

PD-L1 IHC 28-8 pharmDx Interpretation Manual - Esophageal Squamous Cell Carcinoma (ESCC)

Combined Positive Score (CPS)

FDA approved for in vitro diagnostic use

Rx only

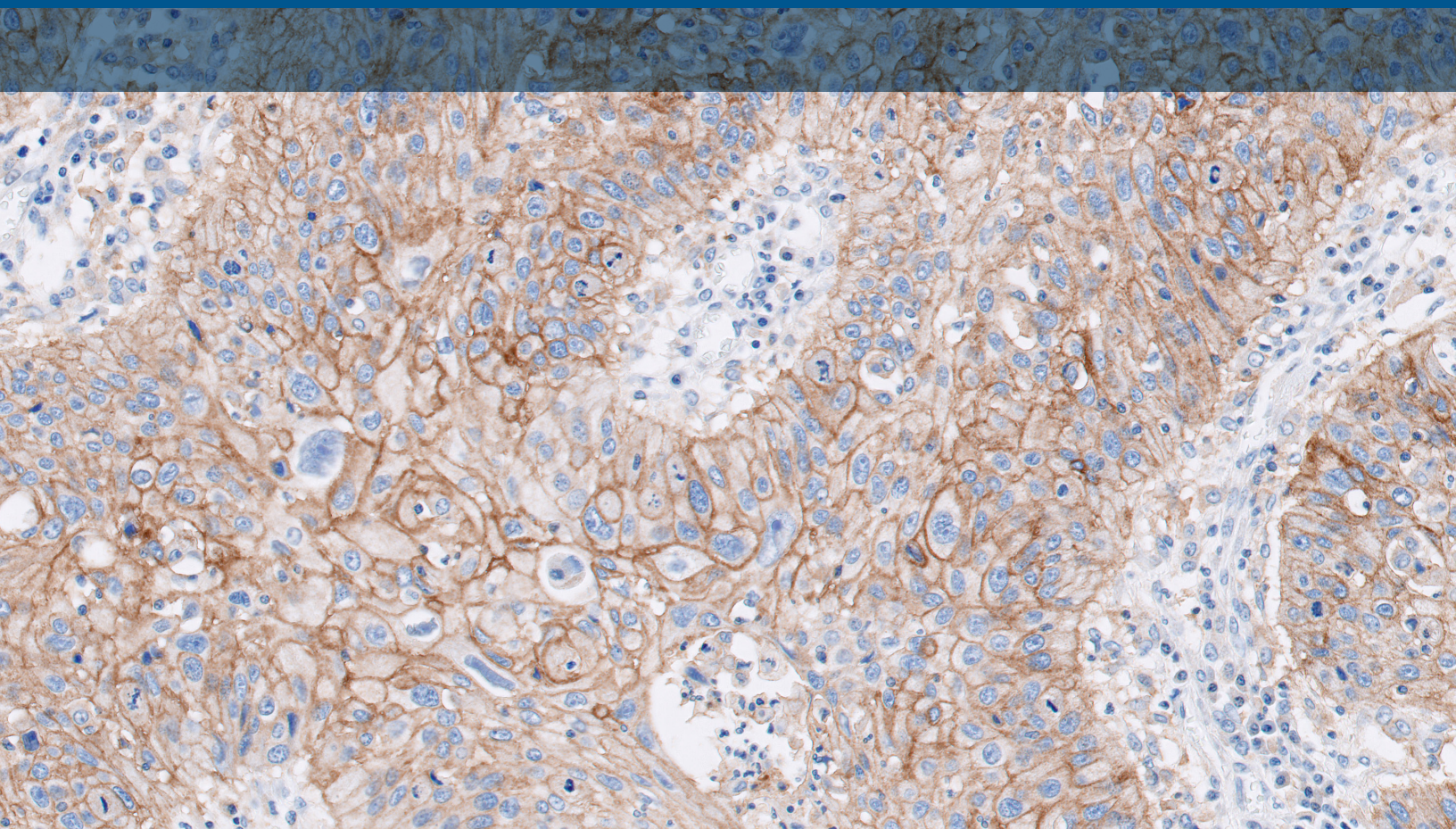
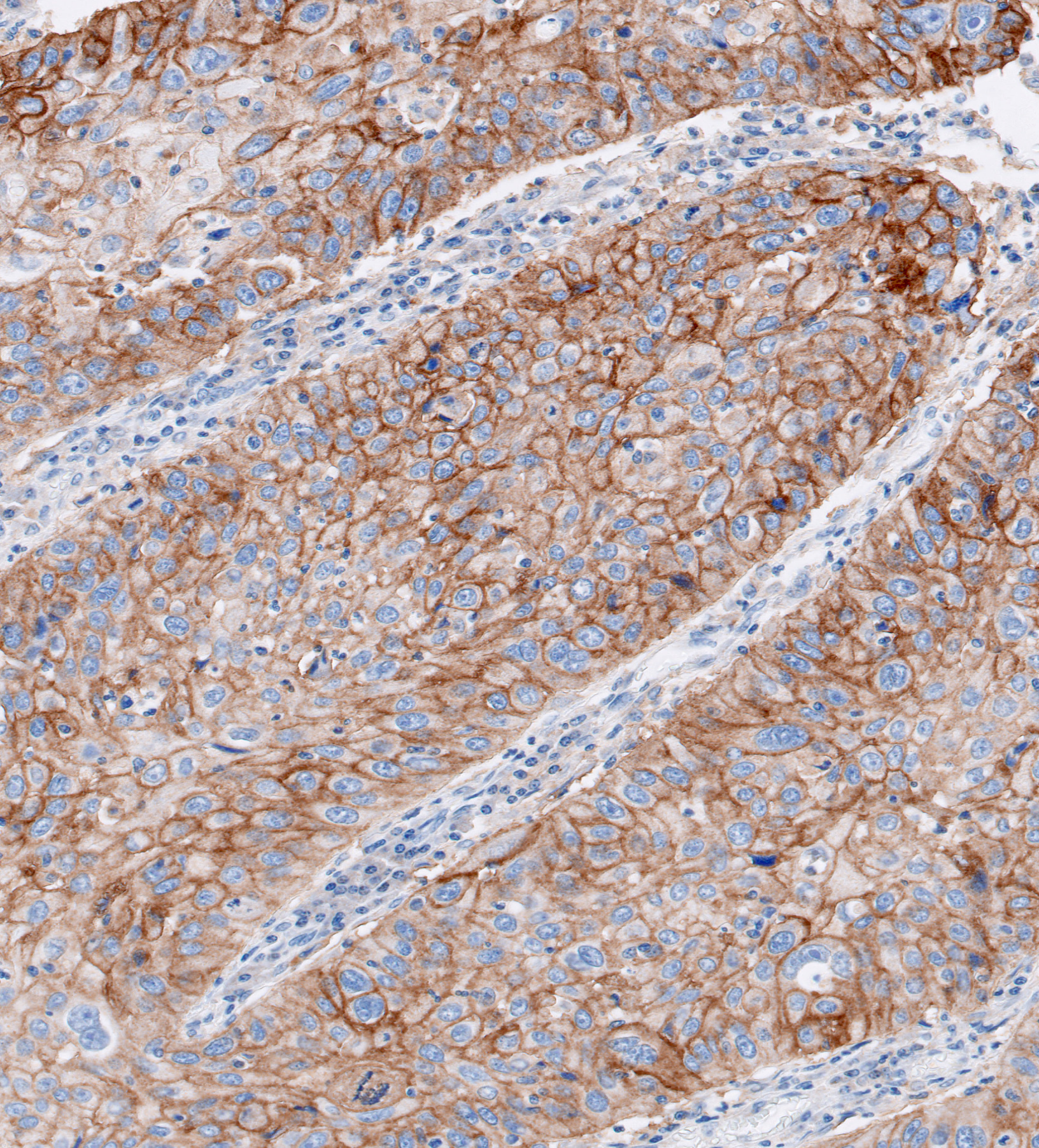


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PD-L1 IHC 28-8 pharmDx Interpretation Manual - ESCC
Combined Positive Score (CPS)

Introduction

Intended Use

For In Vitro Diagnostic Use

PD-L1 IHC 28-8 pharmDx is a qualitative immunohistochemical assay using Monoclonal Rabbit Anti-PD-L1, Clone 28-8 intended for use in the detection of PD-L1 protein in formalin-fixed, paraffin-embedded (FFPE) esophageal squamous cell carcinoma (ESCC) tissues using EnVision FLEX visualization system on Autostainer Link 48.

PD-L1 protein expression in esophageal squamous cell carcinoma (ESCC) is determined by using Combined Positive Score (CPS), which is the number of PD-L1 staining cells (tumor cells, lymphocytes, macrophages) divided by the total number of viable tumor cells, multiplied by 100.

Tumor Indication	PD-L1 Expression Level	Therapy
ESCC	CPS ≥ 1	OPDIVO® (nivolumab) or OPDIVO QVANTIG® (nivolumab and hyaluronidase-nvhy)

See the OPDIVO®, and OPDIVO QVANTIG® product labels for specific clinical circumstances guiding PD-L1 testing.

PD-L1 IHC 28-8 pharmDx Interpretation Manual - Overview

This ESCC PD-L1 IHC 28-8 pharmDx Interpretation Manual is provided as a tool to help guide pathologists and laboratory technicians to achieve correct and reproducible results in assessing PD-L1 expression in FFPE ESCC specimens. The goal of this manual is to familiarize you with the requirements for scoring ESCC specimens stained with PD-L1 IHC 28-8 pharmDx. Photomicrographs of example cases are provided for reference.

This manual provides detailed scoring guidelines and technical information from the PD-L1 IHC 28-8 pharmDx Instructions for Use (IFU) to ensure high-quality staining and diagnostic assessment.

Review of this ESCC PD-L1 IHC 28-8 pharmDx Interpretation Manual will provide a solid foundation for evaluating ESCC slides stained with PD-L1 IHC 28-8 pharmDx. For more details, please refer to the current version of the package insert provided with PD-L1 IHC 28-8 pharmDx or visit [Instructions For Use | Agilent](#)

The included photomicrographs are ESCC unless otherwise noted.

Acknowledgment

Assay Interpretation

The clinical interpretation of any staining, or the absence of staining, must be complemented by the evaluation of proper controls. An evaluation must be made by a qualified pathologist within the context of the patient's clinical history and other diagnostic tests. This product is intended for in vitro diagnostic (IVD) use.

Reporting Results

To help understand what information should be reported to the treating physician, please refer to the Reporting Results section of this manual on page 26.

Photomicrographs

Photomicrograph magnification levels may appear different than indicated in respective annotations due to adjustment of image size.

The included photomicrographs are ESCC unless otherwise noted.

Note: Photomicrographs included in this interpretation manual include specimens provided by the following suppliers:

- Tissue samples supplied by BioIVT (Hicksville, NY, USA).
- The data and ESCC specimens used in this project were provided by National BioService LLC (Saint Petersburg, Russia) with appropriate ethics approval and through Trans-Hit Biomarkers Inc.
- The data and ESCC specimens used in this project were provided by Nottingham University Hospitals NHS Trust (Nottingham, UK) with appropriate ethics approval and through Trans-Hit Biomarkers Inc.

PD-L1 Overview

The PD-1/PD-L1 Pathway Controls the Immune Response in Normal Tissue

Programmed death-ligand 1 (PD-L1) is a transmembrane protein that binds to the programmed death-1 receptor (PD-1) during immune system modulation. The PD-1 receptor is typically expressed on cytotoxic T-cells and other immune cells, while the PD-L1 ligand is typically expressed on normal cells. Normal cells use the PD-1/PD-L1 interaction as a mechanism of protection against immune recognition by inhibiting the action of T-cells (Figure a). Inactivation of cytotoxic T-cells downregulates the immune response such that the inactive T-cell is exhausted, ceases to divide, and might eventually die by programmed cell death, or apoptosis.

The Tumor Escapes Detection by Utilizing the PD-1/PD-L1 Pathway

Many tumor cells are able to upregulate the expression of PD-L1 as a mechanism to evade the body's natural immune response. Activated T-cells recognize the PD-L1 marker on the tumor cell, similar to that of a normal cell, and PD-L1 signaling renders the T-cell inactive (Figure b). The tumor cell escapes the immune cycle, continues to avoid detection for elimination and is able to proliferate.

Anti-PD-1 Therapy Enables the Immune Response Against Tumors

Anti-PD-1 therapy works by blocking the PD-1/PD-L1 interaction between tumor cells and activated T-cells, helping to prevent immunosuppression, thereby enabling cytotoxic T-cells to actively remove tumor cells (Figure c).

The Role of the PD-1/PD-L1 Pathway in Cancer

Limiting damage to healthy tissue

Inactivation of T-cells limits damage to healthy tissue.

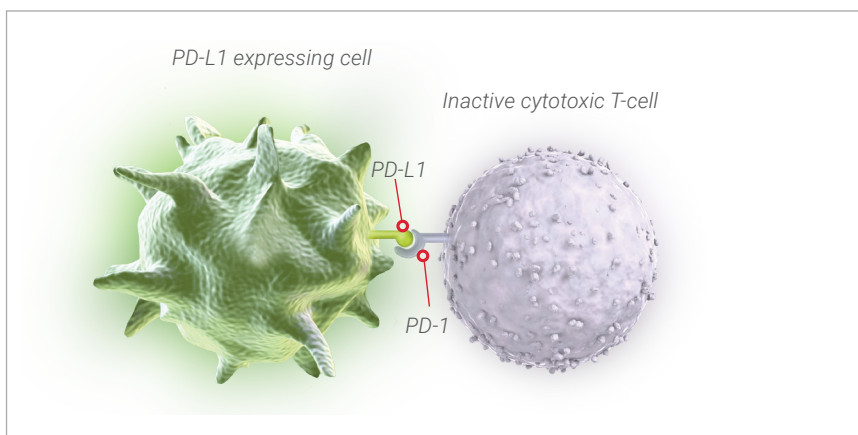


Figure a.

The tumor escapes detection

Inactivation of T-cells reduces tumor cell killing.

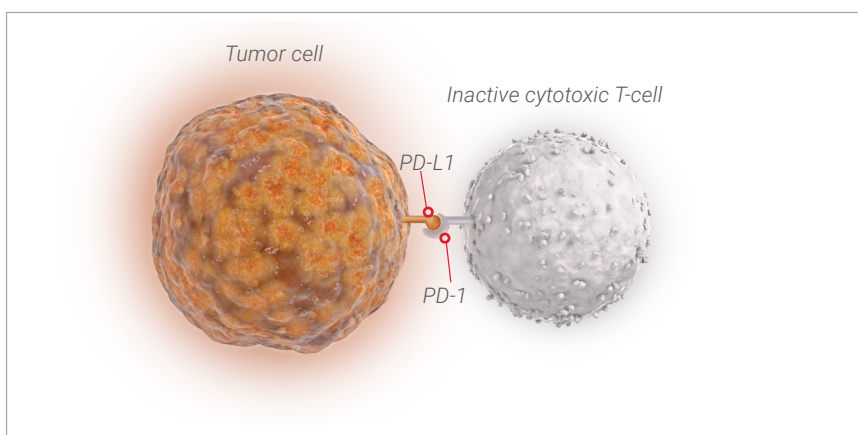


Figure b.

Immuno-oncology therapies harness the immune response to fight tumors

Blocking the PD-1 enables cytotoxic T-cells to actively remove tumor cells.

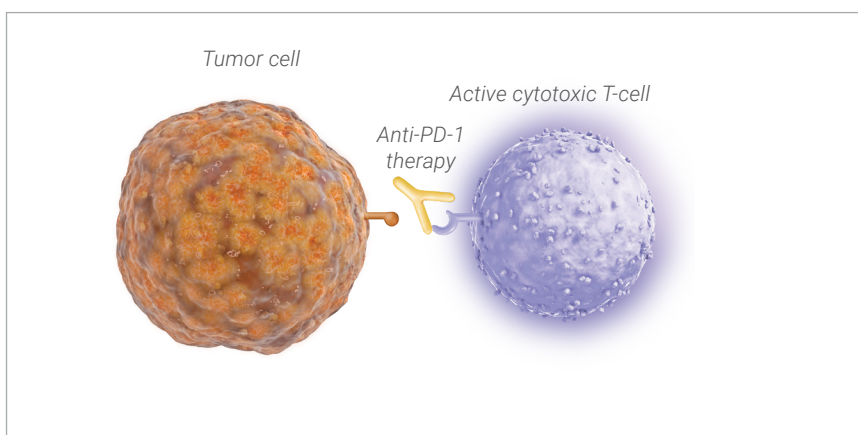


Figure c.

PD-L1 IHC 28-8 pharmDx Overview

Code SK005

PD-L1 IHC 28-8 pharmDx contains optimized reagents and protocol required to complete an IHC staining procedure of FFPE specimens using PT Link Pre-treatment Module and Autostainer Link 48.

Following incubation with the primary monoclonal antibody to PD-L1 or the Negative Control Reagent (NCR), specimens are incubated with a linker antibody specific to the host species of the primary antibody, and then are incubated with a ready-to-use visualization reagent consisting of secondary antibody molecules and horseradish peroxidase molecules coupled to a dextran polymer backbone (see Figure 1a). The enzymatic conversion of the subsequently added chromogen results in precipitation of a visible reaction product at the site of the antigen. The color of the chromogenic reaction is modified by a chromogen enhancement reagent (see Figure 1b). The specimen may then be counterstained and coverslipped. Results are interpreted using a light microscope. Control Slides containing two FFPE human cell lines are provided to validate staining runs.

PD-L1 IHC 28-8 pharmDx staining procedure

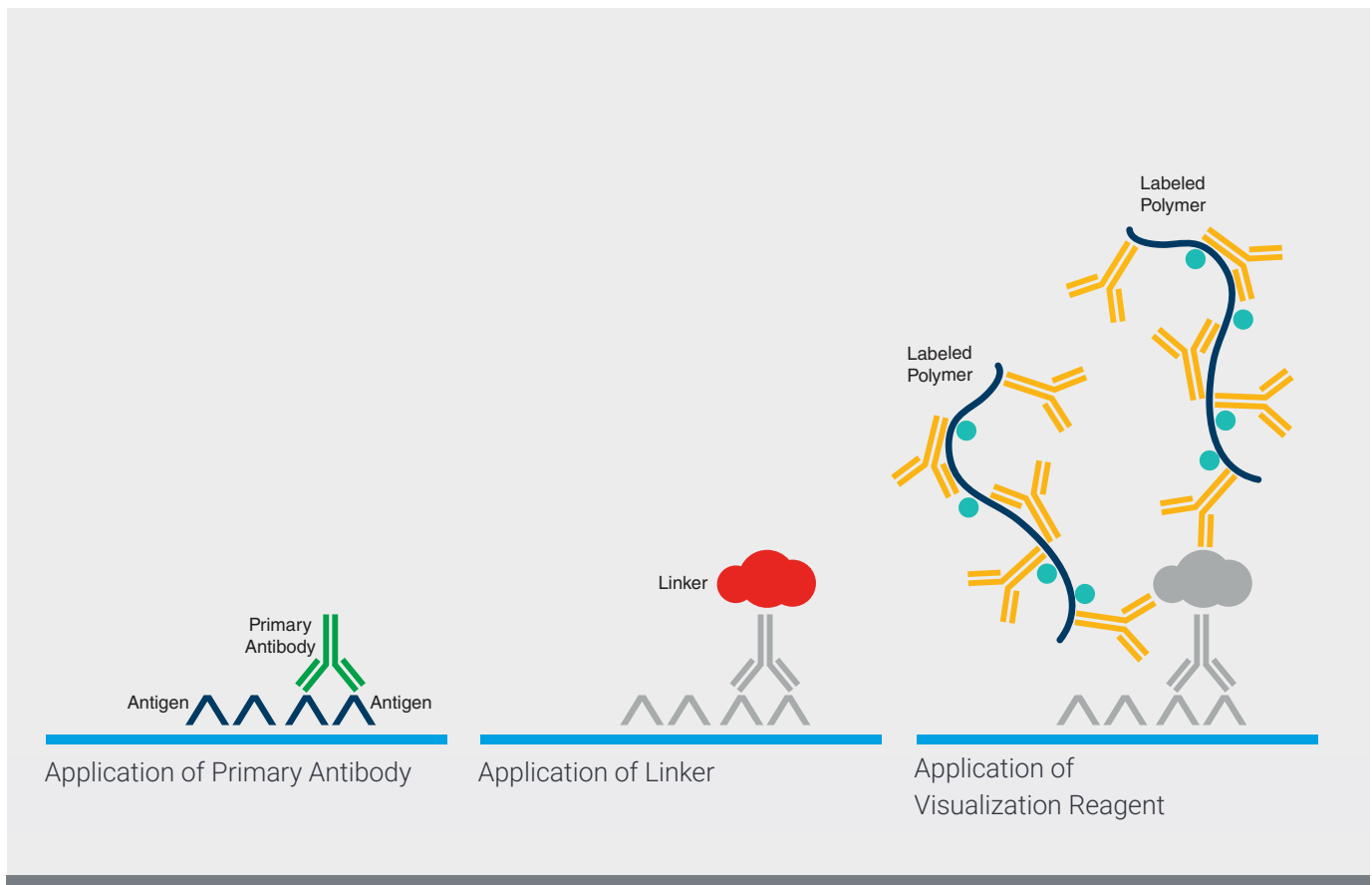


Figure 1a. PD-L1 IHC 28-8 pharmDx staining procedure.

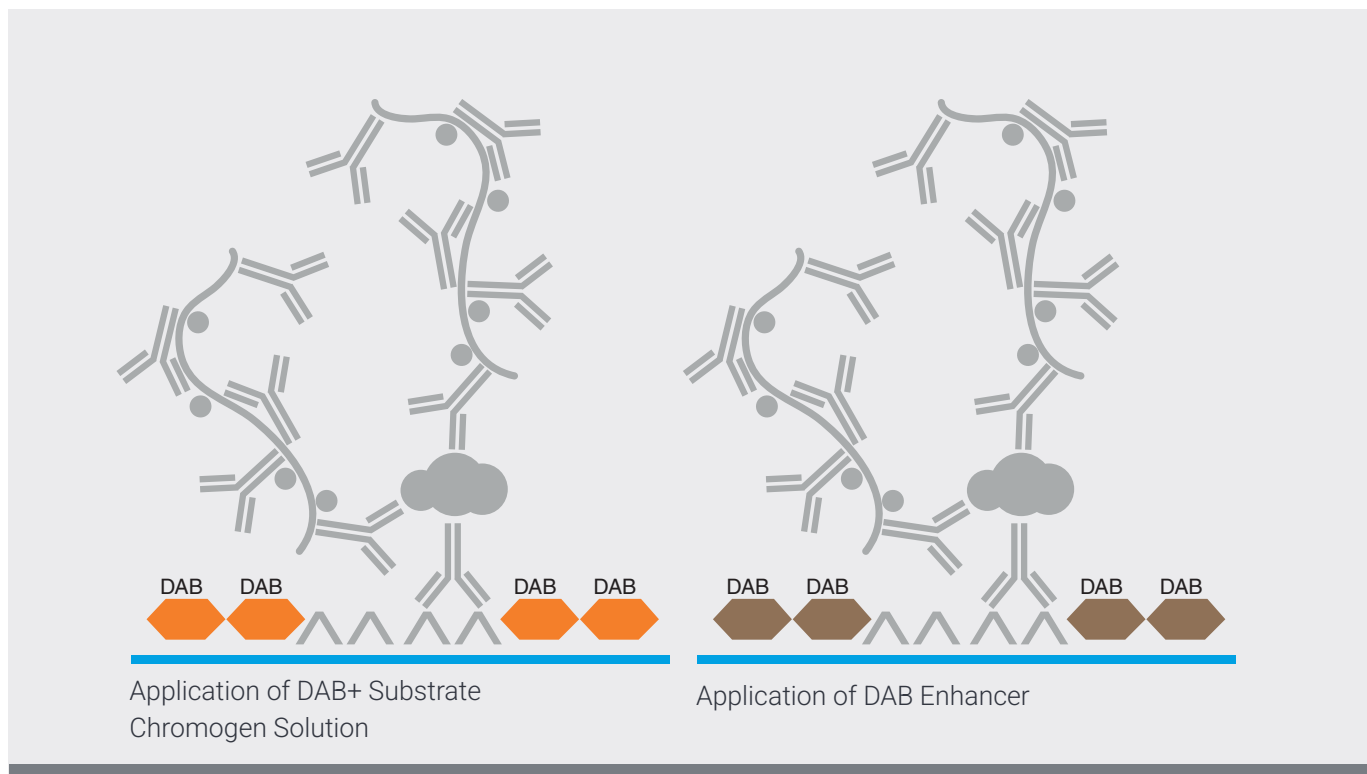


Figure 1b. PD-L1 IHC 28-8 pharmDx staining procedure.



Figure 2. PD-L1 IHC 28-8 pharmDx staining component.

All PD-L1 IHC 28-8 pharmDx reagents are to be used on the Autostainer Link 48. All reagents must be used as indicated in the IFU in order for the test to perform as specified.

PD-L1 IHC 28-8 pharmDx contains reagents to perform 50 tests in up to 15 individual runs, (see Figure 2).

- EnVision FLEX Target Retrieval Solution, Low pH, 50x
- Peroxidase-Blocking Reagent
- Primary Antibody: Monoclonal Rabbit Anti-PD-L1, Clone 28-8
- Negative Control Reagent
- Linker, Anti-Rabbit
- Visualization Reagent-HRP
- DAB+ Substrate Buffer
- DAB+ Chromogen
- DAB Enhancer
- PD-L1 IHC 28-8 pharmDx Control Slides

EnVision FLEX Wash Buffer (20x, Code K8007) and EnVision FLEX Hematoxylin (Code K8008), are required but not included in the kit. Refer to the Instructions for Use (IFU) for required materials and equipment.

Technical Considerations for Optimal Performance of PD-L1 IHC 28-8 pharmDx

Optimal staining performance is achieved by adhering to the PD-L1 IHC 28-8 pharmDx protocol. Technical problems relating to the performance of PD-L1 IHC 28-8 pharmDx may arise in two areas; those involving specimen collection and specimen preparation prior to performing the test, as well as problems involving the actual performance of the test itself. Technical problems related to the performance of the test generally are related to procedural deviations and can be controlled and minimized through training and thorough understanding of the product instructions by the user.

Specimen Collection and Preparation

Specimens must be handled in a way which preserves the tissue for immunohistochemical staining. Tissue should be stained and interpreted as close to the time of biopsy as possible. The stability of PD-L1 immunoreactivity in tissue blocks has not been assessed. Tissue may be susceptible to loss of PD-L1 immunoreactivity with age. Confirm appropriate intact tumor morphology and the presence of sufficient tumor cells for evaluation. Use recommended methods of tissue processing for all specimens.

Tissue Processing

FFPE tissues are suitable for use. Recommended handling and processing conditions are: < 30 minutes ischemia time prior to immersion in fixative, and 24–48 hours fixation time in 10% neutral buffered formalin. Alternative fixatives have not been validated and may give erroneous results. Specimens should be blocked into a thickness of 3 or 4 mm, fixed in 10% neutral buffered formalin, and dehydrated and cleared in a series of alcohols and xylene, followed by infiltration with melted paraffin. The paraffin temperature should not exceed 60 °C. The use of PD-L1 IHC 28-8 pharmDx on decalcified tissues has not been validated and is not recommended.

Cut tissue specimens into sections of 4–5 µm. After sectioning, mount tissues on FLEX IHC microscope slides (Code K8020) or Superfrost Plus charged slides and then place in a 58 ± 2 °C oven for 1 hour. To preserve antigenicity, tissue sections, once mounted on slides, should be stored in the dark at 2–8 °C, or room temperature up to 25 °C, and stained within 4 months of sectioning. Slide storage and handling conditions should not exceed 25 °C at any point post mounting to ensure tissue integrity and antigenicity.

Control Tissues

Differences in processing and embedding in the user's laboratory may produce significant variability in results. Include positive and negative control tissue in each staining run, in addition to the PD-L1 IHC 28-8 pharmDx Control Slide. Control tissue must represent one of the approved tumor indications for PD-L1 IHC 28-8 pharmDx as listed in the Intended Use of the IFU. Fix, process, and embed the control tissue in the same manner. Control tissues processed differently from the patient specimen validate reagent performance only and do not verify tissue preparation.

The ideal positive control tissue provides a complete dynamic representation of weak-to-moderate staining when stained with PD-L1. The ideal negative control tissue should demonstrate no staining on tumor cells and immune cells. However, because the prevalence of PD-L1 expression on immune cells is high, a few staining immune cells are acceptable.

PD-L1 IHC 28-8 pharmDx Staining Procedure

The PD-L1 IHC 28-8 pharmDx reagents and instructions have been designed for optimal performance. Further dilution of the reagents, alteration of incubation times, temperatures, or instruments may give erroneous results.

Reagent Storage

Store all components of PD-L1 IHC 28-8 pharmDx, including Control Slides, in the dark at 2–8 °C when not in use on Autostainer Link 48. Do not use after the expiration date printed on the outside package.

Reagent Preparation

Equilibrate all components to room temperature (20–25 °C) prior to immunostaining.

EnVision FLEX Target Retrieval Solution, Low pH (50x)

Prepare a sufficient quantity of 1x Target Retrieval Solution, Low pH by diluting Target Retrieval Solution, Low pH (50x) 1:50 using distilled or de-ionized water; the pH of 1x EnVision FLEX Target Retrieval Solution should be 6.1 ± 0.2 . Do not modify the pH of 1x EnVision FLEX Target Retrieval Solution after preparation under any circumstance. If a problem is suspected with the EnVision FLEX Target Retrieval Solution pH, please refer to the troubleshooting section for more information.

One 30 mL bottle of EnVision FLEX Target Retrieval Solution, Low pH (50x), diluted 1:50 will provide 1.5 L of 1x reagent, sufficient to fill one PT Link tank, which will treat up to 24 slides per use. Discard 1x EnVision FLEX Target Retrieval Solution after 3 uses and no longer than 5 days after dilution. Note, the FLEX Target Retrieval Solution, low pH (50x) is a red-colored solution.

Additional EnVision FLEX Target Retrieval Solution, Low pH (50x), if required, is available as Code K8005.

EnVision FLEX Wash Buffer (20x)

Prepare a sufficient quantity of 1x EnVision FLEX Wash Buffer for the wash steps by diluting EnVision FLEX Wash Buffer (20x) 1:20 using distilled or de-ionized water and mix thoroughly. Store unused 1x solution at 2–8 °C for no more than 1 month. Discard buffer if cloudy in appearance. Refer to the User Guide for your Autostainer Link 48 for further information.

EnVision FLEX Wash Buffer (20x) is available as Code K8007.

DAB+ Substrate-Chromogen Solution

This solution should be mixed thoroughly prior to use. Any precipitate developing in the solution does not affect staining quality.

To prepare DAB+ Substrate-Chromogen Solution, add 9 drops of Liquid DAB+ Chromogen per 1 bottle of DAB+ Substrate Buffer and mix. Prepared Substrate-Chromogen is stable for 5 days if stored in the dark at 2–8 °C.

Important Notes:

- When mixing DAB+ Substrate Buffer with DAB+ Chromogen, add 9 drops of DAB+ Chromogen. Although the label states 7.2 mL, this is the useable volume and does not account for the “dead volume” in the bottle.
- The color of the Liquid DAB+ Chromogen in the bottle may vary from clear to lavender-brown. This will not affect the performance of this product. Dilute per the guidelines in this section. Addition of excess Liquid DAB+ Chromogen to the DAB+ Substrate Buffer will result in deterioration of the positive signal.

Control Slides

Each slide contains sections of two pelleted, FFPE cell lines: NCI-H226* with positive PD-L1 protein expression (originating from human lung squamous cell carcinoma with positive PD-L1 protein expression) and MCF-7 with negative PD-L1 protein expression (originating from human breast adenocarcinoma with negative PD-L1 protein expression).

* Dr. AF Gazdar and Dr. JD Minna at NIH are acknowledged for their contribution in developing NCI-H226 (ATCC Number: CRL-5826™).

Staining Protocol

Please select the PD-L1 IHC 28-8 pharmDx staining protocol from the options in the DakoLink drop down menu.

All of the required steps and incubation times for staining are preprogrammed in the DakoLink software. If the appropriate PD-L1 IHC 28-8 pharmDx protocols are not on your server, please contact your local Technical Service Representative or Agilent Pathology Support to obtain the protocols.

Deparaffinization, Rehydration, and Target Retrieval (3-in-1) Procedure

Recommended procedure:

For details, please refer to the PT Link User Guide.

Set PT Link (Code PT100/PT101/PT200) Preheat and Cool to 65 °C. Set Heat to 97 °C for 20 minutes.

- Fill PT Link tanks with 1.5 L per tank of EnVision FLEX Target Retrieval Solution, Low pH, 1x working solution to cover the tissue sections.
- Preheat the EnVision FLEX Target Retrieval Solution to 65 °C.
- Immerse Autostainer racks containing mounted, FFPE tissue sections into the preheated EnVision FLEX Target Retrieval Solution, Low pH (1x working solution) in PT Link tank. Incubate for 20 minutes at 97 °C.
- As soon as target retrieval incubation time has been completed and the temperature has cooled to 65 °C, remove each Autostainer slide rack with the slides from the PT Link tank and immediately place the Autostainer rack with slides into a tank (e.g., PT Link Rinse Station, Code PT109) containing diluted, room temperature EnVision FLEX Wash Buffer (Code K8007).
- Immerse slides in diluted, room temperature Wash Buffer for 5 minutes.

Staining procedure

- After deparaffinization, rehydration and target retrieval (3-in-1) procedure, the Autostainer racks with slides are placed on Autostainer Link 48. Ensure slides remain wet with buffer while loading and prior to initiating run.
- The instrument will perform the staining process by applying the appropriate reagent, monitoring the incubation time and rinsing slides between reagents.

Counterstaining

Slides should be counterstained for 7 minutes with EnVision FLEX Hematoxylin (Link) (Code K8008). The Hematoxylin incubation time is preprogrammed in the protocol as shown above.

Mounting

Nonaqueous, permanent mounting medium is required.

PD-L1 IHC 28-8 pharmDx Technical Checklist

Customer Name / Institution: _____

Name and Title: _____

Autostainer Link 48 Serial Number: _____ Software Version: _____

	Yes	No
1. Regular preventive maintenance is performed on the Autostainer Link 48 and PT Link?	☐	☐
2. PD-L1 IHC 28-8 pharmDx is used before the expiration date printed on the outside of the box?	☐	☐
3. All PD-L1 IHC 28-8 pharmDx components, including Control Slides, are stored in the dark at 2–8 °C?	☐	☐
4. All PD-L1 IHC 28-8 pharmDx components, including Control Slides, are equilibrated to room temperature (20–25 °C) prior to immunostaining?	☐	☐
5. Appropriate positive and negative control tissues are identified?	☐	☐
6. Tissues are fixed in neutral buffered formalin?	☐	☐
7. Tissues are infiltrated with melted paraffin, at or below 60 °C?	☐	☐
8. Tissue sections of 4–5 µm are mounted on FLEX IHC Microscope Slides, or Superfrost Plus charged slides?	☐	☐
9. ESCC specimens are stained within 4 months of sectioning when stored in the dark at 2–8 °C or at room temperature up to 25 °C?	☐	☐
10. EnVision FLEX Target Retrieval Solution, Low pH is prepared properly (working solution pH 6.1 ± 0.2)?	☐	☐
11. EnVision FLEX Wash Buffer is prepared properly?	☐	☐
12. DAB+ Substrate-Chromogen Solution is prepared properly?	☐	☐
13. The Deparaffinization, Rehydration, and Target Retrieval 3-in-1 procedure is followed, using PT Link?	☐	☐
14. Slides remain wet with buffer while loading and prior to initiating run on Autostainer Link 48?	☐	☐
15. The PD-L1 IHC 28-8 pharmDx protocol is selected on Autostainer Link 48?	☐	☐
16. Slides are counterstained with EnVision FLEX Hematoxylin?	☐	☐
17. Do you have all the necessary equipment to perform the PD-L1 IHC 28-8 pharmDx according to the protocol? If not, specify what is missing in the comments below.	☐	☐

If you answered “No” to any of the above, consult with your local Agilent Technical Support Representative for assistance.

Additional Observations or Comments:

Recommendations for Interpretation of PD-L1 IHC

28-8 pharmDx in Esophageal Squamous Cell Carcinoma

PD-L1 IHC 28-8 pharmDx evaluation must be performed by a pathologist using a light microscope. Before examining the patient specimen for PD-L1 staining, it is important to examine the hematoxylin and eosin (H&E) and controls first. Examine a serial section of the patient specimen stained with H&E for histology and preservation quality. Then, examine the PD-L1 IHC 28-8 pharmDx Control Slide, the positive and negative control tissue slides, and the patient specimen slide stained with the Negative Control Reagent (NCR) to assess reagent performance. Lastly, examine the patient specimen stained with Primary Antibody to assess the staining of viable tumor and mononuclear inflammatory cells.

PD-L1 staining is defined as complete circumferential or convincing partial linear plasma membrane staining of tumor cells and mononuclear inflammatory cells (MICs) within tumor nests and adjacent supporting stroma, at any intensity. Cytoplasmic staining is considered positive for MICs only, any cytoplasmic staining in tumor cells should be ignored. MICs are included in the evaluation of the CPS numerator and should be included during determination of PD-L1 positivity. Adjacent MICs are defined as being within the same 20x field as the tumor. However, MICs that are NOT directly associated with the response to the tumor should be excluded.

Positive control tissue slides and negative control tissue slides should be supplied by the laboratory. Only the Control Slide is provided in the PD-L1 IHC 28-8 pharmDx.

Patient Specimen Stained with H&E

An H&E stained section is required for the evaluation of histology and preservation quality. PD-L1 IHC 28-8 pharmDx and the H&E staining should be performed on serial sections from the same paraffin block of the specimen.

PD-L1 IHC 28-8 pharmDx Control Slide

Examine the PD-L1 IHC 28-8 pharmDx Control Slide to ascertain that reagents are functioning properly. Each slide contains sections of cell pellets with positive and negative PD-L1 expression, see Figure 3. The 10x objective is recommended for the evaluation of the cell pellets as a whole. If any staining of the Control Cell Line is not satisfactory, all results with the patient specimens should be considered invalid. For a borderline Control Slide, run outcome should be considered in the context of all run controls, including control tissue. Do not use the Control Slide as an aid in the interpretation of patient results.

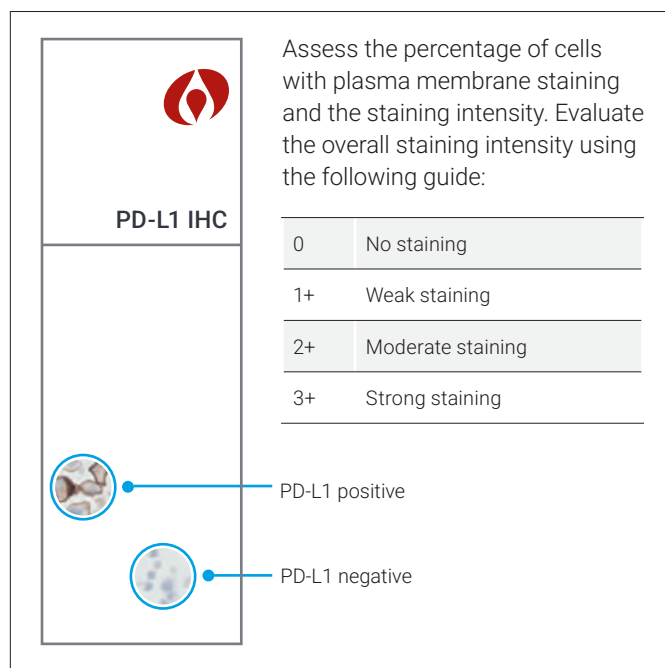


Figure 3. Each Control Slide contains sections of cell pellets with positive and negative PD-L1 expression.

For the PD-L1 positive cell pellet, the following staining is acceptable, see Figure 4.

- Plasma membrane staining of $\geq 80\%$ of cells
- $\geq 2+$ average staining intensity of cells with membrane staining
- Nonspecific staining $< 1+$ intensity

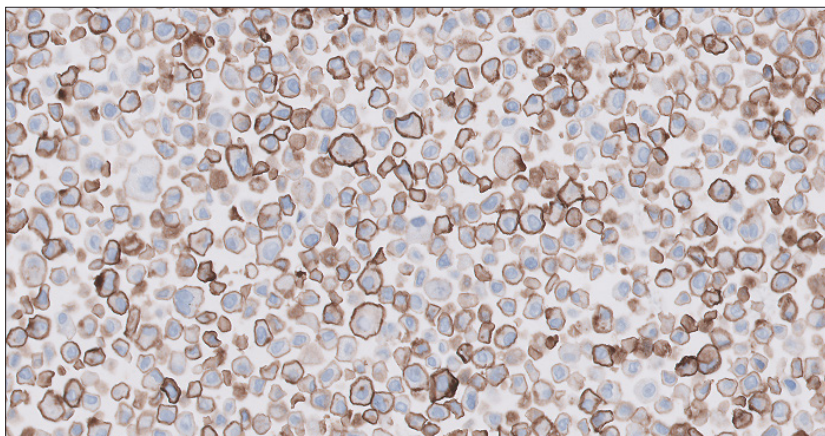


Figure 4. Acceptable Positive PD-L1 Control.

For the PD-L1 negative cell pellet, the following staining is acceptable, see Figure 5.

- No specific staining
- Nonspecific staining is of $< 1+$ staining intensity

Staining of a few cells in the negative pellet may occasionally be observed. The presence of 10 or less cells with distinct plasma membrane staining, and/or cytoplasmic staining with $\geq 1+$ intensity within the boundaries of the cell pellet are acceptable.

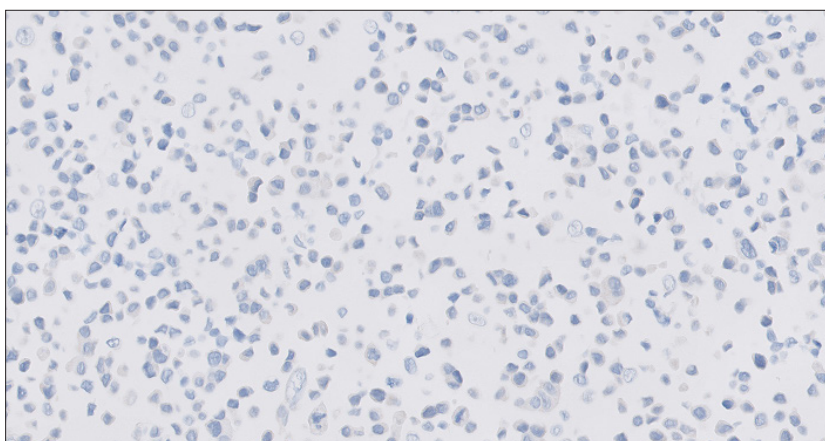


Figure 5. Acceptable Negative PD-L1 Control.

Positive Control Tissue Slides

Examine the positive control tissue slides

(Primary Antibody, NCR) to ascertain if tissues are correctly prepared, and reagents are functioning properly. Any nonspecific staining should be of $\leq 1+$ staining intensity. Exclude necrotic or nonviable tumor cells from the evaluation. If the staining of positive control tissues is not satisfactory, all results with the patient specimens should be considered invalid. Do not use control tissue as an aid in the interpretation of patient results.

Negative Control Tissue Slides

Examine the negative control tissue slides

(Primary Antibody, NCR) to confirm that there is no unintended staining. Any nonspecific staining should be $\leq 1+$ staining intensity. If plasma membrane staining of malignant cells occurs in the negative control tissue, all results with the patient specimens should be considered invalid. Do not use control tissue as an aid in the interpretation of patient results.

Patient Specimen Stained with Negative Control Reagent

Examine the patient specimen stained with NCR to ascertain that reagents are functioning properly. The absence of plasma membrane staining of viable tumor cells is satisfactory and nonspecific staining should be $\leq 1+$ staining intensity. If any staining is not satisfactory, results with the patient specimen should be considered invalid.

The NCR indicates nonspecific staining and allows better interpretation of the patient specimen stained with the Primary Antibody.

Patient Specimen Stained with Primary Antibody

Staining should be assessed within the context of any nonspecific staining of the patient specimen stained with NCR. A minimum of 100 viable tumor cells must be present in the PD-L1 stained patient slide in order to perform an evaluation.

1	At 10–20x objective magnification, carefully examine the tumor areas of the entire specimen. All areas with viable tumor cells on the specimen should be evaluated. Exclude necrotic cells and cellular debris. Nonspecific cytoplasmic staining, if present, should be disregarded.
2	A 20x objective magnification is required to determine the PD-L1 expression. Tumor cells are considered to be PD-L1 positive if they exhibit either partial linear or complete circumferential staining of the plasma membrane at any intensity. MICs within the tumor nests and/or adjacent supporting stroma are considered positive if they exhibit partial or complete membrane staining, and/or cytoplasmic staining, at any intensity.
3	When determining the CPS of the entire specimen, the numerator is the number of stained viable tumor cells and tumor-associated MICs (lymphocytes and macrophages [^]) and the denominator is the total number of viable tumor cells in the specimen. Record if the specimen has PD-L1 expression of CPS ≥ 1.

$$\text{CPS}^* = \frac{\text{\# PD-L1 staining cells (tumor cells, lymphocytes, macrophages}^{\wedge}\text{)}}{\text{Total \# viable tumor cells}} \times 100$$

[^]Macrophages and histiocytes are considered the same cells

*Note: Even though a calculated CPS may be greater than 100, only a maximum CPS of 100 should be given

Tips and Special Considerations

- Include the entire specimen for evaluation of PD-L1 expression
- Use higher magnifications to confirm cell types and areas absent of staining
- Be careful not to overlook weak 1+ staining, which can be missed at 4x and 10x
- Necrotic tissue may stain but should be excluded
- Granular staining must demonstrate a perceptible and convincing membrane pattern
- Cells within foci of dysplasia and carcinoma in situ are excluded from scoring. Accompanying H&E slides allow for the proper assessment of invasive carcinoma, carcinoma in situ, and adjacent normal epithelium
- Due to the nature of IHC, it is recommended that challenging cases with scores near the cutoff are reviewed by a second pathologist and consensus results be provided for these cases

Indeterminate Specimen

High cytoplasmic staining of tumor cells can hamper the scoring of the membrane staining. An additional cut section or section from another block of the same patient may be required for PD-L1 IHC 28-8 pharmDx evaluation.

Slide Evaluation Flowchart

The following flow of slide review is recommended when conducting interpretation of PD-L1 IHC 28-8 pharmDx. Refer to detailed description on pages 19–23.

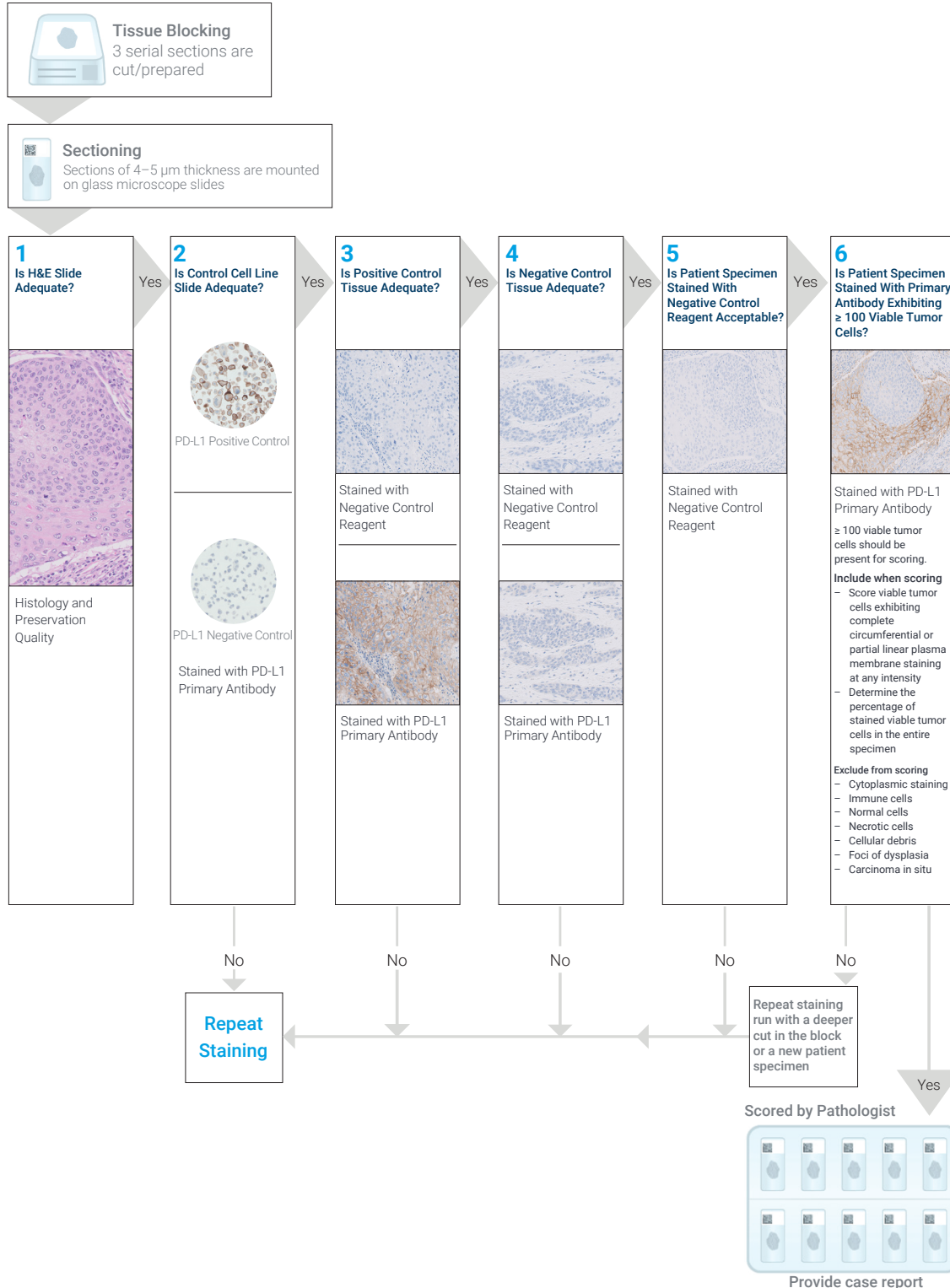


Figure 6. Slide evaluation procedure steps.

Combined Positive Score

Definition of Combined Positive Score (CPS)

PD-L1 expression in ESCC is determined using the Combined Positive Score (CPS), which is the number of PD-L1 staining cells (tumor cells, lymphocytes, macrophages[^]) divided by the total number of viable tumor cells, multiplied by 100. Although the result of the calculation can exceed 100, the maximum score is defined as CPS 100.

CPS is defined accordingly:

$$\text{CPS}^* = \frac{\text{\# PD-L1 staining cells (tumor cells, lymphocytes, macrophages}^{\wedge}\text{)}}{\text{Total \# viable tumor cells}} \times 100$$

[^] Macrophages and histiocytes are considered the same cells

^{*} Note: Even though a calculated CPS may be greater than 100, only a maximum CPS of 100 should be given.

Table 2. CPS Numerator Inclusion/Exclusion Criteria

Tissue Elements	Included in the Numerator	Excluded from the Numerator
Tumor Cells	Convincing partial linear or complete circumferential membrane staining (at any intensity) of viable invasive and metastatic ESCC	– Nonstaining tumor cells – Tumor cells with only cytoplasmic staining – Dysplasia – In situ carcinoma
Immune Cells	Membrane and/or cytoplasmic* staining (at any intensity) of mononuclear inflammatory cells (MICs) within tumor nests and adjacent supporting stroma [†] : – Lymphocytes (including lymphocyte aggregates) – Macrophages[‡] Only MICs within 20x field and directly associated with the response to the tumor are scored	– Nonstaining MICs – MICs (including lymphoid aggregates) not associated with the tumor – MICs associated with in situ carcinoma – MICs associated with benign structures – Neutrophils, eosinophils, and plasma cells
Other Cells	Not included	– Normal cells – Stromal cells (including fibroblasts) – Necrotic cells and/or cellular debris

^{*} In MICs, membrane and cytoplasmic staining are often indistinguishable due to high nuclear to cytoplasmic ratio. Therefore, membrane and/or cytoplasmic staining of MICs are included in the score

[†] Adjacent MICs are defined as being within the same 20x field as the tumor. However, MICs that are NOT directly associated with the response to the tumor should be excluded

[‡] Macrophages and histiocytes are considered the same cells

Table 3. CPS Denominator Inclusion/Exclusion Criteria

Tissue Elements	Included in the Denominator	Excluded from the Denominator
Tumor Cells	All viable, invasive tumor cells and metastatic cells	- Any necrotic or non-viable tumor cells - Dysplasia - In situ carcinoma
Immune Cells	Not included	All immune cells of any type
Other Cells	Not included	- Normal cells - Stromal cells (including fibroblasts) - Necrotic cells and/or cellular debris

Determining Combined Positive Score (CPS)

- For evaluation of the immunohistochemical staining, an objective of 10–20x magnification is appropriate. Examine the entire tumor area and evaluate overall areas of PD-L1 staining and nonstaining tumor cells, keeping in mind that partial membrane staining or 1+ intensity membrane staining may be difficult to see at low magnifications. Ensure there are at least 100 viable tumor cells in the sample
 - A minimum of 100 viable tumor cells must be present in the PD-L1 stained slide (biopsy or resection) for the specimen to be considered adequate for evaluation
 - For specimens with less than 100 viable tumor cells, tissue from a deeper level of the block or potentially another block could have a sufficient number of tumor cells for evaluation of PD-L1 expression. Repeat staining with a deeper cut in the block or a new patient specimen should be done in consultation with a qualified pathologist
- For determination of PD-L1 expression, an objective of 20x magnification is required. Evaluate PD-L1 expression and calculate CPS:
 - Determine the total number of viable tumor cells, both PD-L1 staining and nonstaining (CPS denominator)
 - Determine the number of PD-L1 staining cells, tumor cells, lymphocytes, and macrophages (CPS numerator)
 - See Tables 2 and 3 on pages 19 and 20 respectively for additional CPS inclusion/exclusion criteria
 - Calculate CPS

PD-L1 IHC 28-8 pharmDx Suggested Scoring Methods for Calculating Combined Positive Score

Agilent recommends that scoring be performed within the context of the pathologist's past experience and best judgment in interpreting IHC stains. We offer three different examples of techniques that may be used when determining the respective CPS of various staining patterns.

Example 1: Calculation of Combined Positive Score based on a small PD-L1 staining area

First: Evaluate the tumor area for perceptible and convincing staining as described in "Determining Combined Positive Score" on page 20.

Assessment: 10% of area shows staining, 90% of area shows no staining.

Second: Evaluate the area of staining to estimate the number of PD-L1 staining cells (tumor cells, lymphocytes, macrophages).

Assessment: There are approximately 100 viable tumor cells and about 80 PD-L1 staining cells (per the CPS numerator).



Figure 7. Example of tumor with a small PD-L1 staining area.

Calculate the CPS of the entire tumor area:

Assessment:

CPS of the area with staining:

$$\text{CPS} = \frac{\# \text{ PD-L1 staining cells}^*}{\text{Total \# viable tumor cells}} \times 100 = \frac{\sim 80 \text{ PD-L1 staining cells}}{100 \text{ tumor cells}} \times 100 = 80$$

* Tumor cells, lymphocytes, macrophages

CPS of entire tumor area: $10\% \times 80 \approx \text{CPS } 8$

Clinical Interpretation: CPS ≥ 1

Example 2: Calculation of Combined Positive Score based on a heterogeneous PD-L1 staining area

First: Visually divide the tumor area into regions with equal numbers of tumor cells.

Second: Observe each region and estimate the total number of viable tumor cells and PD-L1 staining cells (tumor cells, lymphocytes, macrophages). Calculate the CPS for each region.

Assessment: The four sections have ~80, ~30, ~50, and 100 PD-L1 staining cells (tumor cells, lymphocytes, macrophages). Each section has a total of 100 tumor cells (including PD-L1 staining cells). The CPS for each section: ~CPS 80, ~CPS 30, ~CPS 50, and CPS 100.

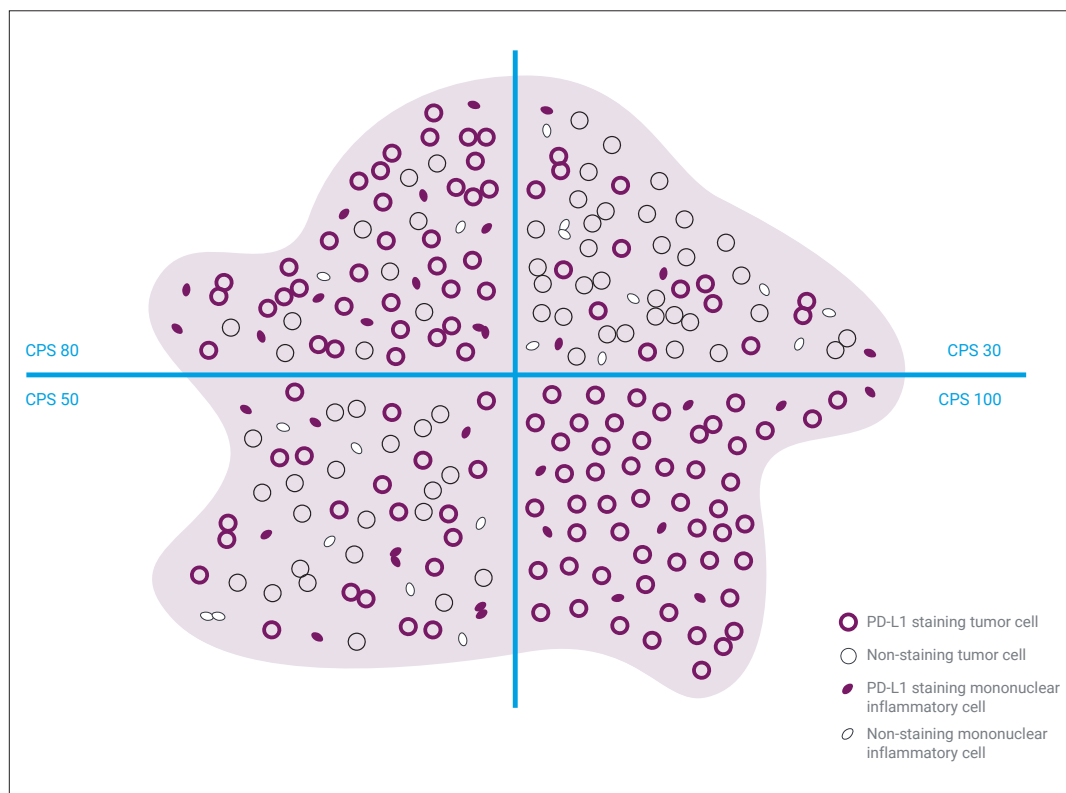


Figure 8. Example of a specimen with a heterogeneous PD-L1 staining area.

Calculate the CPS of the entire tumor area:

Assessment:

$$\text{CPS} = \frac{\# \text{ PD-L1 staining cells}^*}{\text{Total \# viable tumor cells}} \times 100$$

*Tumor cells, lymphocytes, macrophages

$$(80 + 30 + 50 + 100)/4 \approx \text{CPS } 65$$

Clinical Interpretation: CPS ≥ 1

Example 3: Calculation of Combined Positive Score for a near cut-off specimen

First: Evaluate the specimen for perceptible and convincing staining as described in “Determining Combined Positive Score” on page 20.

Second: Confirm that there is no staining in areas that appeared void of staining at lower magnifications. Evaluate all staining areas and estimate the total number of PD-L1 staining cells (tumor cells, lymphocytes, macrophages). Then re-evaluate the entire specimen (staining and nonstaining areas) and estimate the total number of viable tumor cells (PD-L1 staining and nonstaining tumor cells). Calculate the CPS.

Assessment: Tumor specimen has perceptible and convincing staining. There are 10 PD-L1 staining cells (tumor cells, lymphocytes, macrophages). There are 200 viable tumor cells present in the entire specimen.

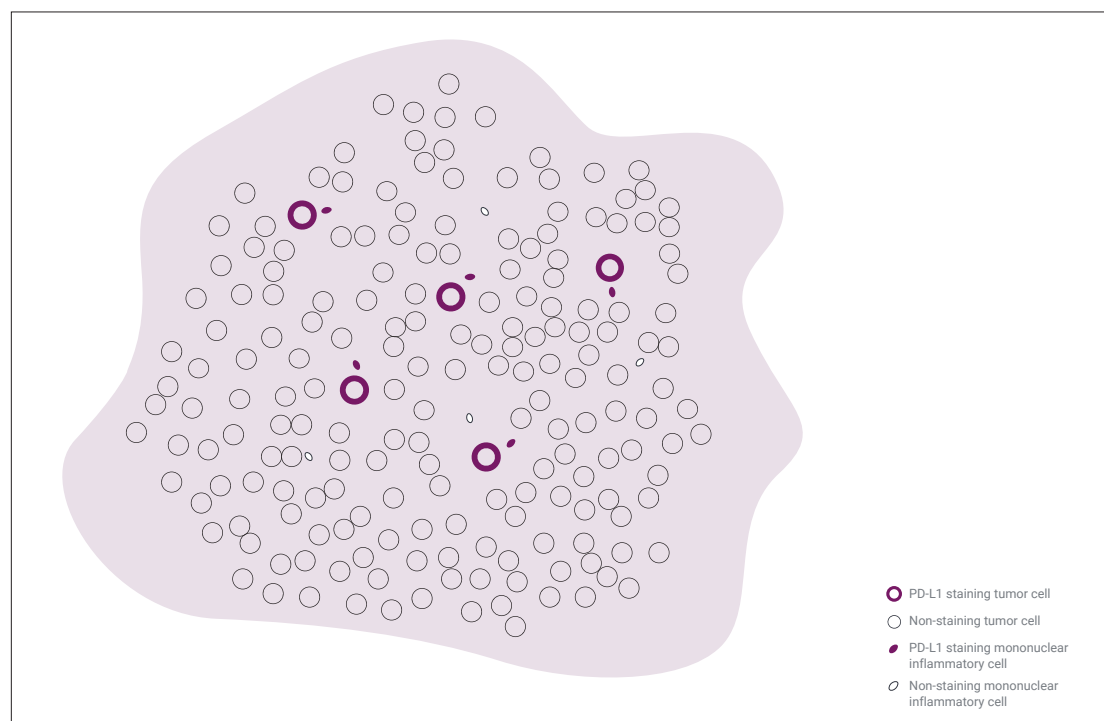


Figure 9. Example of a near cut-off specimen.

Calculate the CPS of the entire tumor area:

Assessment:

CPS of area with staining:

$$\text{CPS} = \frac{\# \text{ PD-L1 staining cells}^*}{\text{Total \# viable tumor cells}} \times 100 = \frac{10 \text{ PD-L1 staining cells}}{200 \text{ tumor cells}} \times 100 = \text{CPS } 5$$

*Tumor cells, lymphocytes, macrophages

Clinical Interpretation: CPS ≥ 1

Image Guide for Interpretation of PD-L1 IHC 28-8 pharmDx Staining in ESCC

Agilent emphasizes that scoring of PD-L1 IHC 28-8 pharmDx must be performed in accordance with the guidelines established in the IFU, within the context of best practices and the pathologist’s experience.

The CPS determines the PD-L1 IHC 28-8 pharmDx result. Scoring guidelines and reporting recommendations are presented on the following pages. See page 25 (Reporting Results form), for an example of a pathology report form for PD-L1 IHC 28-8 pharmDx. Figure 10 below demonstrates near cut-off specimens without and with PD-L1 expression.

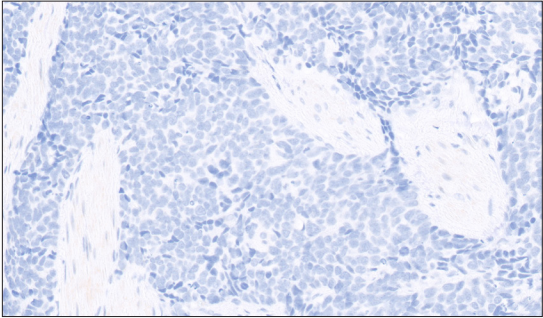
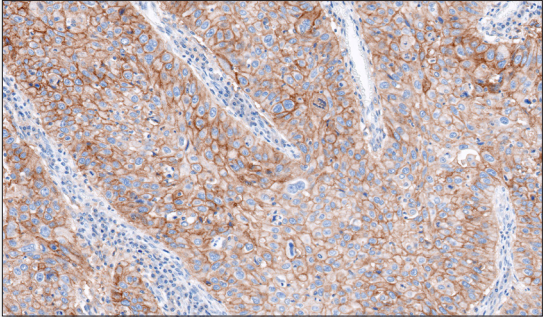
CPS	Expression Level	Image (20x magnification)
< 1	No PD-L1 Expression	
≥ 1	PD-L1 Expression	

Figure 10. Examples of near cut-off specimens.

PD-L1 IHC 28-8 pharmDx Reporting Results: ESCC

Suggested information to include when reporting results with PD-L1 IHC 28-8 pharmDx in ESCC

PD-L1 IHC 28-8 pharmDx, Code SK005

Summary of Sample Tested:

Date of Run: _____ PD-L1 IHC 28-8 pharmDx Lot: _____

Staining Run Log ID: _____ Specimen ID: _____

Patient Identifier: _____

Type of Service: IHC Stain with Manual Interpretation

Other: _____

Type of Tissue: _____

Additional Tests Performed with PD-L1 IHC 28-8 pharmDx: _____

PD-L1 IHC 28-8 pharmDx Controls Results:

PD-L1 IHC 28-8 Control Cell Slide: Pass ☐ Fail ☐

Positive Control Tissue Slides: Pass ☐ Fail ☐

Negative Control Tissue Slides: Pass ☐ Fail ☐

Patient Specimen, Negative Control Reagent: Pass ☐ Fail ☐

PD-L1 Results:

Viable Tumor Cells Present: ☐ $\geq$ 100 cells ☐ Not evaluable

☐ CPS is $\geq$ 1 ☐ CPS is $<$ 1

Pathologist's comments: _____

PD-L1 IHC 28-8 pharmDx

Immunostaining Examples in ESCC

Partial and complete membrane stain

ESCC specimen stained with PD-L1 primary antibody exhibiting partial (**red arrows**), and complete (**black arrows**), linear membrane staining of tumor cells. Tumor cells exhibiting partial or complete linear membrane staining at any intensity are included in the CPS numerator.

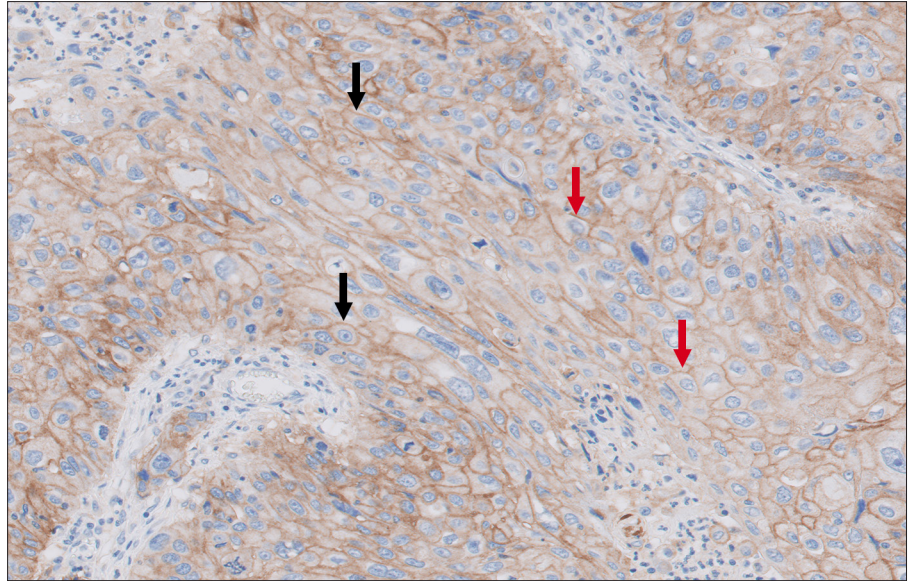


Figure 11. 20x magnification.

Linear membrane staining intensities 1-3+

ESCC specimen stained with PD-L1 primary antibody exhibiting mainly 1+ linear membrane staining (**red arrows**) of tumor cells.

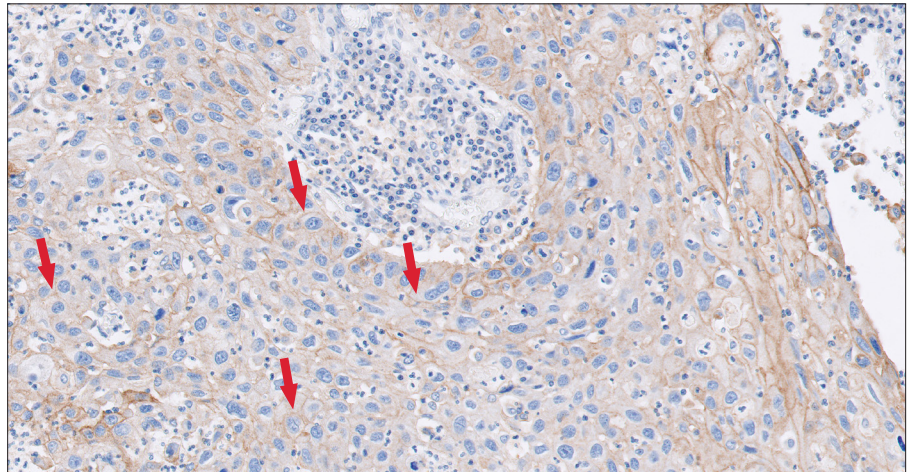


Figure 12. 20x magnification.

Linear membrane staining intensities 1-3+

ESCC specimen stained with PD-L1 primary antibody exhibiting mainly 2+ linear membrane staining (**red arrows**) of tumor cells.

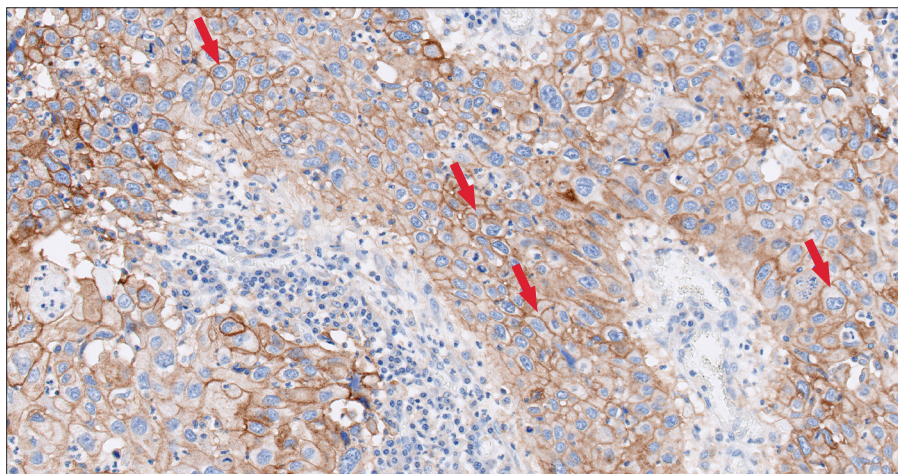


Figure 13. 20x magnification.

Linear membrane staining intensities 1-3+

ESCC specimen stained with PD-L1 primary antibody exhibiting 3+ linear membrane staining (**red arrows**) of tumor cells.

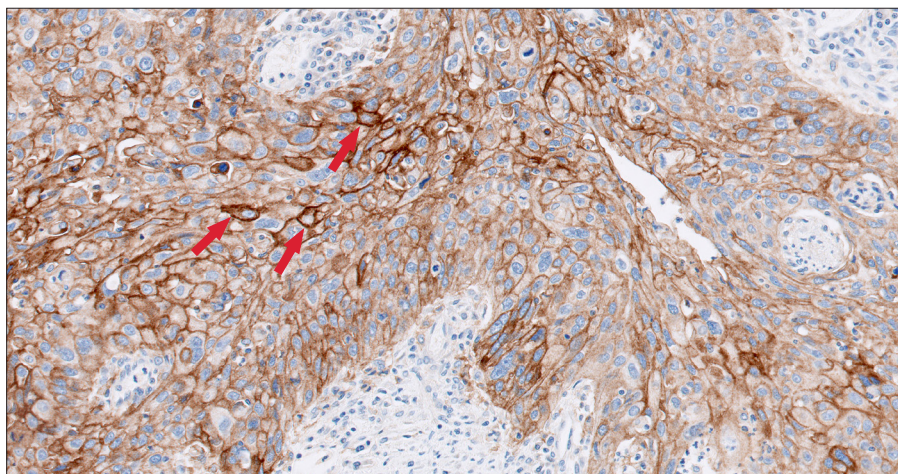


Figure 14. 20x magnification.

Cytoplasmic Staining

Positive linear membrane staining of tumor cells (**black arrows**) is observed and is distinguishable from the cytoplasmic staining (**red arrows**).

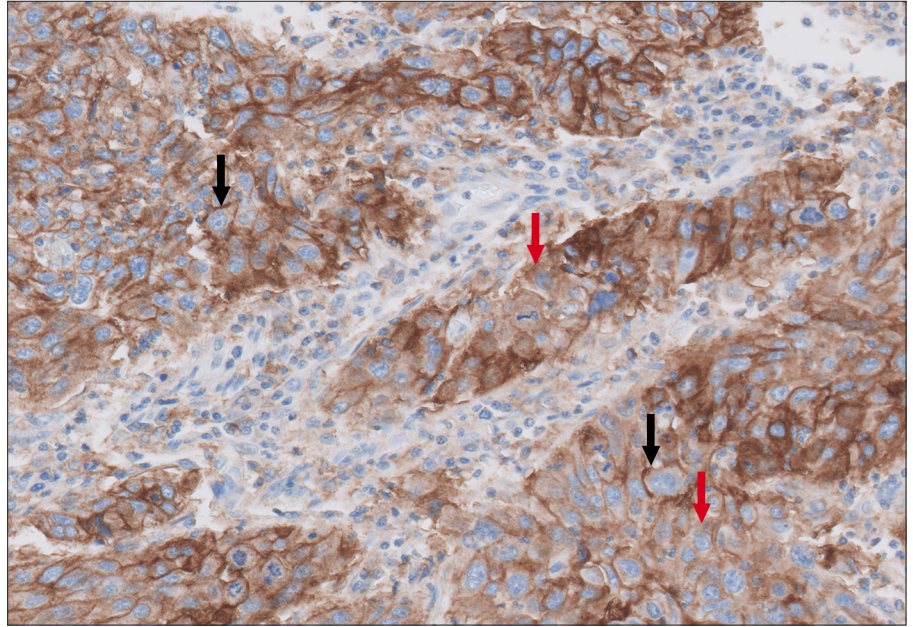


Figure 15. 20x magnification.

Granular Staining

Granular staining (**red arrows**) is present in the cytoplasm of tumor cells. Positive linear membrane staining of the tumor cells is observed (**black arrows**).

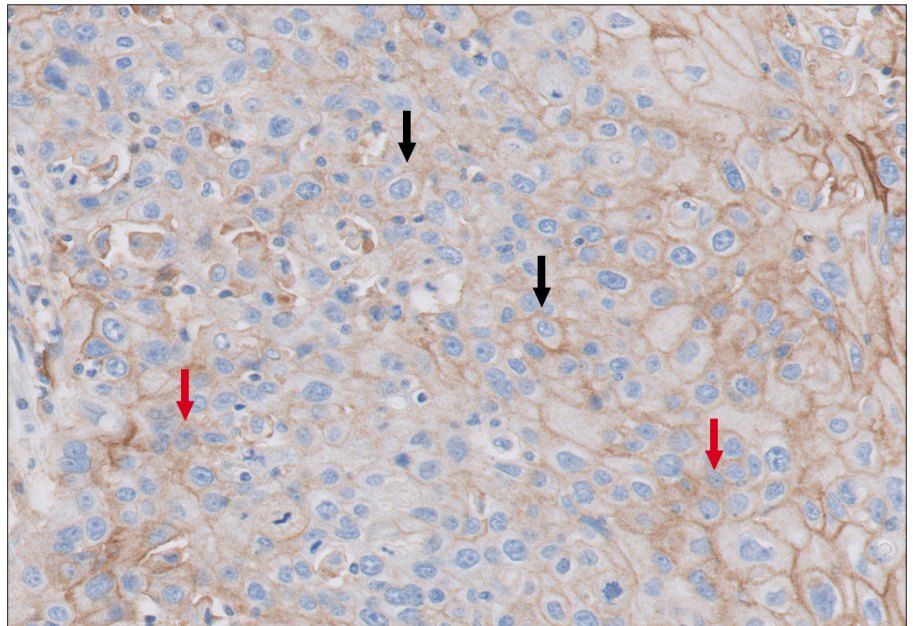


Figure 16. 20x magnification.

Multinucleate tumor cells

Some tumor cells in esophageal squamous cell carcinoma may be multinucleate and each should be counted as one cell. The same rules should apply for inclusion in the numerator and denominator: all viable tumor cells should be included in the denominator and all tumor cells with partial or complete linear membrane staining should be included in the numerator.

ESCC specimen exhibiting linear membrane staining of multinucleate tumor cells (**black arrows**). Some tumor cells may be multinucleate and should be counted as one cell and included in the numerator and denominator.

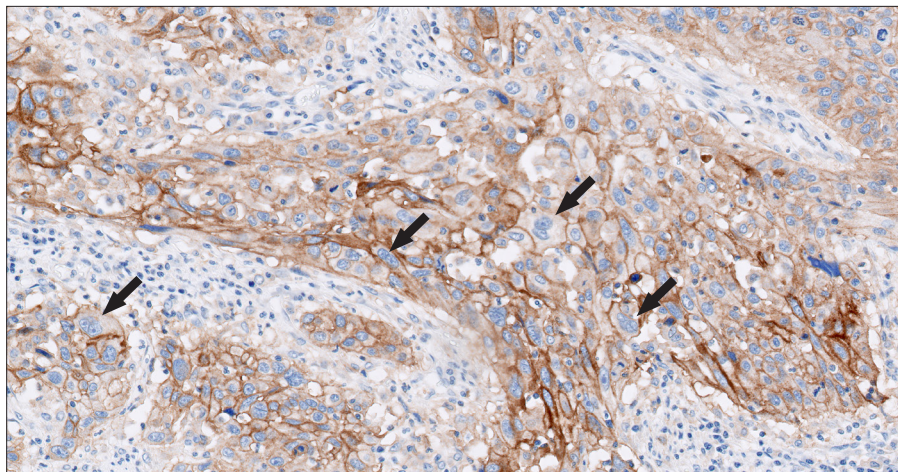


Figure 17. 20x magnification.

Immune cells included in CPS

Tumor-associated mononuclear inflammatory cells (MICs)

Tumor-associated mononuclear inflammatory cells (MICs: lymphocytes and macrophages) exhibiting membrane and/or cytoplasmic staining at a 20x magnification (at any intensity) are considered PD-L1 staining cells and should be included in the CPS numerator. Tumor-associated MICs are present within the tumor nests and/or adjacent supporting stroma and are directly associated with the response against the tumor.

PD-L1 staining lymphocytes and macrophages

ESCC specimen stained with PD-L1 primary antibody exhibiting linear membrane staining of tumor cells (**black arrows**) and of tumor-associated macrophages (**red arrows**) and lymphocytes (**blue arrows**).

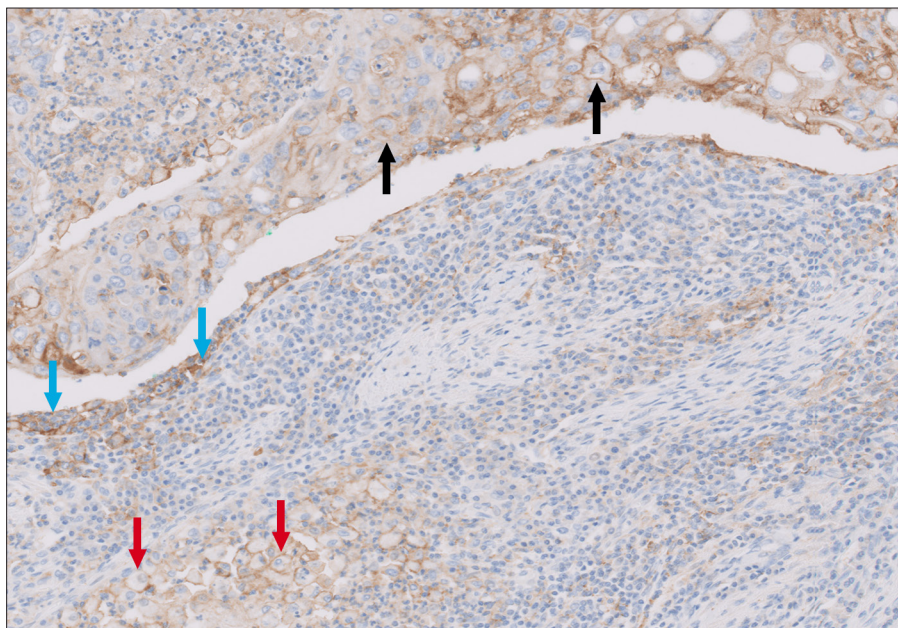


Figure 18. 20x magnification.

PD-L1 staining lymphocytes

ESCC specimen stained with PD-L1 primary antibody exhibiting strong staining of tumor-associated lymphocytes (**red arrows**), while the tumor cells are negative (**black arrows**) for PD-L1 positivity.

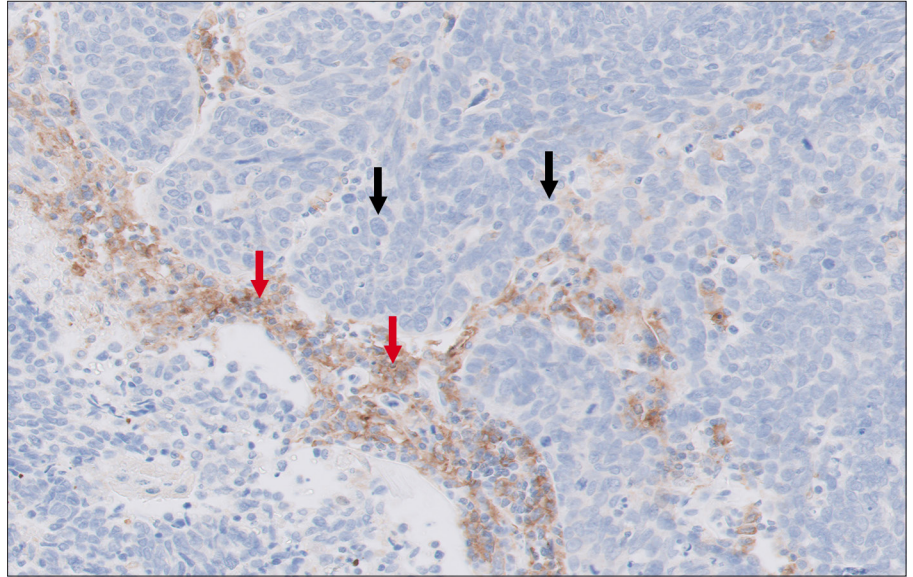


Figure 19. 20x magnification.

PD-L1 staining macrophages

Specimen stained with PD-L1 primary antibody exhibiting strong staining of tumor-associated macrophages (**red arrows**), while the tumor cells are negative (**black arrows**) for PD-L1 positivity.

The fusion of macrophages can occur as a result of chronic inflammation. PD-L1 staining multinucleate macrophages (giant cells) should be counted as one cell and included in the numerator.

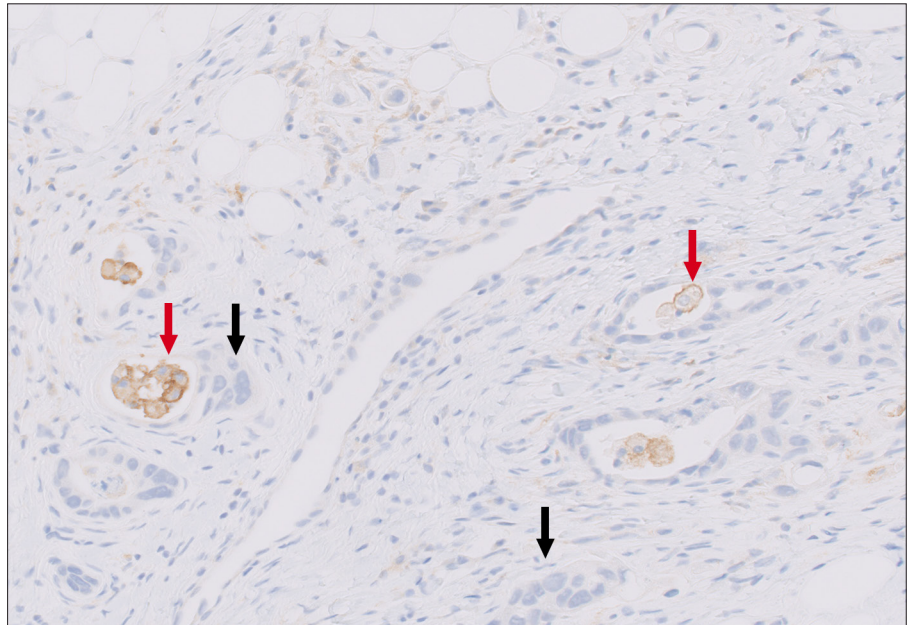


Figure 20. 20x magnification; esophageal adenocarcinoma specimen pictured.

20x Field of View Rule

PD-L1 staining MICs must be directly associated with the response against the tumor to be included in the CPS numerator. MICs are considered tumor-associated if they are present within the tumor nests and/or adjacent supporting stroma within a 20x magnification field of view. In cases where it is difficult to tell if MICs are tumor-associated, the following is suggested as a guideline: Move the slide so that the tumor is in the approximate center of a 20x field. Immune cells surrounding the tumor in this field should be included in the scoring. Immune cells outside of this field should be excluded from scoring as long as they do not surround neighboring tumor cells. In general, include PD-L1 staining MICs that are within 0.5 mm of the tumor cells. This rule may be applied to tumors within lymph nodes that contain PD-L1 staining MICs. See [Figures 25 and 27](#) for an example of determining which MICs are included in the CPS numerator.

Specimen stained with PD-L1 primary antibody. At 5x magnification, several areas of staining MICs are visible. To demonstrate which immune cells include in the numerator, zoom in to 20x magnification on the boxed fields.

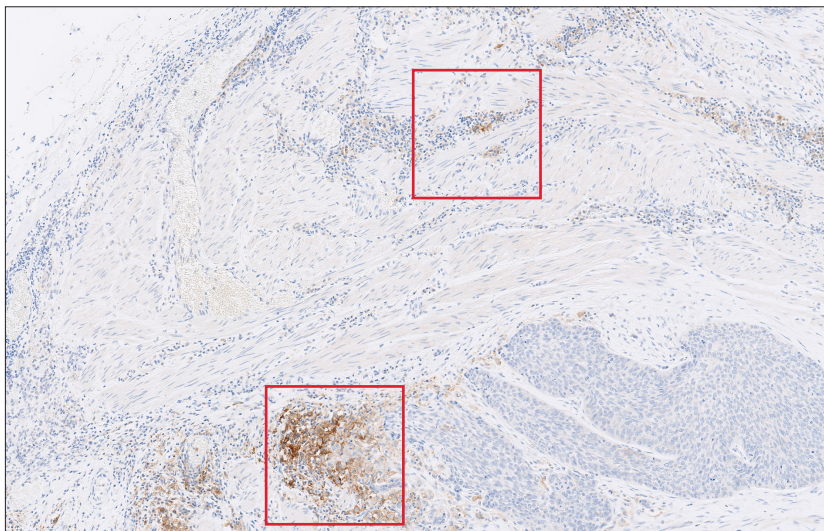


Figure 21. 20x magnification; gastroesophageal squamous cell carcinoma specimen pictured.

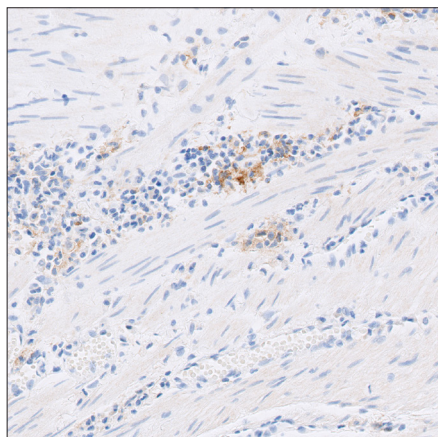


Figure 22. 20x magnification; gastroesophageal squamous cell carcinoma specimen pictured.

Tumor cells are absent from this 20x field containing PD-L1 staining mononuclear inflammatory cells, thus these cells should be excluded from the numerator.

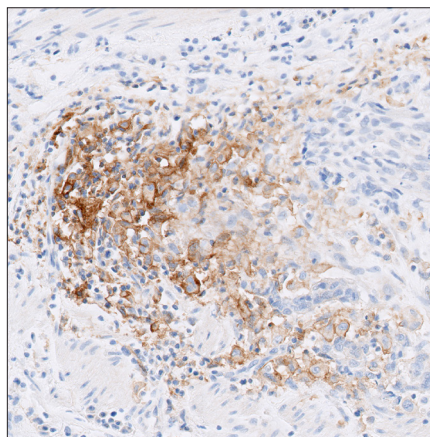


Figure 23. 20x magnification; gastroesophageal squamous cell carcinoma specimen pictured.

When positioning the tumor cells in the approximate center of a 20x field, PD-L1 staining mononuclear inflammatory cells that are present within the same field should be included in the numerator.

Cells excluded from CPS

Only tumor cells exhibiting PD-L1 membrane staining and MICs exhibiting PD-L1 membrane and/or cytoplasmic staining should be included in the CPS numerator. Below are common examples of other cells that can exhibit PD-L1 expression but should be excluded from the CPS calculation (CPS numerator and/or denominator). For complete inclusion/exclusion criteria refer to Tables 2 and 3 on page numbers 19 and 20 respectively.

Tumor cells with cytoplasmic stain only

ESCC specimen stained with PD-L1 primary antibody exhibiting only cytoplasmic staining.

Tumor cells exhibiting only cytoplasmic staining are excluded from the CPS numerator. They should, however, still be included in the CPS denominator.

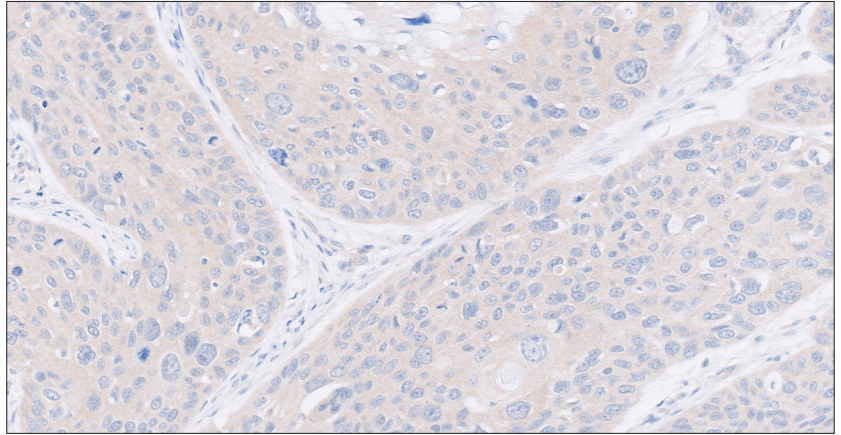


Figure 24. 20x magnification.

Key highlights

- Tumor cells exhibiting only cytoplasmic staining should not be included in the CPS numerator
- Membrane staining occluded by strong cytoplasmic staining should be excluded from the CPS numerator and denominator

Carcinoma in situ

H&E section of an ESCC specimen demonstrating carcinoma in situ (CIS). The boxed region is shown below at higher magnification.

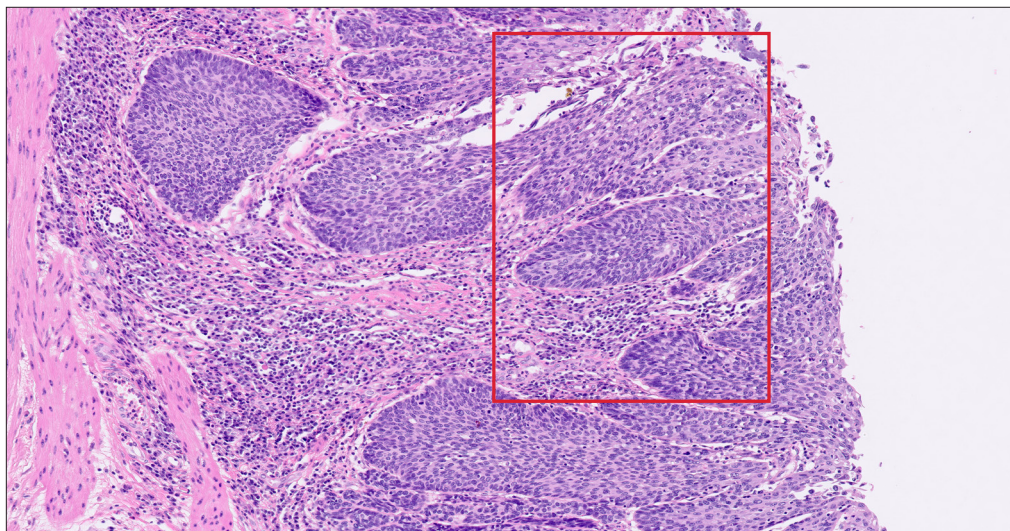


Figure 25. 5x magnification.

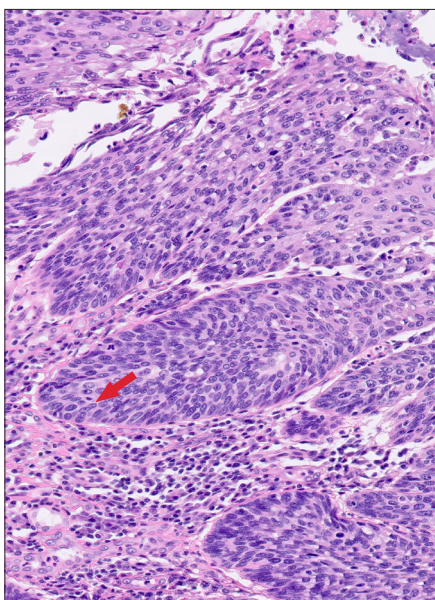


Figure 26. 10x magnification.

H&E section demonstrating tumor cells involved in a CIS component (**red arrow**).

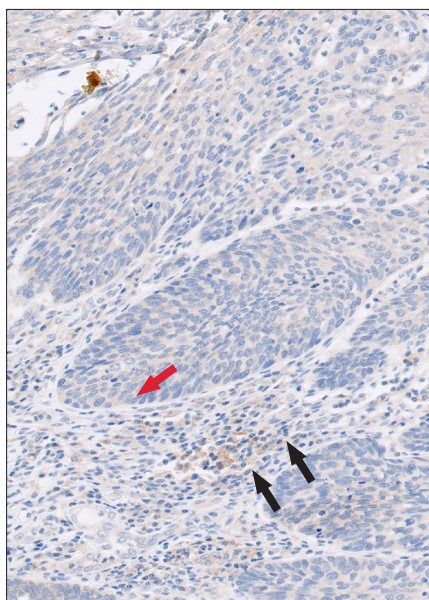


Figure 27. 10x magnification.

Any tumor cells that are part of the CIS component should be excluded from the numerator and denominator (**red arrows**). Any MICs (**black arrows**) associated with the CIS component should be excluded from the numerator.

Key highlights

Any tumor cells and MICs associated with the CIS component should be excluded from the score

Staining of fibroblasts

ESCC specimen stained with PD-L1 primary antibody exhibiting staining of fibroblasts (**red arrows**), which should be excluded from the score.

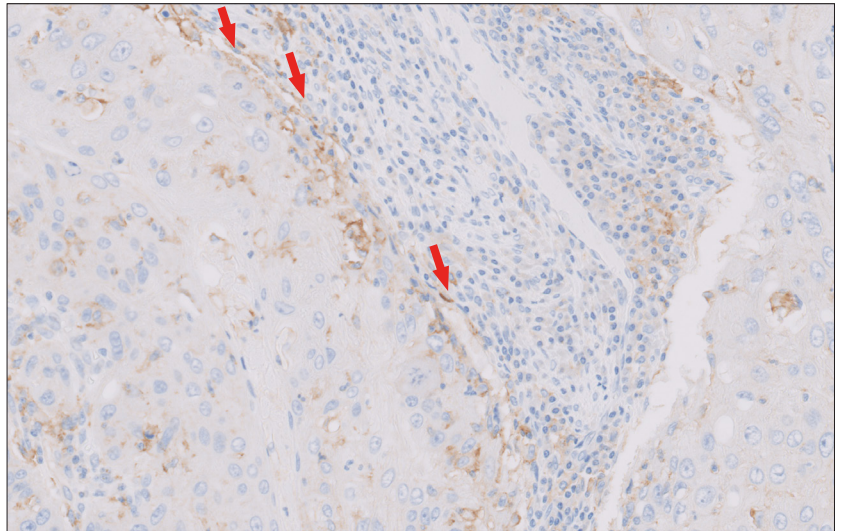


Figure 28. 20x magnification.

Staining normal epithelium

ESCC specimen stained with PD-L1 primary antibody exhibiting staining of benign epithelial cells (**red arrows**) and associated MICs (**black arrows**), both of which should be excluded from the score.

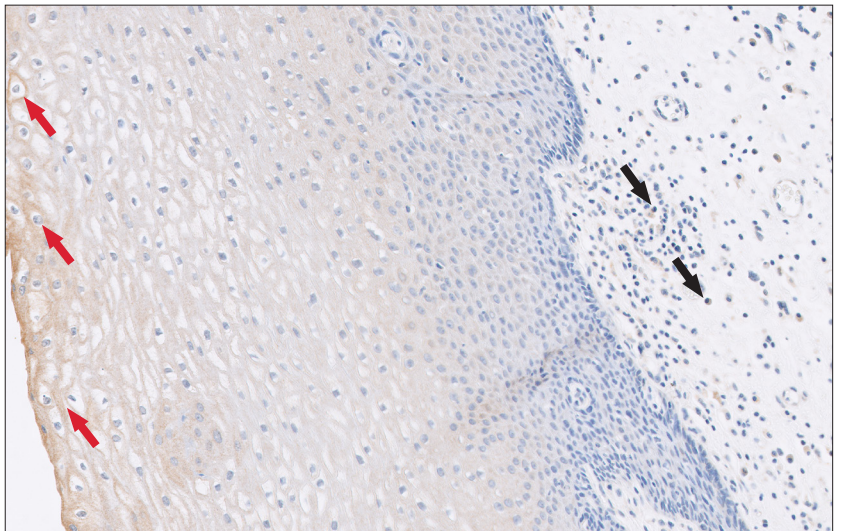


Figure 29. 20x magnification.

Staining ulcerated epithelium

Specimen stained with PD-L1 primary antibody exhibiting staining of benign ulcerated epithelial cells (**red arrows**) and associated MICs (**black arrows**), both of which should be excluded from the score.

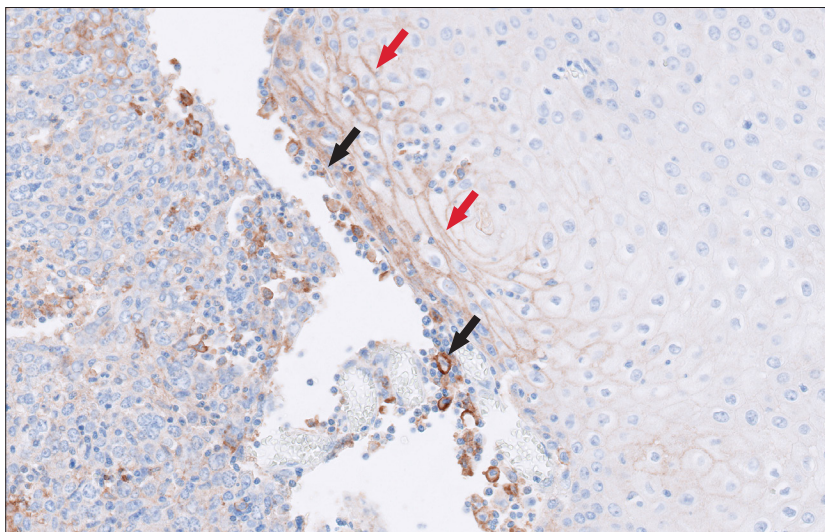


Figure 30. 20x magnification; gastroesophageal squamous cell carcinoma specimen pictured.

Key highlights

- PD-L1 staining of normal cells should be excluded from the numerator and denominator
- PD-L1 staining of MICs unassociated with the direct tumor response should be excluded from the numerator

Immune cells excluded from CPS

Plasma cells

ESCC specimen stained with PD-L1 primary antibody exhibiting staining of plasma cells (**red arrows**), which should be excluded from the score.

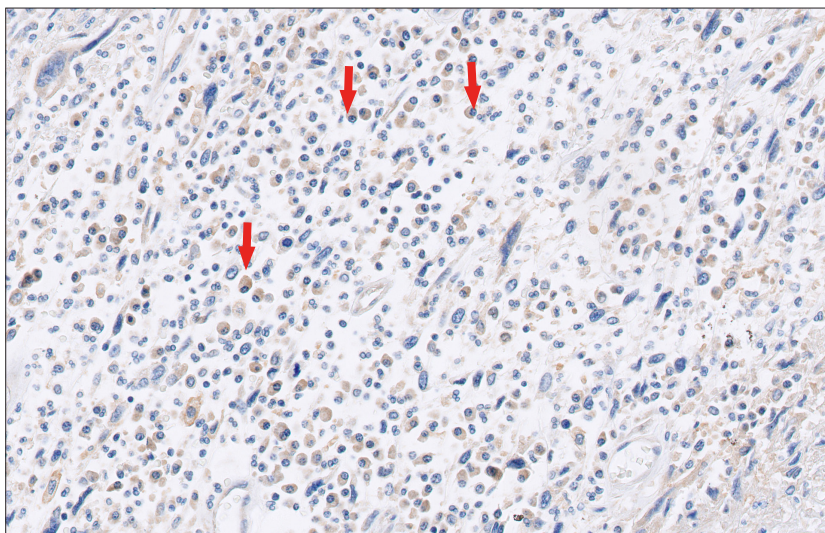


Figure 31. 20x magnification.

Neutrophils

ESCC specimen stained with PD-L1 primary antibody exhibiting staining of neutrophils (**black arrows**), which should be excluded from the score.

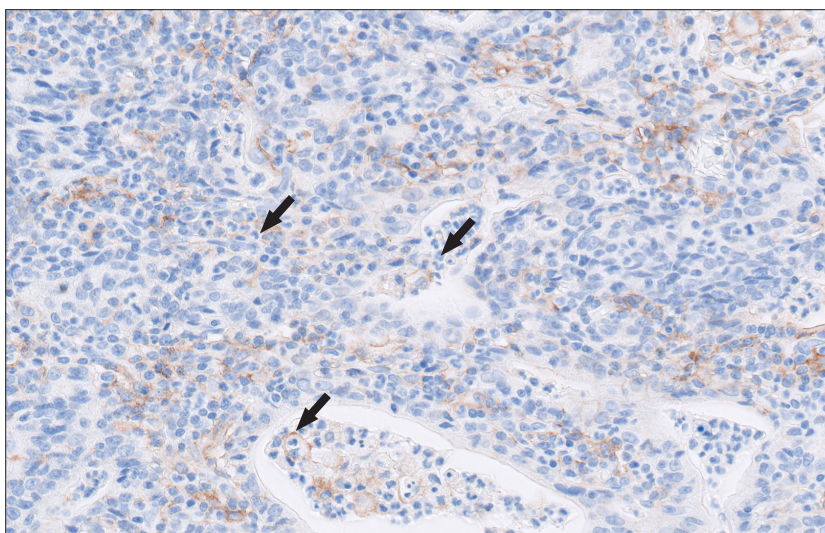


Figure 32. 20x magnification.

Key highlights

- Only lymphocytes and macrophages with cytoplasmic and/or membrane staining are included in the numerator
- Plasma cells, neutrophils, and eosinophils are excluded from the CPS numerator

PD-L1 IHC 28-8 pharmDx ESCC Case Examples

CPS 0 case examples

ESCC specimen stained with PD-L1 primary antibody exhibiting CPS 0.

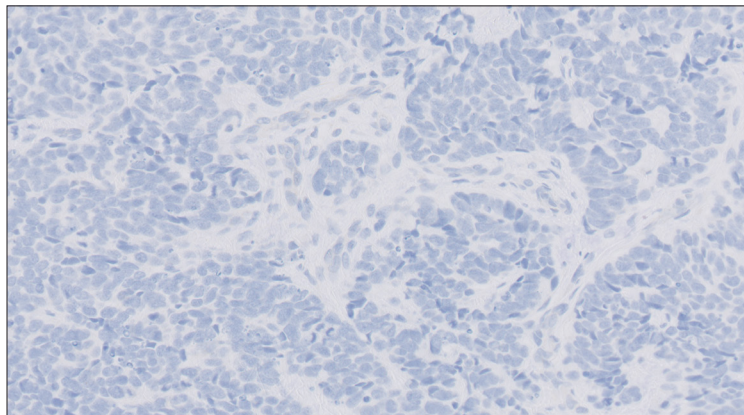


Figure 33. 20x magnification.

ESCC specimen stained with PD-L1 primary antibody exhibiting CPS 0

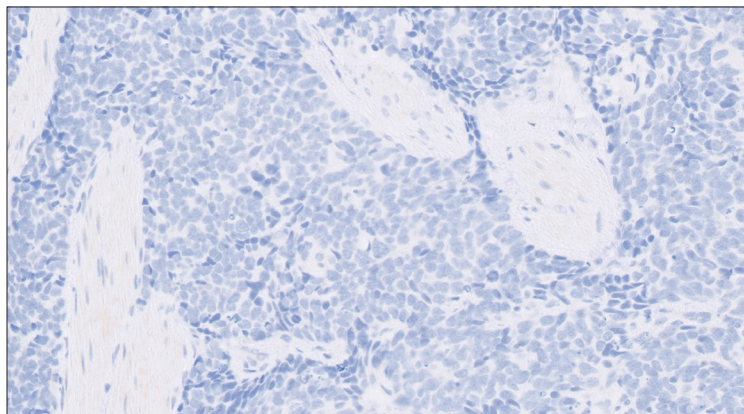


Figure 34. 20x magnification.

Challenging cases: CPS < 1

ESCC specimen stained with PD-L1 primary antibody exhibiting CPS < 1.

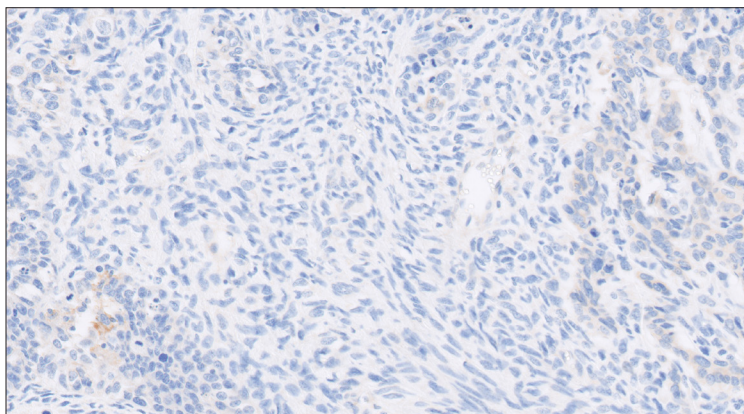


Figure 35. 20x magnification.

ESCC specimen stained with PD-L1 primary antibody exhibiting CPS < 1.

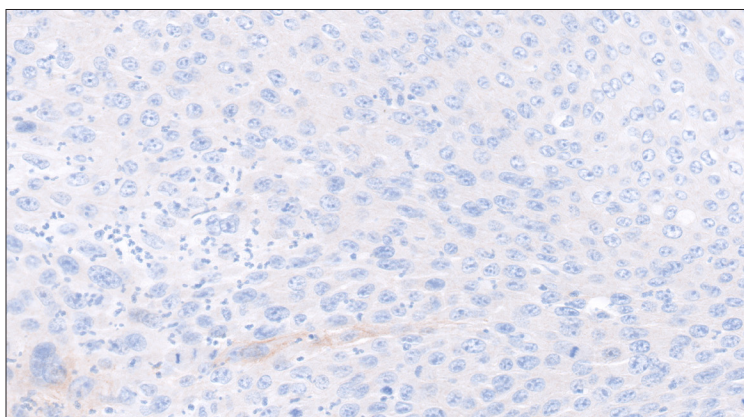


Figure 36. 20x magnification.

Challenging cases: CPS 1-10

ESCC specimen stained with PD-L1 primary antibody exhibiting CPS 5.

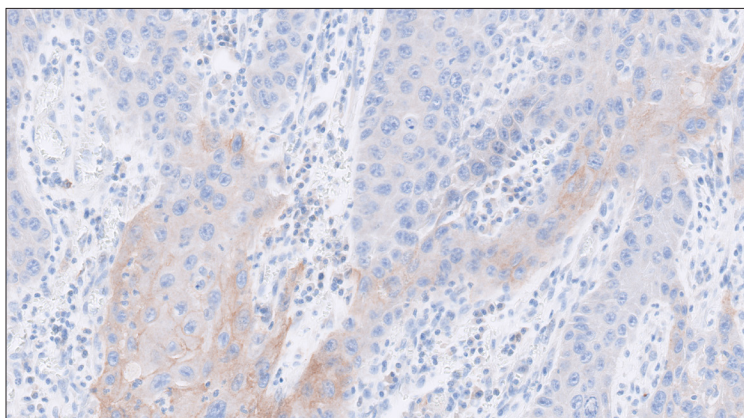


Figure 37. 20x magnification.

ESCC specimen stained with PD-L1 primary antibody exhibiting CPS 8.

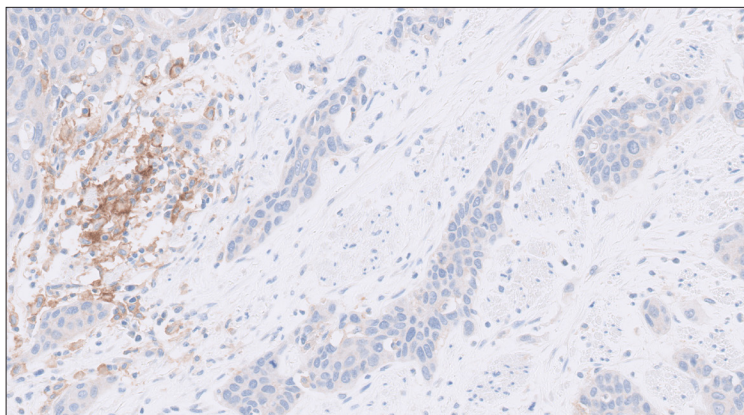


Figure 38. 20x magnification.

ESCC specimen stained with PD-L1 primary antibody exhibiting CPS 10.

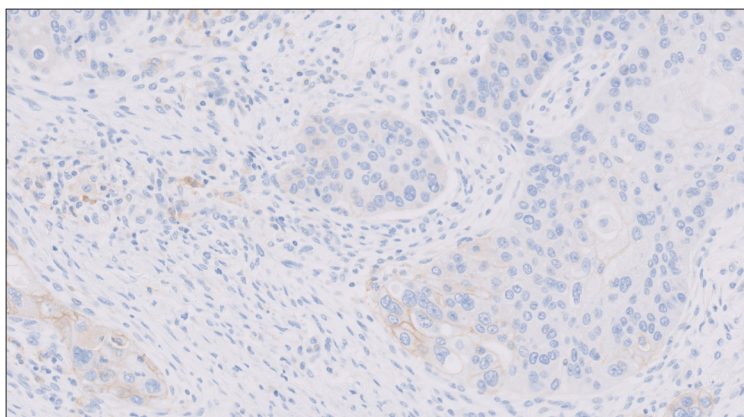


Figure 39. 20x magnification.

ESCC specimen stained with PD-L1 primary antibody exhibiting CPS 10.

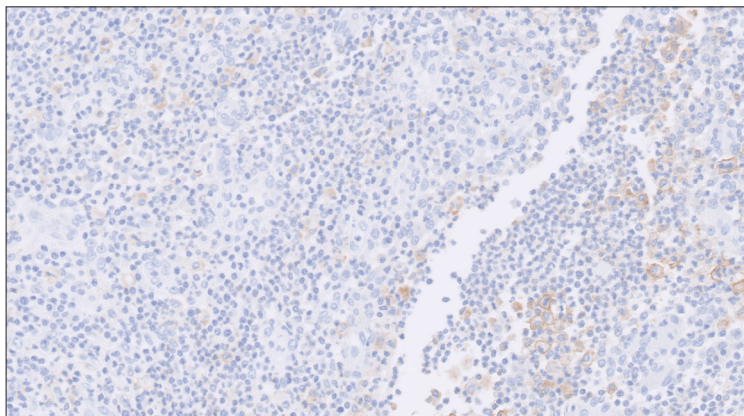


Figure 40. 20x magnification.

Case examples: CPS >10 (11–59)

ESCC specimen stained with PD-L1 primary antibody exhibiting CPS 25.

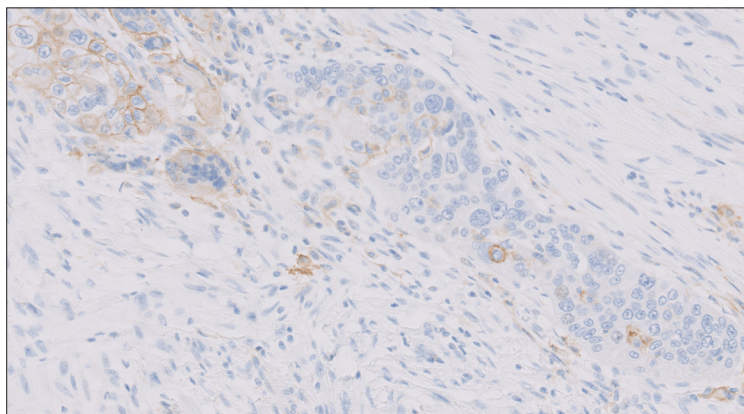


Figure 41. 20x magnification

ESCC specimen stained with PD-L1 primary antibody exhibiting CPS 25.

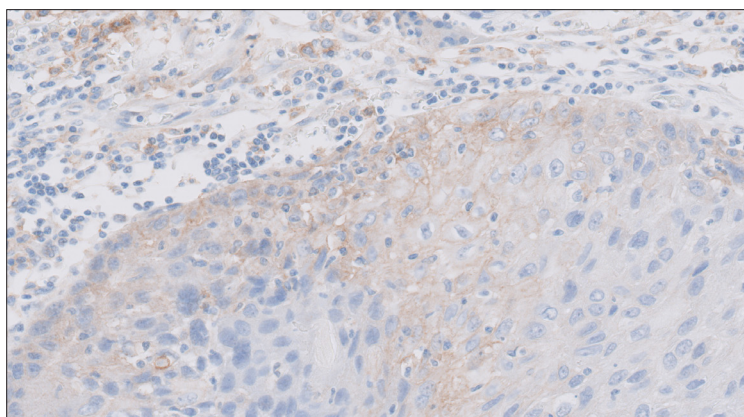


Figure 42. 20x magnification.

ESCC specimen stained with PD-L1 primary antibody exhibiting CPS 50.

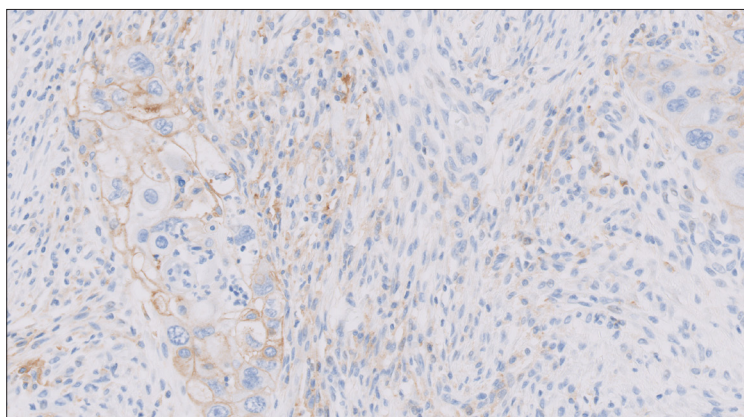


Figure 43. 20x magnification.

Case examples: CPS >10 (60–100)

ESCC specimen stained with PD-L1 primary antibody exhibiting CPS 60.

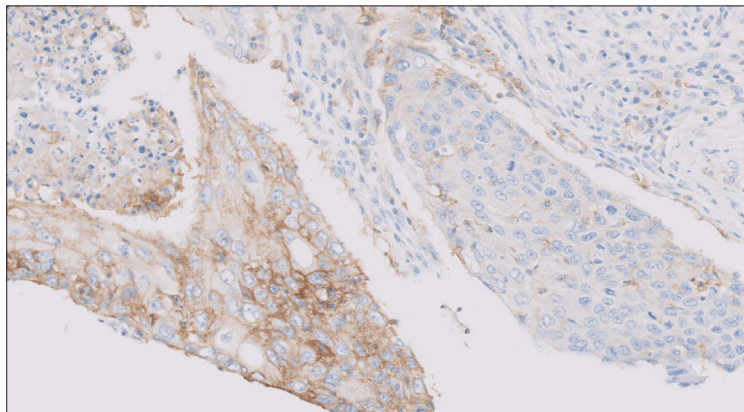


Figure 44. 20x magnification.

ESCC specimen stained with PD-L1 primary antibody exhibiting CPS 100.

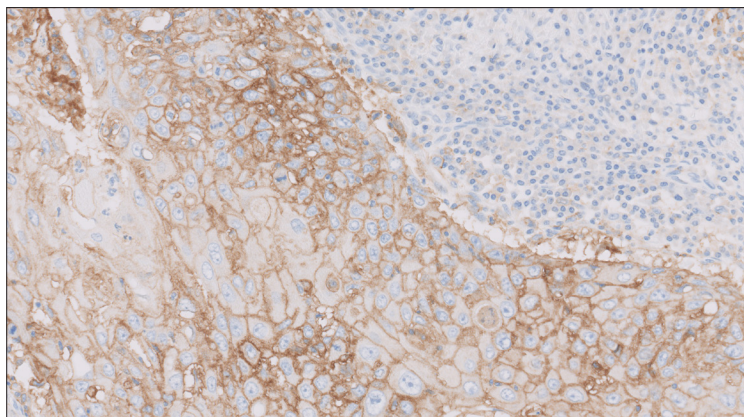


Figure 45. 20x magnification.

Artifacts

Nonspecific Staining

Nonspecific staining is defined as staining that is not related to primary antibody-antigen interaction and represents issues such as reagent trapping, cartilage staining, DAB deposits, tissue folds, and edge drying. Other notable factors include, but are not limited to, pre-analytic fixation and processing of the specimen, incomplete removal of paraffin from sections, and incomplete rinsing of slides.

The use of fixatives other than 10% neutral buffered formalin may be a source of nonspecific staining. If nonspecific staining interferes with interpretation of specific staining, the slide may be considered unacceptable.

Possible cause of nonspecific staining

- Improper drying of slides; ensure slides remain wet with buffer while loading onto Autostainer Link 48 and prior to initiating run
- Improper deparaffinization procedure
- Incomplete rinsing of reagents from slides
- Improper mixing of wash buffer

The nonspecific staining present on the patient specimen stained with Negative Control Reagent is useful in determining the level of nonspecific staining in the same patient tissue specimen stained with PD-L1. All specimens must have $\leq$ 1+ nonspecific staining.

This ESCC example may be considered an indeterminate case if the excess cytoplasmic staining hampers scoring. Positive linear membrane staining of the tumor is observed (**black arrow**), however cytoplasmic staining is excessive in some of the specimen (**red arrows**).

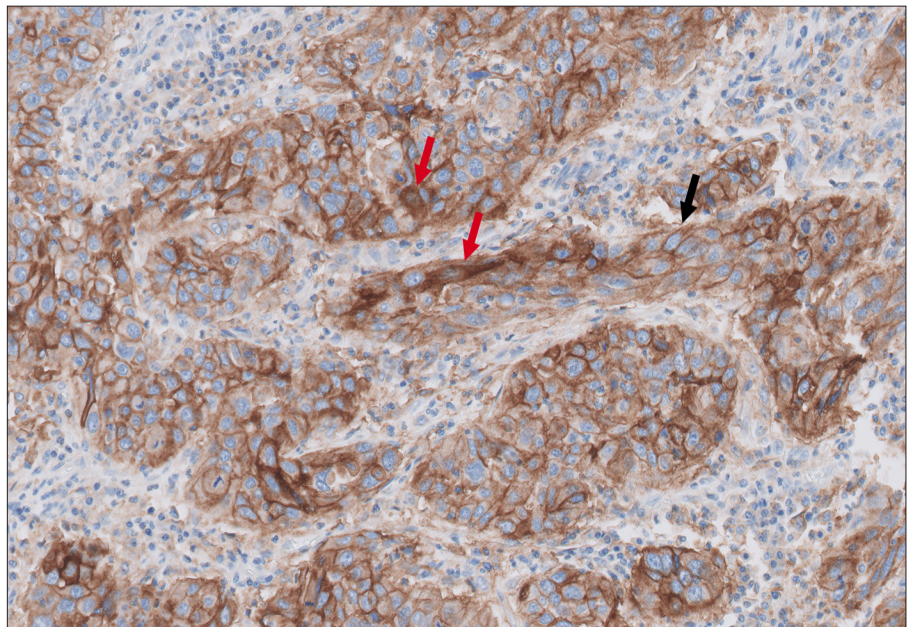


Figure 46. 20x magnification.

Necrosis

Necrotic tissue may show nonspecific staining and should not be included in the scoring.

Note: If the specimen is excessively necrotic and contains < 100 viable tumor cells, the specimen is considered not evaluable.

Necrotic tissue may show nonspecific staining and should not be included in scoring percent positivity of the tumor. Care should be taken to only include viable tumor cells for scoring and not necrotic regions.

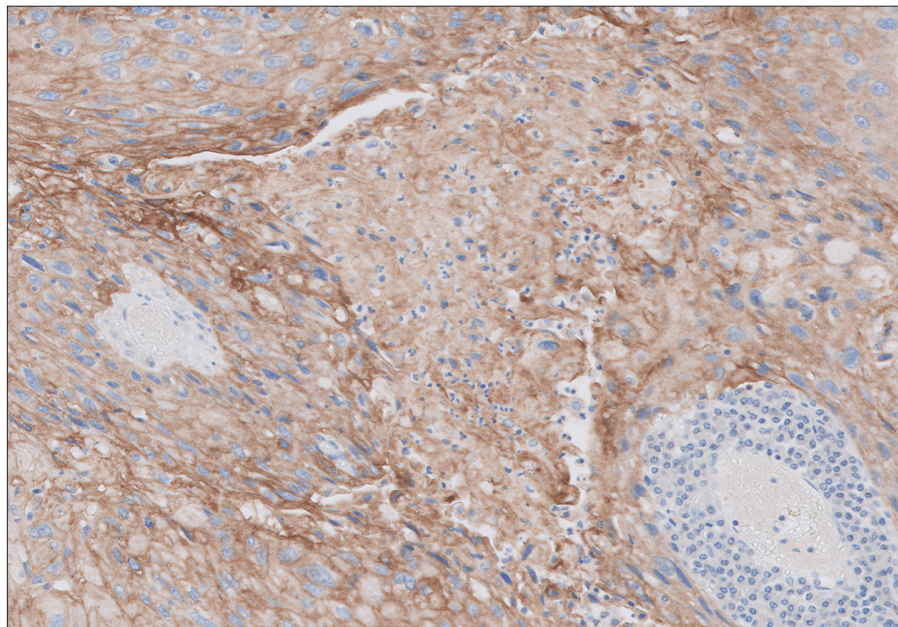


Figure 47. 20x magnification.

Hemosiderin 20X magnification

Specimen stained with PD-L1 antibody exhibiting negative tumor cells and hemosiderin artifact (**black arrows**). Hemosiderin should not be included in the scoring of PD-L1 expression. Note the staining of immune cells are not included in determining the percent PD-L1 expression.

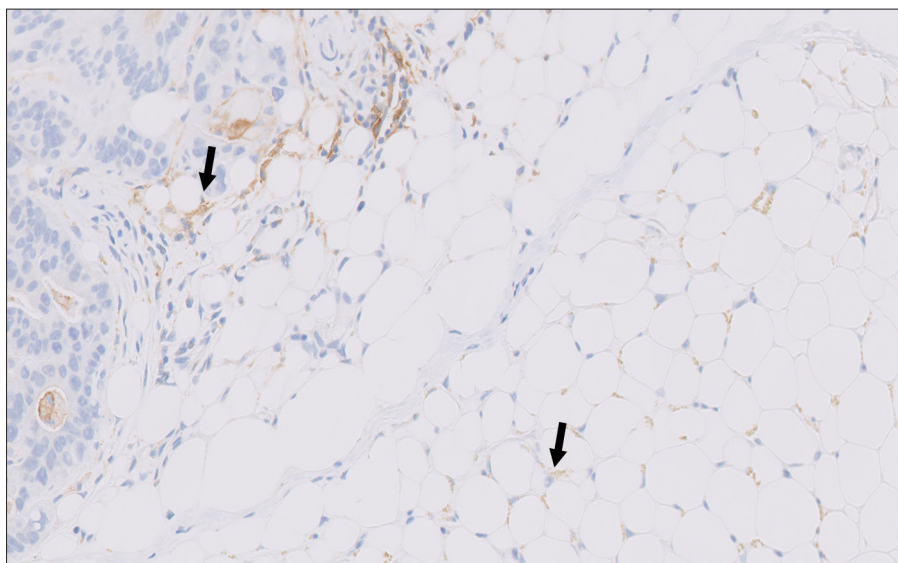


Figure 48. 20x magnification; esophageal adenocarcinoma specimen pictured.

DAB staining

ESCC specimen stained with PD-L1 primary antibody exhibiting nonspecific DAB staining; nonspecific DAB staining should be excluded from the score.

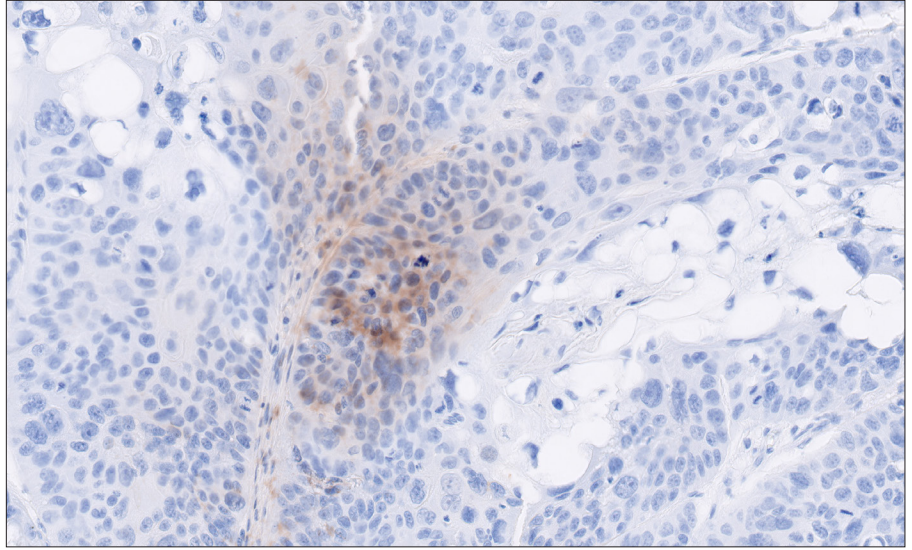


Figure 49. 20x magnification.

Poor fixation

ESCC specimen stained with PD-L1 primary antibody exhibiting poor tissue fixation. Larger specimens can suffer from poor fixation issues. These issues can cause poor tissue integrity, impaired morphology, and loss of antigen leading to an incorrect diagnosis of PD-L1 expression.

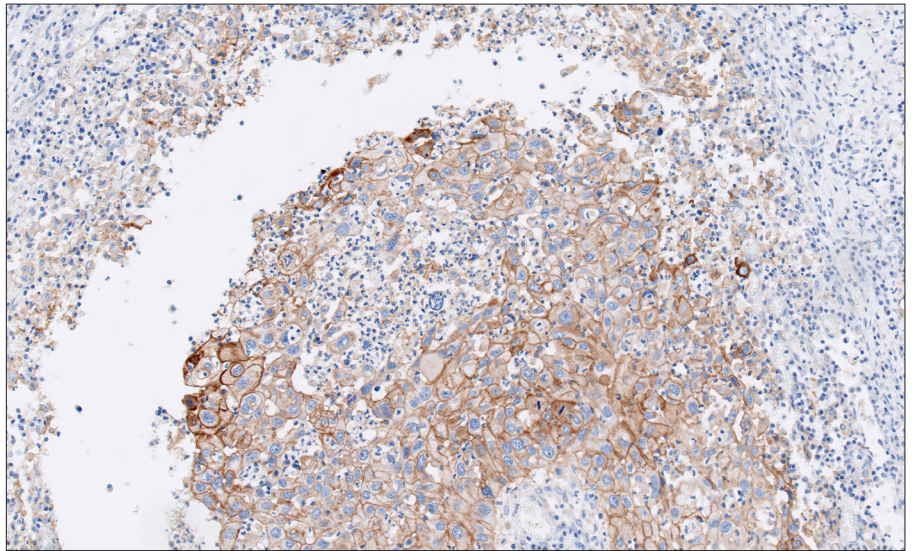


Figure 50. 20x magnification.

Edge effect

ESCC specimen stained with PD-L1 primary antibody exhibiting edge effect; edge staining should be excluded from the score. Edge effect can be more convincingly called if the central tumor mass is completely negative or shows significantly lower staining.

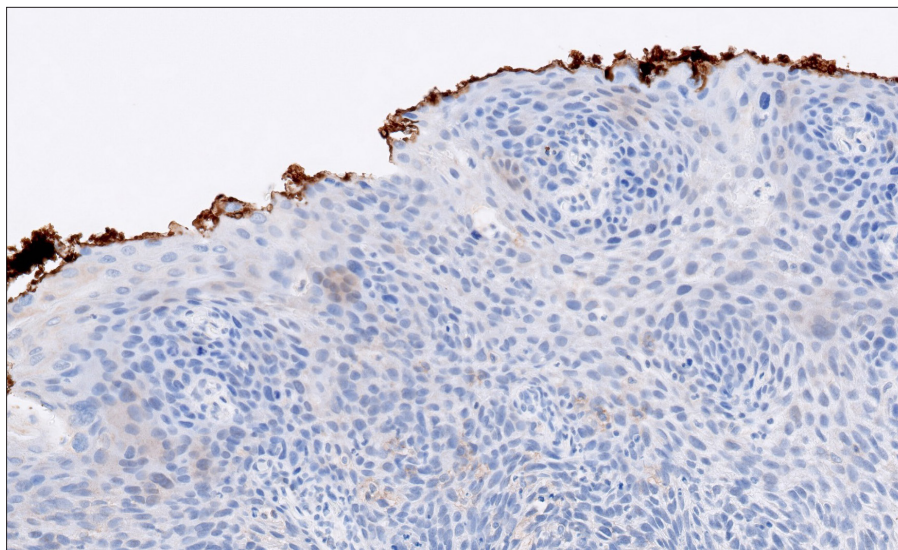


Figure 51. 20x magnification.

Crush artifact

ESCC specimen stained with PD-L1 primary antibody exhibiting crush artifact; crush artifact should be excluded from the score.

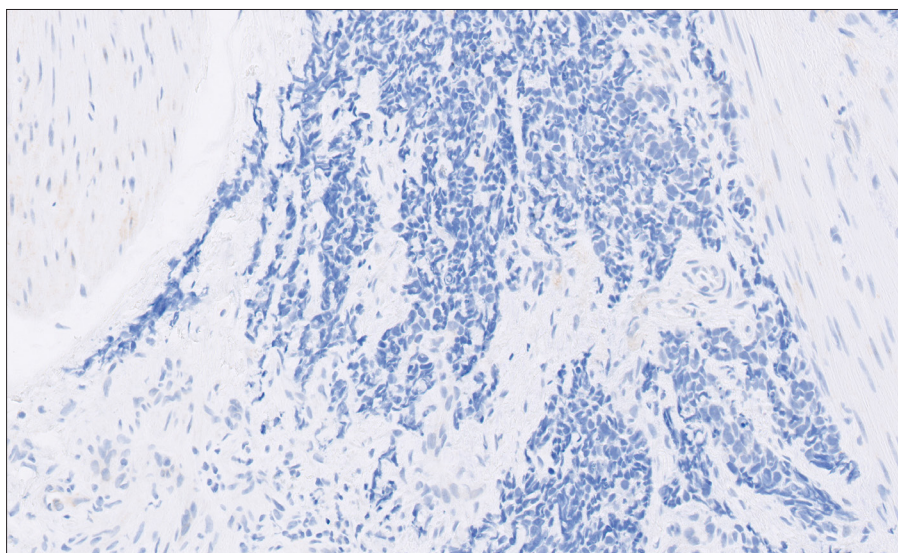


Figure 52. 20x magnification.

Troubleshooting Guide for PD-L1 IHC 28-8 pharmDx

Problem	Probable Cause	Suggested Action
1. No staining of control or specimen slides	1a. Programming error	1a. Verify that the SK005 PD-L1 IHC 28-8 pharmDx program was selected for programming of slides
	1b. Lack of reaction with DAB+ Substrate - Chromogen Solution (DAB)	1b. Verify that DAB+ Substrate-Chromogen Solution was prepared properly
	1c. Sodium azide in wash buffer	1c. Use only EnVision FLEX Wash Buffer, Code K8007
	1d. Degradation of Control Slide	1d. Check kit expiration date and kit storage conditions on outside of package
2. Weak staining of specimen slides	2a. Inappropriate fixation method used	2a. Ensure that only neutral buffered formalin fixative and approved fixation methods are used
	2b. Insufficient reagent volume applied	2b. Check size of tissue section and reagent volume applied
	2c. Inappropriate wash buffer used	2c. Use only EnVision FLEX Wash Buffer, Code K8007
3. Weak staining of specimen slides or the positive cell line on the Agilent-supplied Control Slide	3a. Inadequate target retrieval	3a. Verify that the 3-in-1 pre-treatment procedure was correctly performed
	3b. Inappropriate wash buffer used	3b. Use only EnVision FLEX Wash Buffer, Code K8007
4. Excessive nonspecific staining of slides	4a. Paraffin incompletely removed	4a. Verify that the 3-in-1 pre-treatment procedure was correctly performed
	4b. Slides dried while loading onto the Autostainer Link 48	4b. Ensure slides remain wet with buffer while loading and prior to initiating run
	4c. Nonspecific binding of reagents to tissue section	4c. Check for proper fixation of the specimen and/or the presence of necrosis
	4d. Inappropriate fixation method used	4d. Ensure that only neutral buffered formalin fixative and approved fixation methods are used
	4e. Inadequate mixing of wash buffer	4e. Ensure wash buffer is properly mixed
	4f. Increased slide drying	4f. Increase slide quantity per run to extend wash times for slides. Two full racks totaling 24 slides may demonstrate sufficient wash time increases to ameliorate slide drying. If further action is needed, three drop zones may be utilized to increase the amount of reagent on slides which may result in decreased slide drying
	4g. Improper humidity level maintained during run	4g. Ensuring a complete closure of the instrument lid to create a sealed humidity chamber may decrease slide drying. Loading slide racks from the back to the front of the instrument away from airflow may decrease slide drying. If further action is needed, additional measures to increase humidity can be used
	4h. Instrument is not properly maintained	4h. Ensure that the instrument is maintained and calibrated per manufacturer's recommendations. Refer to Autostainer Plus Link and Autostainer Link 48 Basic User Guide for proper maintenance to ensure staining quality

Problem	Probable Cause	Suggested Action
	4i. Autostainer slide racks are not level	4i. Ensure Autostainer slide racks are level prior to initiation of the IHC staining procedure. Please refer to Autostainer Plus Link and Autostainer Link 48 Basic User Guide for additional details
	4j. Insufficient quality of DI water	4j. Ensure that distilled or de-ionized water (reagent-grade water) is being used and that the water is changed frequently. Refer to 'Materials Required, but Not Supplied' Section 5 for further details
5. Tissue detached from slides	5a. Use of incorrect microscope slides	5a. Use FLEX IHC Microscope Slides (Code K8020), or Superfrost Plus slides
	5b. Inadequate preparation of specimens	5b. Cut sections should be placed in a 58 ± 2 °C oven for 1 hour prior to staining
6. Excessively strong specific staining	6a. Inappropriate fixation method used	6a. Ensure that only approved fixatives and fixation methods are used
	6b. Inappropriate wash buffer used	6b. Use only EnVision FLEX Wash Buffer, Code K8007
7. 1x EnVision FLEX Target Retrieval Solution is cloudy in appearance when heated	7. When heated the 1x EnVision FLEX Target Retrieval Solution turns cloudy in appearance	7. This is normal and does not influence staining
8. 1x EnVision FLEX Target Retrieval Solution does not meet pH specifications	8a. pH meter is not calibrated correctly	8a. Ensure pH meter is calibrated per manufacturer's recommendations. After re-calibration, re-test the pH of 1x EnVision FLEX Target Retrieval Solution. Do not modify the pH of 1x EnVision FLEX Target Retrieval Solution. If the pH is outside the acceptable range (6.1 ± 0.2), discard 1x EnVision FLEX Target Retrieval Solution. Prepare new 1x EnVision FLEX Target Retrieval Solution. Check the pH of the new 1x EnVision FLEX Target Retrieval Solution
	8b. Inferior quality water is used to dilute the EnVision FLEX Target Retrieval Solution concentrate	8b. Ensure that distilled or deionized water is used to prepare 1x Target Retrieval Solution
	8c. Incorrect Target Retrieval Solution is used	8c. Ensure that the correct EnVision Flex Target Retrieval Solution specified in "Materials Provided" and "Reagent Preparation" sections of the IFU is used

Note: If the problem cannot be attributed to any of the above causes, or if the suggested corrective action fails to resolve the problem, please contact Agilent Pathology Support for further assistance. Additional information on staining techniques and specimen preparation can be found in the Education Guide: Immunohistochemical Staining Methods (Taylor C. R. and Rudbeck L. Education Guide: Immunohistochemical Staining Methods – Sixth Edition. Dako, Carpinteria, California. 2013; available from Agilent).

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