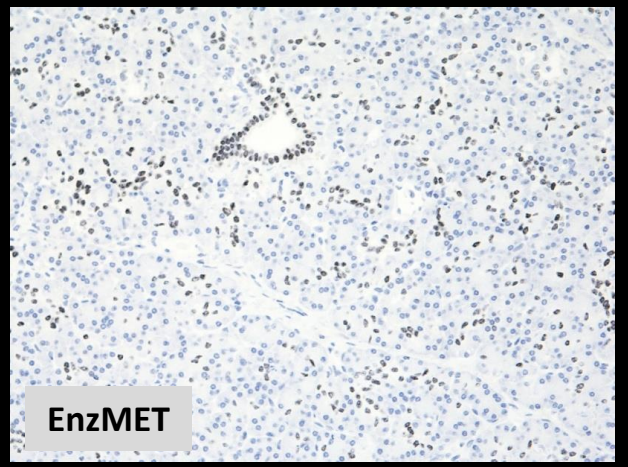
EnzMET versus DAB

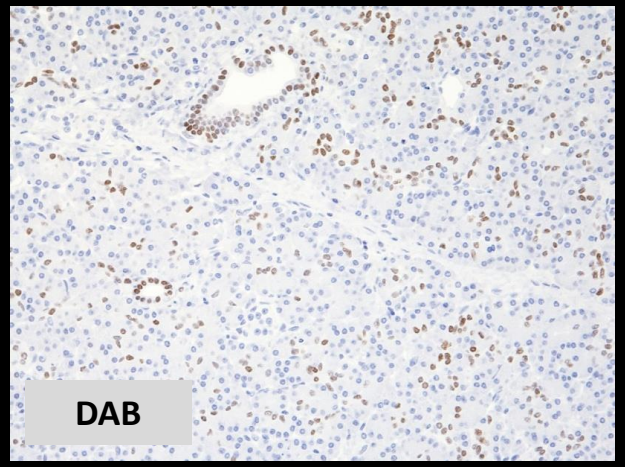
CDX-2, DAK-CDX2

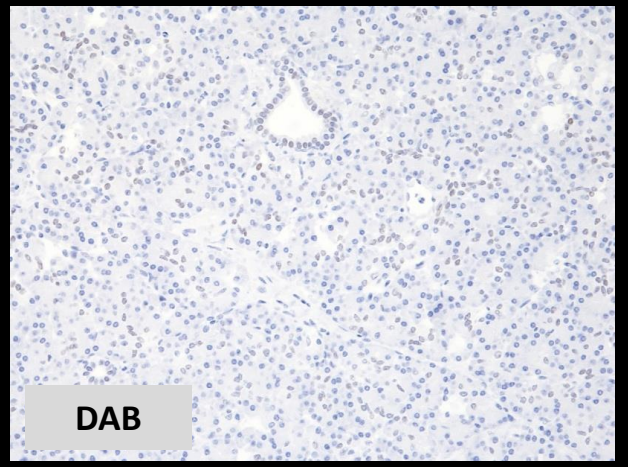
Pancreas

1:25 **1:100**



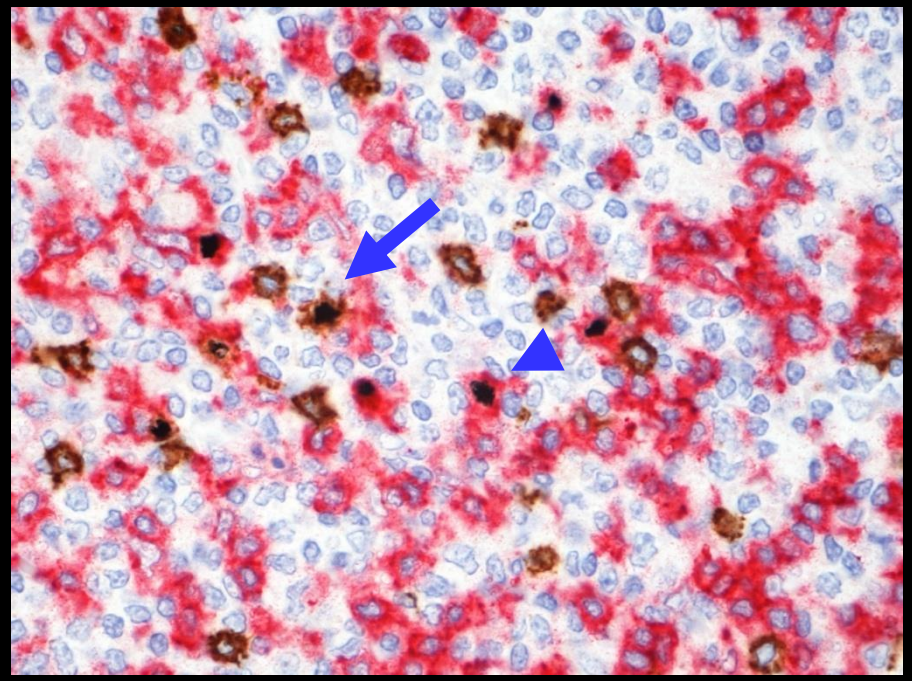


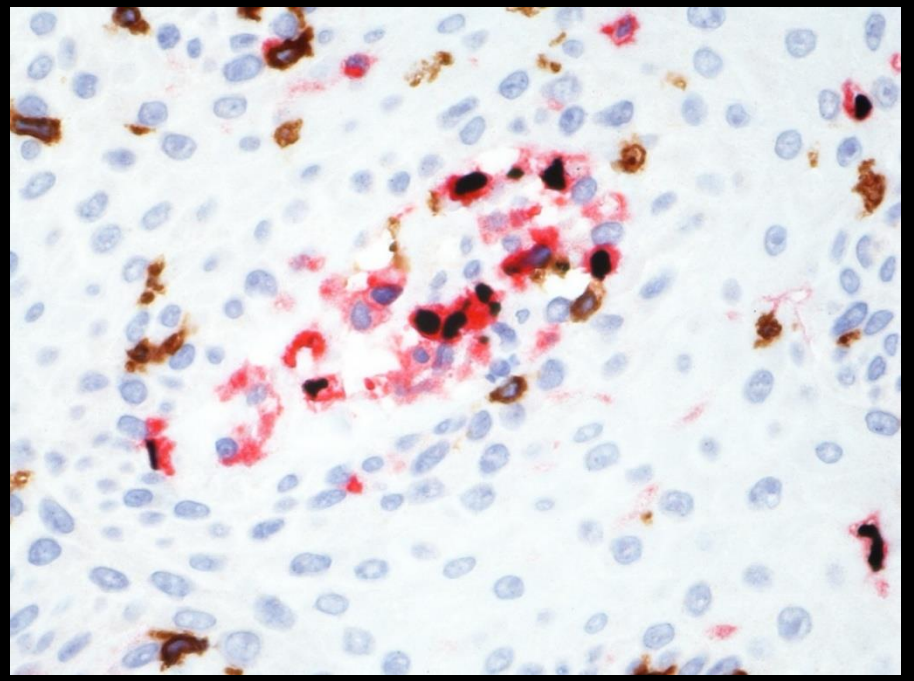




Triple staining using sequential technique (Immuno-enzymatic)

FoxP3 (236/E7) + CD8 (C8/144B) + CD4 (EPR6855) (Mab+Mab+Rab)





Tonsil

FoxP3 (black nuclear staining)

CD8 (brown membraneous/cytoplasmic staining, arrow)

CD4 (red membraneous/cytoplasmic staining, arrow-head)

Skin

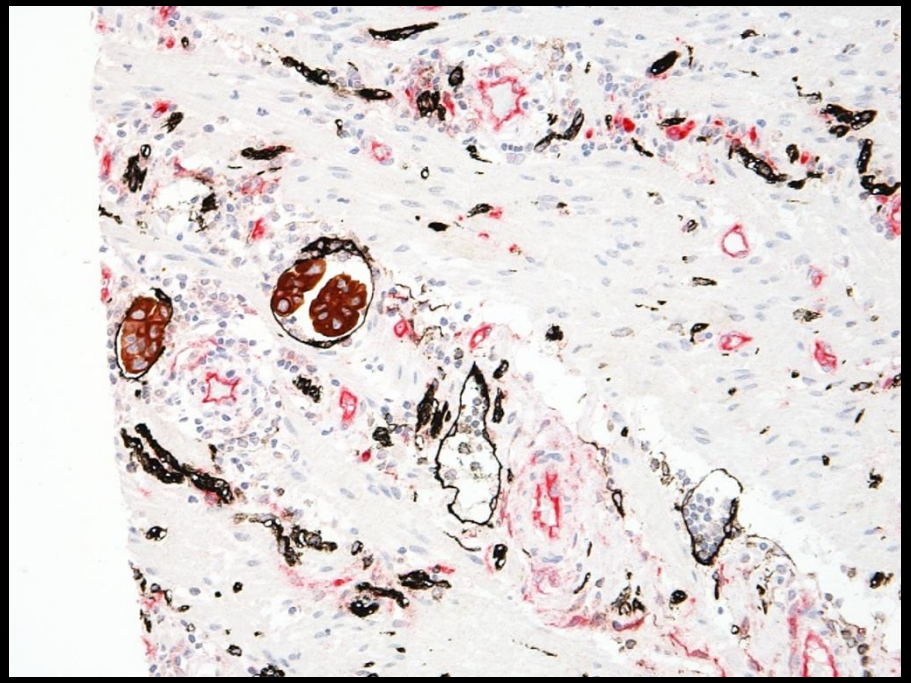
FoxP3 (black nuclear staining)

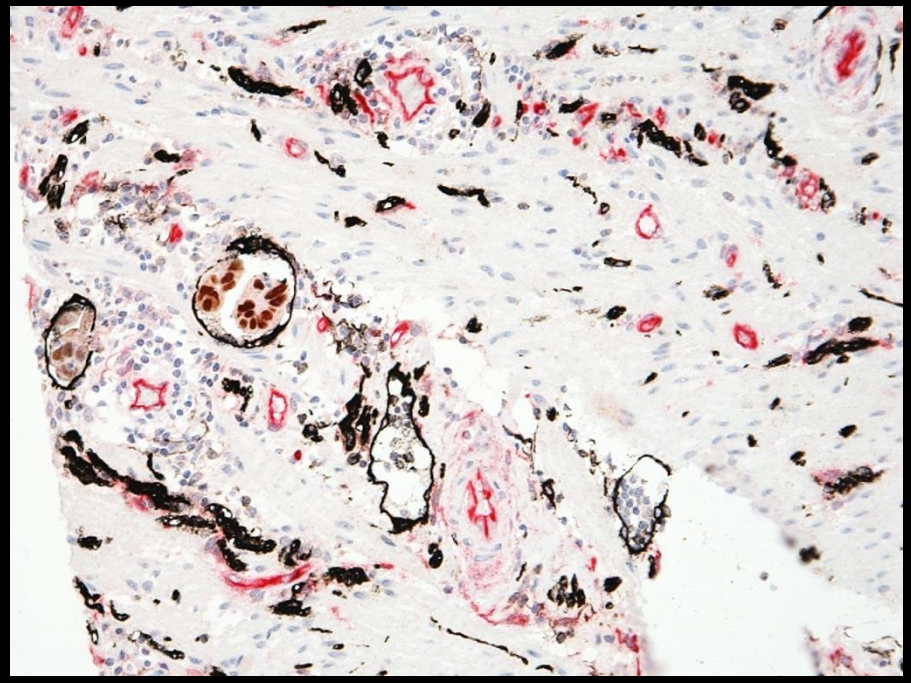
CD8 (brown membraneous/cytoplasmic staining, arrow)

CD4 (red membraneous/cytoplasmic staining, arrow-head)

Triple staining using sequential technique (Immuno-enzymatic)

Podoplanin (D2-40) + CDX-2(DAK-CDX2) or CK20 (K_s20.8) + CD34 (QBEND10) / (Mab x3)





Adenocarcinoma colon:

D2-40 (black lymph-endotheliale staining)

CK20 (brown cytoplasmic staining of the tumor cells)

CD34 (red membraneous endotheliale staining)

Adenocarcinoma colon:

D2-40 (black lymph-endotheliale staining)

Cdx-2 (brown nuclear staining of the tumor cells)

CD34 (red membraneous endotheliale staining)

A simple approach to double immuno-staining

Are antigens of interest located in the same cellular compartment (e.g. the nuclei`s) ?

NO

Use a DAB based sequential or a simultaneous technique

Enzyme conjugates

Conventional bright field microscopy

Include controls

YES

Use a immuno-fluorescence simultaneous technique.

Fluorochrome conjugates

Fluorescence microscopy

Mixed colors will be present at sites of co-localization

Include controls

J Pathol. 2000 Aug;191(4):452-61.

Double immunofluorescence labelling of routinely processed paraffin sections.

Mason DY, Micklem K, Jones M.

Argued that double immuno-enzymatic labelling of routinely processed tissue are :

- Time-consuming
- Prone to background staining
- Rarely suitable for detecting two antigens present at the same site- since one label tends to obscure the other.

Demonstrated that double immunofluorescence labelling :

- Is more rapid than enzyme-based techniques
- Avoids the problems of interpreting two antigens present at the same site
- Only minimal tissue autofluorescence was observed.

The double immunoflourescence procedure may represent the optimal technical approach to the co-localization of pairs of antigens in routinely processed tissue samples.

❑ Double immunofluorescence staining using simultaneous technique – Næstved LAB

- Primary antibody cocktail is applied to the tissue at the same time (simultaneously)

- Primary antibodies must be of different host (e.g. mouse and rabbit) or at least different Ig-types, subclass or one primary Ab with a conjugate (e.g. biotin).

- Reactions is detected with a mix of secondary antibodies conjugated with two different fluorescent dyes (e.g. A488 and A594) and applied to the tissue at the same time (simultaneously).

  To prevent cross-reaction between secondary antibodies raised against different species, it is recommended to apply second-step antibodies raised in the same host – if not possible, use pre-absorbed secondary antibodies.

- Each antibody: antigen reaction will yield a specific color of staining that can be easily identified (Fluorescence microscopy with appropriate single, double or triple filters).

- Preferred method to detect targets in the same cell compartment (co-localized signal)

Double immuno-fluorescence staining using simultaneous technique

Simultaneous procedure (Immuno-Fluorescence):

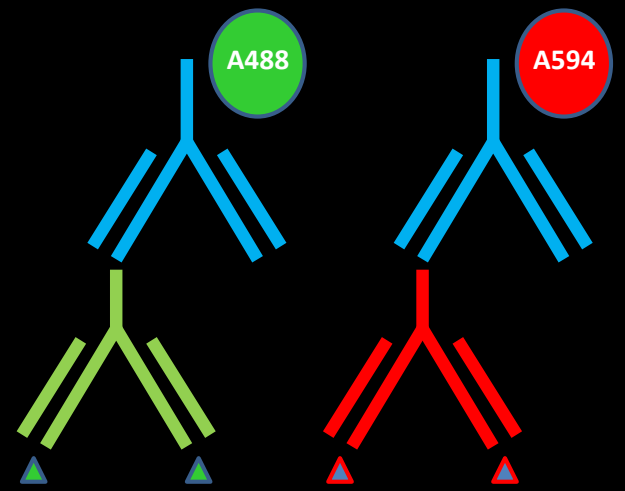
Pre-treatment (Antigen Retrieval)

Incubation with Primary Ab mix (e.g different host/ Mab+Rab) (1h).

Incubation with Secondary Ab mix (Goat -anti Mab+Rab) (1h).

Alexa Fluor 488 anti mouse Ig + Alexa Fluor 594 anti rabbit Ig

Dehydration + air-drying + coverslipping with Vectashield (+ DAPI)

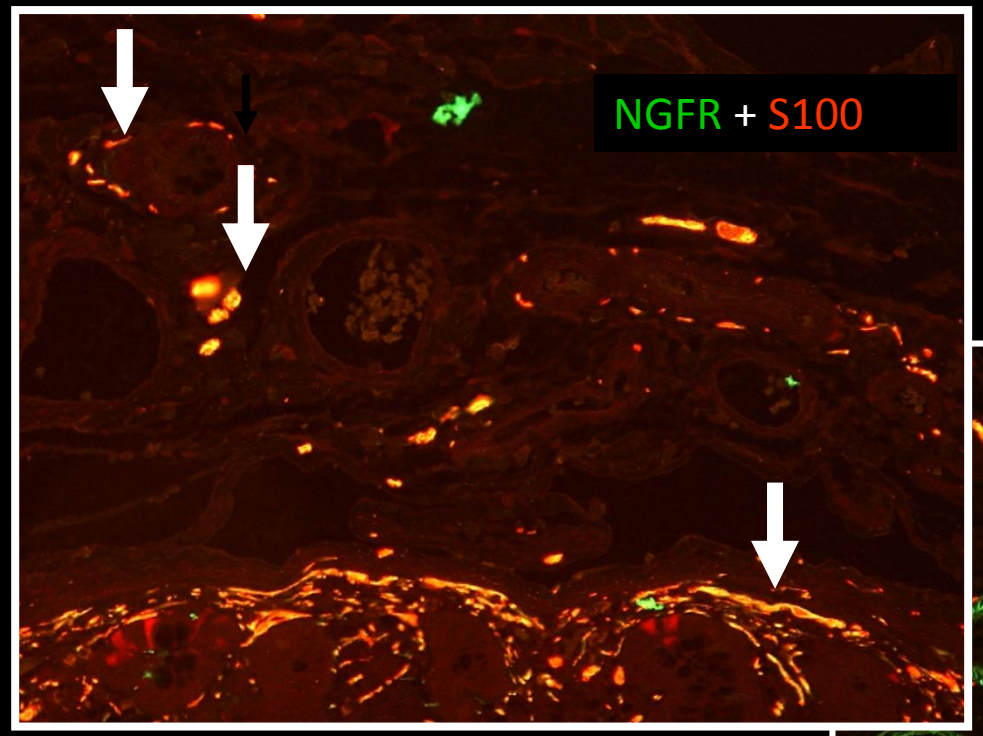


- **Goat anti mouse IgG (H+L):**
  - **Alexa Fluor 488 (Cat.no. A11001 / Molecular Probes)**
  - **TSA-Alexa 488 (Cat.no. T20912 / Molecular Probes)**
- **Goat anti rabbit IgG (H+L):**
  - **Alexa Fluor 594 (Cat.no. A11012 / Molecular Probes)**
  - **TSA-Alexa 594 (Cat.no. T20927 / Molecular Probes)**

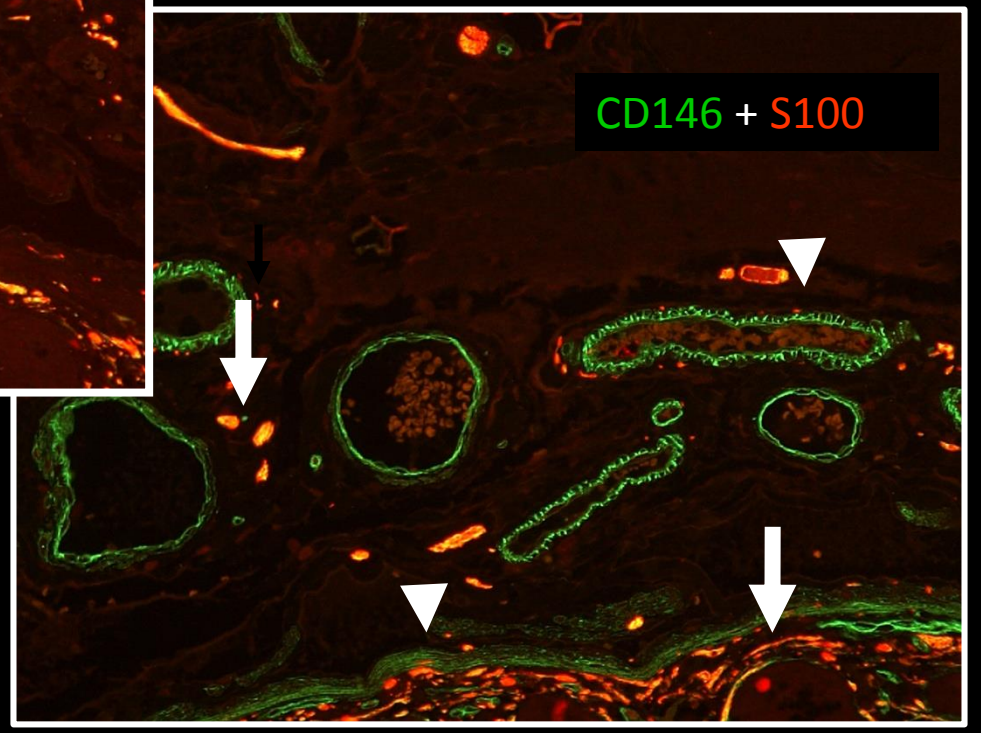
If required – increase sensitivity with Tyramide Signal Amplification (TSA-Alexa Fluor 488 anti mouse Ig **)**

S100(Rab, poly) + CD146 (Mab, N1238) / NGFR (Mab, MRQ-21)

Bowell

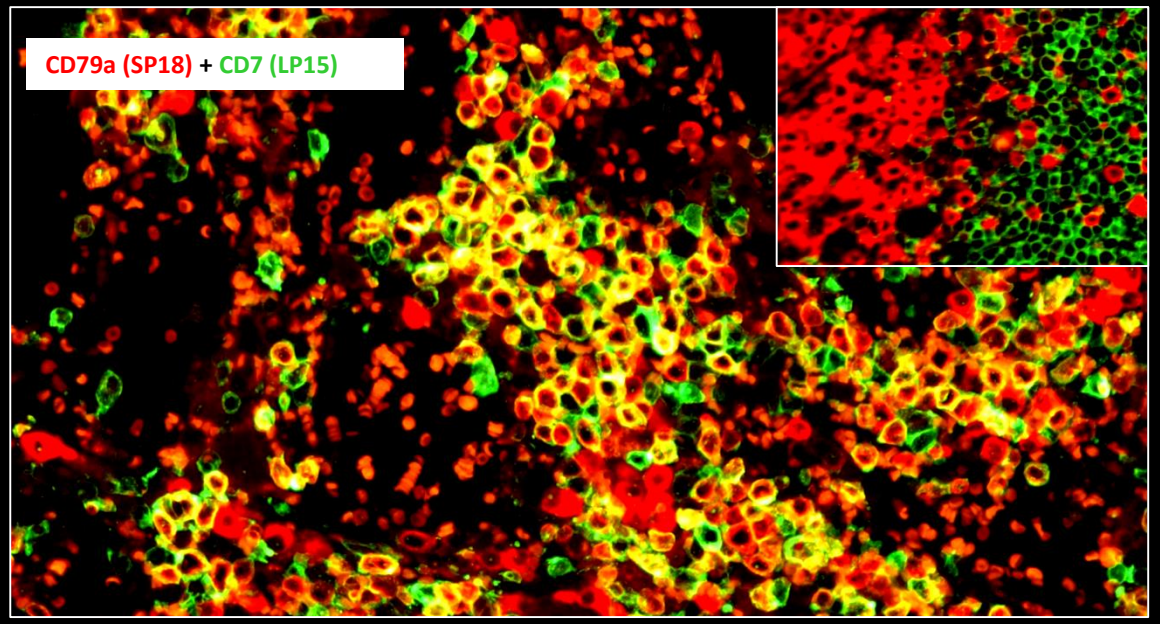


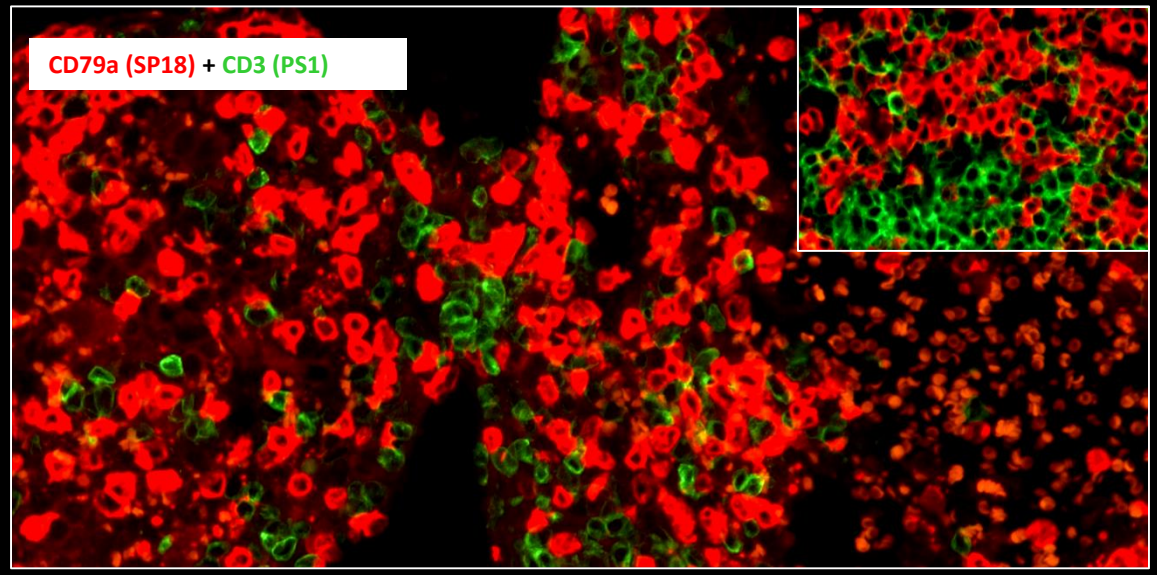
Note: Co-localization of NGFR and S100 in peripheral nerves and ganglion cells (arrows) (yellow colour) .



Note: Co-localization of CD146 and S100 in peripheral nerves and ganglion cells (arrows).

Also, CD146 stains peri-vascular structures and smooth muscles of lamina muscularis mucosa (arrowheads).





PT : ALL (B-type)

Flowcytometry showed aberrant expression of CD7 in neoplastic B-cells

Note: Aberrant co-localization between CD79a (B-cell marker) and CD7 (T-cell marker) of the neoplastic B-cells in the ALL

The reaction pattern between CD79 and CD3 showed expression of the respective markers in different cell types (neoplastic B-cells and T-cells).

Tonsil (insert`s)

Normal expression of the B-cell marker (CD79a) and the T-cell markers (CD7 or CD3). No co-localized signals

Double immuno-fluorescence staining using simultaneous technique

LAB Næstved

Simultaneous procedure using TSA amplification:

Exactly the same method as the "normal" double immufluorescence procedure except for introducing HRP in the secondary Ab mix and a final amplification step using Alexa Fluor 488 conj. Tyramide reagent.

Mechanism of Tyramide amplification:

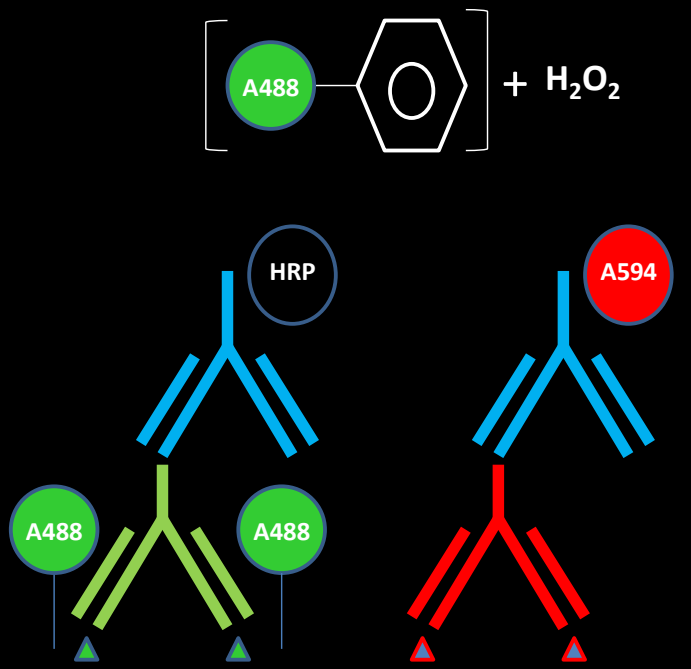
-Introducing HRP
-Incubation with A488 conjugated Tyramide and H_2O_2

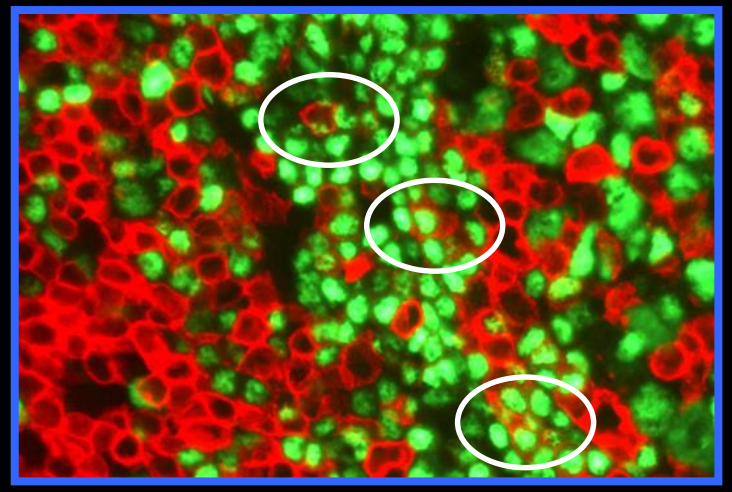
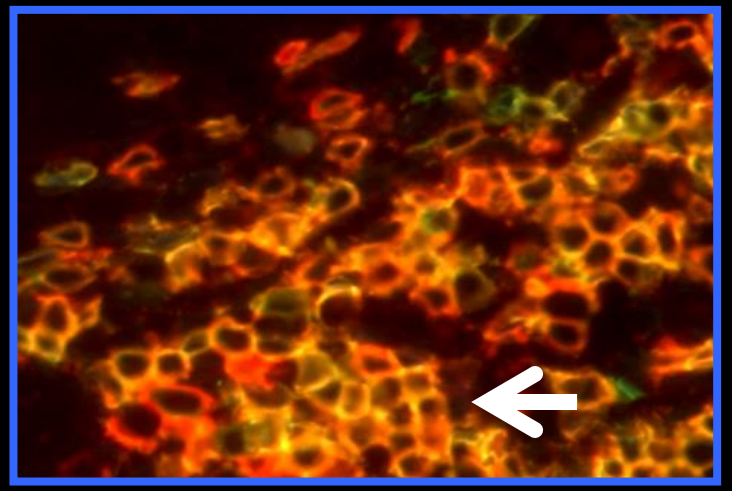
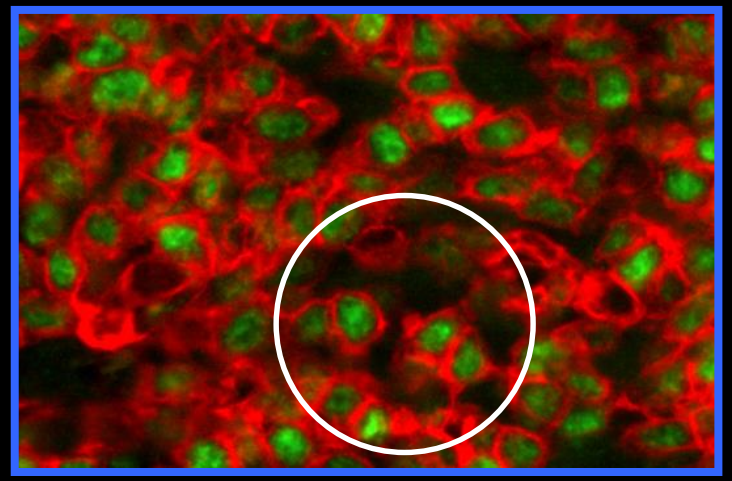
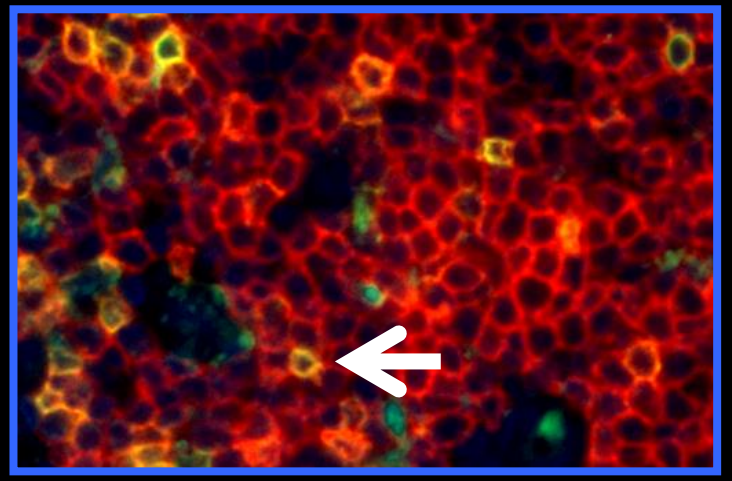
Tyramide , phenolic compound, converted into an short-lived extremely reactive intermediate

Intermediates covalently binds to electron rich regions of adjacent proteins (esp. tyrosine) – rapidly

- Deposit of A488 in close vicinity of Ab/Ag reactions

-Visualization of A488 deposit under fluorescence microscopy



	PAX-5, 1EW (TSA amp.) + CD5, SP19	CD3, PS1 + CD5, SP19
Tonsil		
B-CLL		

Note : Co-localization of normal T-cells in the tonsil and in the B-CLL (CD3+CD5) and co-expression of the neoplastic B-cell (Pax-5 and CD5) in the B-CLL and normal B-Cells in the mantle zone of the tonsil

Some final remarks to double immunofluorescence labeling using simultaneous technique:

Control of cross-reactivity between secondary Abs and primary Abs:

Test on tissue specimens in which two antigens is expressed in different cells and easy to differentiate (e.g. SMA and CD68)

Incubate with primary Ab-X followed by detection with secondary antibody anti-Y
= Negative

Incubate with primary Ab-Y followed by detection with secondary antibody anti-X
= Negative

Omission of primary Ab-X followed by detection with secondary antibody cocktails (anti-X and anti-Y)
= Only antigen Y should display a positive signal without any signs of co-localized signal

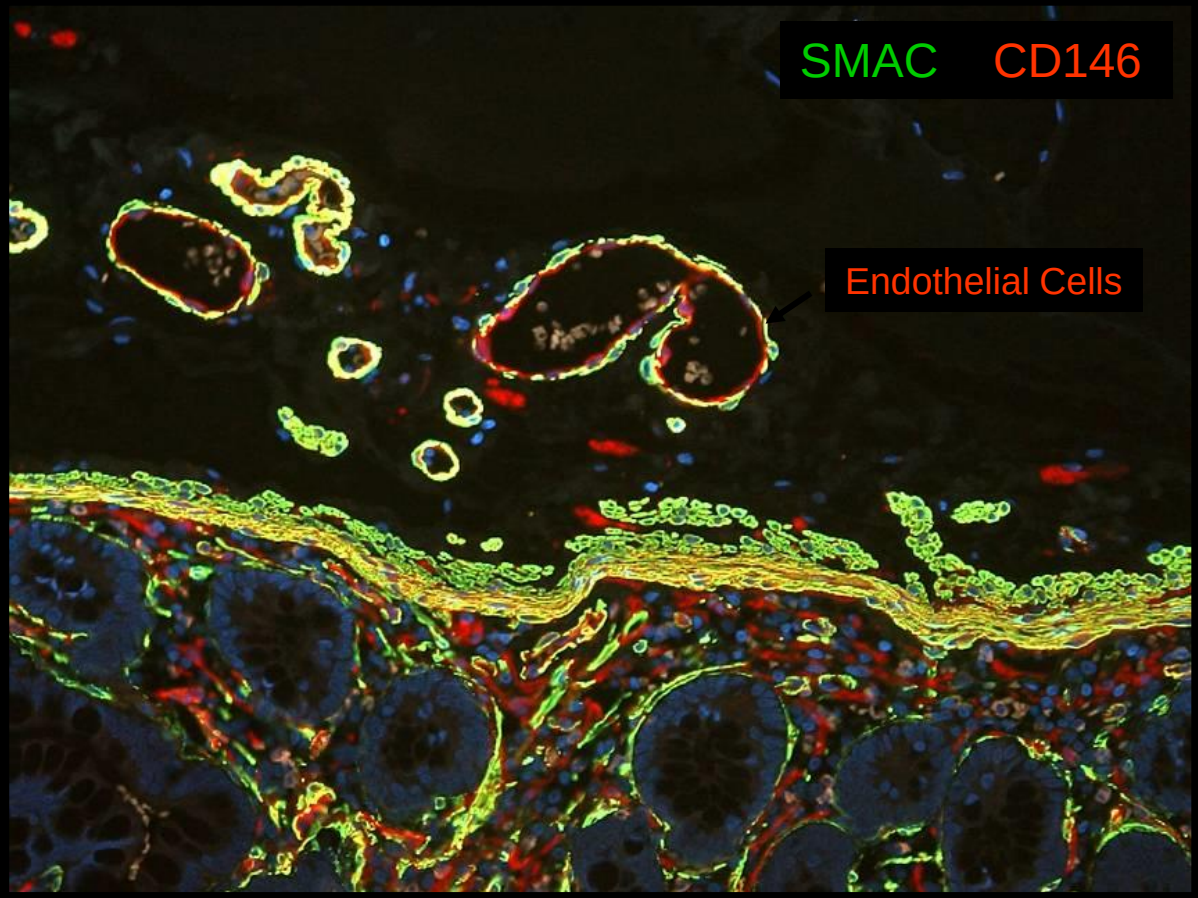
Omission of primary Ab-Y followed by detection with secondary antibody cocktails (anti-X and anti-Y)
= Only antigen X should display a positive signal without any signs of co-localized signal

Drawbacks of immunofluorescence techniques:

Fading of fluorescence signal upon storage

Quenching of fluorescence signal at excitation (fluorescence microscopy)

Auto fluorescence cause by formaldehyde fixation (especially connective tissue – collagen fibers)



Note: Co-expression of CD146 and SM-actin (SMAC) in peri-vascular structures.

Note: Cells of Nervous system - Red

NGFR (MRQ21) + CD146 (EPR3208)

NGFR (MRQ21) + CD146 (EPR3208)

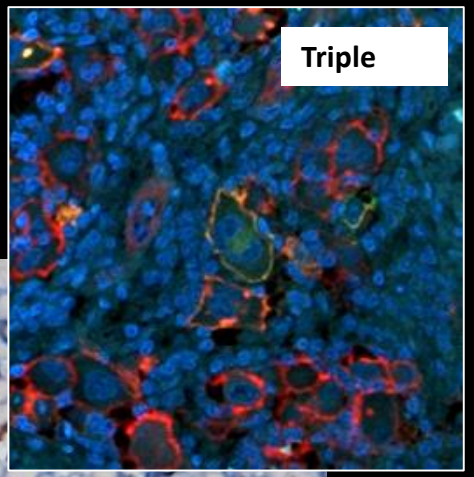
Double immuno-fluorescence technique

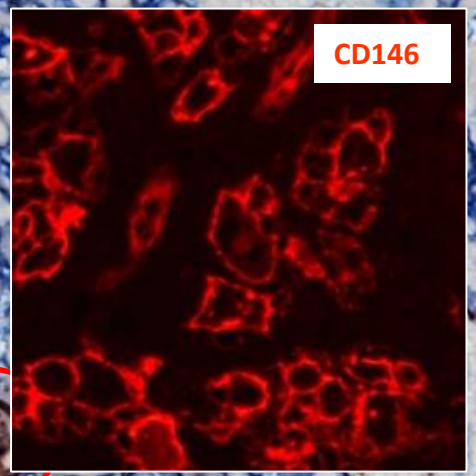
Melanoma

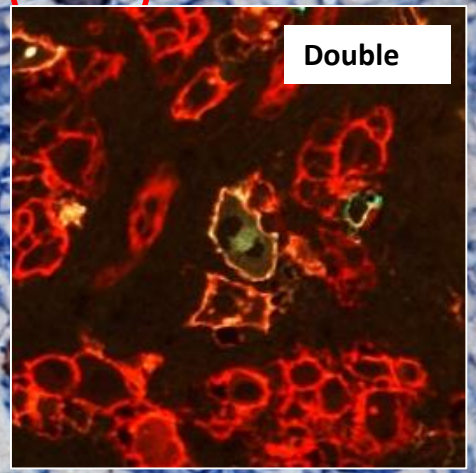
Melanoma

Thermo/ LabVision – Multivision KIT

Co-localization ?







Note: Co-expression in tumour cells from melanoma (yellow colour).