

# Generalizable Whole Slide Image Classification with Fine-Grained Visual-Semantic Interaction

## Supplementary Material

This supplementary material includes demonstrations of raw unstandardized pathology reports as presented in Sec. A. And the detailed process of generating label descriptions using GPT-4, as well as specific label descriptions, are provided in Section B. Additionally, further elaboration on the prompts utilized for Text Standardization is provided in Sec. C. Moreover, a comprehensive explanation of the Fine-Grained Guidance Construction is outlined in Sec. D.

### A. Pathology Report Example

We present a range of pathology report demonstrations in Fig. 4, highlighting the extracted information utilizing GPT-4 to generate fine-grained text description label, as depicted in Tab. 6. The sampled diagrams depict considerable variability in the formats of pathology reports stemming from diverse data sources. After the data extraction by GPT-4, the textual descriptions exhibit a more structured format. Although some inconsistencies in expression persist, our objective differs from multi-label classification, emphasizing the semantic expression within the text. This kind of comprehensive description at the slide level enhances our model’s understanding of semantics, consequently refining the model’s ability to generalize.

### B. TCGA Label Description

We utilize the prompt “Describe the morphological characteristics of the LABEL in a single sentence in English.” to obtain label descriptions through GPT-4. When utilized, the placeholder tag LABEL is substituted with each specific label in the process.

#### B.1. TCGA Lung Cancer Label

**LUAD:** LUAD (Lung Adenocarcinoma) typically exhibits a diverse array of cell types, including glandular, papillary, and acinar structures with mucin production, and varying differentiation levels from well-differentiated to poorly-differentiated.

**LUSC:** LUSC (Lung Squamous Cell Carcinoma) is characterized by tumor cells forming sheet-like squamous structures, possibly showing keratinization features like keratin pearl formation, and is typically well-differentiated.

#### B.2. TCGA-LUAD Subtype Label

To evaluate the generalizability of our model and perform zero-shot classification, we curate a dataset of histological subtype labels for TCGA-LUAD, including histological

subtypes of 54 samples of Lung Adenocarcinoma Mixed Subtype, 10 samples of Lung Bronchioloalveolar Carcinoma Nonmucinous, 5 samples of Lung Acinar Adenocarcinoma, 1 sample of Mucinous Adenocarcinoma, 4 samples of Micropapillary (colloid) Adenocarcinoma, 3 samples of Lung Bronchioloalveolar Carcinoma Mucinous, 2 samples of Lung Micropapillary Adenocarcinoma, 8 samples of Lung Papillary Adenocarcinoma.

**Adenocarcinoma Mixed Subtype:** Adenocarcinoma mixed subtype is a cancer characterized by the presence of diverse cell types, exhibiting a combination of morphological features from various adenocarcinoma subtypes within the same tumor, making it a heterogeneous and challenging histological entity.

**Bronchioloalveolar Carcinoma Nonmucinous:** Bronchioloalveolar carcinoma nonmucinous is a type of lung cancer characterized by the proliferation of well-differentiated, nonmucinous glandular cells along the bronchiolar and alveolar structures within the lung tissue, often presenting as solitary nodules or lepidic growth patterns.

**Papillary Adenocarcinoma:** Papillary adenocarcinoma is a type of cancer characterized by finger-like projections or papillae composed of malignant glandular cells, often exhibiting a well-differentiated appearance under a microscope.

**Acinar Adenocarcinoma:** Acinar adenocarcinoma is a form of cancer marked by the presence of glandular structures resembling acini, often comprised of well-differentiated malignant cells that form small, round, or oval-shaped structures.

**Mucinous (colloid) Adenocarcinoma:** Mucinous (colloid) adenocarcinoma is a cancer subtype characterized by the presence of abundant extracellular mucin, produced by malignant glandular cells, giving it a gelatinous or colloid-like appearance when viewed under a microscope.

**Bronchioloalveolar Carcinoma Mucinous:** Bronchioloalveolar carcinoma mucinous is a lung cancer subtype characterized by the proliferation of glandular cells producing abundant mucin, often leading to a lepidic growth pattern and presenting as a mass with a mucinous appearance.

**Mucinous Adenocarcinoma:** Mucinous adenocarcinoma is a type of cancer characterized by the abundant production of mucin, a gel-like substance, by malignant glandular cells, often resulting in a tumor with a significant mucinous component.

**Micropapillary Adenocarcinoma:** Micropapillary adenocarcinoma displays distinct small clusters or papillary

TCGA-64-1678

Final Pathologic Diagnosis:

A. Lymph node, 4R subcarinal, resection: Eight benign lymph nodes.

B. LUNG, Resection: Specimen: Right Lung-Lower lobe of lung; Procedure: lobectomy; Specimen laterality: Right; Tumor site: Right lower lobe; Specimen integrity: Intact; Tumor size (greatest dimension): 2.4x 2.4cm; Tumor focality: Unifocal; Tumor histologic type: Adenocarcinoma; Tumor grade: Moderately differentiated; Visceral pleura invasion: Present; Tumor Extension: Not identified; Margins: Bronchial: Uninvolved by invasive carcinoma; Vascular: Uninvolved by invasive carcinoma; Parenchymal: Uninvolved by invasive carcinoma; Pleural pleura: Not applicable; Chest wall: Not applicable; Other attached tissue margin: Not applicable; If all margins uninvolved by invasive carcinoma: Distance of invasive carcinoma from closest margin: less than 1mm; Specify margin: visceral pleura; Treatment effect: Not applicable; Lymph-vascular invasion: Not identified; Pathologic staging (pT): TNM Descriptors: none; Primary tumor: pT; Regional lymph nodes: pN0; Number examined: 14; Distant metastasis: pM0; Additional pathologic findings: Emphysematous changes in uninvolved lung parenchyma.

C. Lymph nodes, #9 inferior pulmonary, excision: Two benign lymph nodes.

D. Lymph nodes, lower paratracheal, excision: Four benign lymph nodes.

The examination of this case material and the preparation of this report were performed by the staff pathologist.

Electronically Signed: [Redacted]

Signing Location: [Redacted]

Gross Description: Received are three specimen containers, each labeled with the patient's name.

(a) TCGA-64-1678

TCGA-73-4668

Final Pathologic Diagnosis:

A. Lymph node, 4R subcarinal, resection: Eight benign lymph nodes.

B. LUNG, Resection: Specimen: Right Lung-Lower lobe of lung; Procedure: lobectomy; Specimen laterality: Right; Tumor site: Right lower lobe; Specimen integrity: Intact; Tumor size (greatest dimension): 2.4x 2.4cm; Tumor focality: Unifocal; Tumor histologic type: Adenocarcinoma; Tumor grade: Moderately differentiated; Visceral pleura invasion: Present; Tumor Extension: Not identified; Margins: Bronchial: Uninvolved by invasive carcinoma; Vascular: Uninvolved by invasive carcinoma; Parenchymal: Uninvolved by invasive carcinoma; Pleural pleura: Not applicable; Chest wall: Not applicable; Other attached tissue margin: Not applicable; If all margins uninvolved by invasive carcinoma: Distance of invasive carcinoma from closest margin: less than 1mm; Specify margin: visceral pleura; Treatment effect: Not applicable; Lymph-vascular invasion: Not identified; Pathologic staging (pT): TNM Descriptors: none; Primary tumor: pT; Regional lymph nodes: pN0; Number examined: 14; Distant metastasis: pM0; Additional pathologic findings: Emphysematous changes in uninvolved lung parenchyma.

C. Lymph nodes, #9 inferior pulmonary, excision: Two benign lymph nodes.

D. Lymph nodes, lower paratracheal, excision: Four benign lymph nodes.

The examination of this case material and the preparation of this report were performed by the staff pathologist.

Electronically Signed: [Redacted]

Signing Location: [Redacted]

Gross Description: Received are three specimen containers, each labeled with the patient's name.

(b) TCGA-73-4668

TCGA-91-6835

Final Pathologic Diagnosis:

A. Lymph node, 4R subcarinal, resection: Eight benign lymph nodes.

B. LUNG, Resection: Specimen: Right Lung-Lower lobe of lung; Procedure: lobectomy; Specimen laterality: Right; Tumor site: Right lower lobe; Specimen integrity: Intact; Tumor size (greatest dimension): 2.4x 2.4cm; Tumor focality: Unifocal; Tumor histologic type: Adenocarcinoma; Tumor grade: Moderately differentiated; Visceral pleura invasion: Present; Tumor Extension: Not identified; Margins: Bronchial: Uninvolved by invasive carcinoma; Vascular: Uninvolved by invasive carcinoma; Parenchymal: Uninvolved by invasive carcinoma; Pleural pleura: Not applicable; Chest wall: Not applicable; Other attached tissue margin: Not applicable; If all margins uninvolved by invasive carcinoma: Distance of invasive carcinoma from closest margin: less than 1mm; Specify margin: visceral pleura; Treatment effect: Not applicable; Lymph-vascular invasion: Not identified; Pathologic staging (pT): TNM Descriptors: none; Primary tumor: pT; Regional lymph nodes: pN0; Number examined: 14; Distant metastasis: pM0; Additional pathologic findings: Emphysematous changes in uninvolved lung parenchyma.

C. Lymph nodes, #9 inferior pulmonary, excision: Two benign lymph nodes.

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The examination of this case material and the preparation of this report were performed by the staff pathologist.

Electronically Signed: [Redacted]

Signing Location: [Redacted]

Gross Description: Received are three specimen containers, each labeled with the patient's name.

(c) TCGA-91-6835

Figure 4. Pathology report examples. We randomly sample several pathology reports with different reporting standards for display. Sensitive information has been masked.

ID	Fine-Grained Text Description Label
TCGA-64-1678	Differentiation of the lesion is poorly differentiated; Unknown; No indication of vascular invasion by the lesion; No indication of pleural invasion by the lesion, as no visceral pleural invasion is seen; Unknown; Margins of the excised tissue are clear of disease (R0).
TCGA-73-4668	Lesion differentiation is moderately differentiated; Unknown; No indication of vascular invasion by the lesion, as angiolymphatic invasion is absent; No indication of pleural invasion by the lesion, as visceral pleural involvement is absent; Unknown; Margins of the excised tissue are clear of disease, as the bronchial margins are uninvolved.
TCGA-91-6835	Lesion differentiation is moderately differentiated; Unknown; No indication of vascular invasion by the lesion, as vascular margins are uninvolved by invasive carcinoma; Pleural invasion by the lesion is present; Unknown; Margins of the excised tissue are clear of disease, as all margins are uninvolved by invasive carcinoma.

Table 6. Fine-grained text description labels extracted from raw pathology reports.

structures with a central clear space, resembling small grape-like formations when observed under a microscope.

### C. Prompts Used for Text Standardization via GPT-4

We present the prompt template employed for GPT-4 to extract information from the raw pathology report, wherein the placeholder tag **REPORT** is substituted with each distinct raw pathology report. Additionally, besides providing essential prompt information, we have manually annotated some assistant examples to assist GPT-4 in further standardizing the output data format.

### C.1. Prompt Template

Based on the diagnose report provided, please summarize the report briefly and academically from the following perspectives as a medical professional, answer in phrases or medical vocabulary entity whenever possible to save words, don't leave out important information. Connect the answers in one sequence, separated them with semicolons (important). Important notes: For all perspectives, focus on the microscopic description rather than gross description; Ignore the lymph nodes information; If can't answer from the specific perspective, just answer "Unknown." without another words!!! 1. What is the differentiation of the lesion? (maybe: Well-differentiated; Moderately differentiated; Poorly differentiated; Moderately to poorly differentiated; Mixed differentiation. or others.) 2. Is there any

indication of spread through air spaces around the lesion? and explain the reasons. 3. Is there any indication of vascular invasion by the lesion? and explain the reasons. 4. Is there any indication of pleural invasion by the lesion? and explain the reasons. 5. Is there any evidence of the lesion invading adjacent tissues or organs (excluding the current lung organ)? and explain the reasons. 6. Are the margins of the excised tissue clear of disease? (note that: R0 means negative; R1 R2 are both mean positive; Rx means Unknown, just answer 'Unknown' only.). Diagnose report: **REPORT**

### C.2. Assistant Example

**Raw Report Example 1:** Gross Description: Microscopic Description: Diagnosis Details: Comments: Formatted Path Reports: LUNG TISSUE CHECKLIST. Specimen type: Lobectomy. Tumor site: Lung. Tumor size: 6 x6x6cm. Histologic type: Squamous cell carcinoma. Histologic grade: Moderately differentiated. Tumor extent: Visceral pleura. Other tumor nodules: Not specified. Lymph nodes: 1/3 positive for metastasis (Intrathoracical 1/3). Lymphatic invasion: Not specified. Venous invasion: Not specified. Margins: Not specified. Evidence of neo-adjuvant treatment: Not specified. Additional pathologic findings: Not specified. Comments: Left-lower. to 11/8/12 l'es.

**Answer Example 1:** Moderately differentiated; Unknown; Unknown; Pleural invasion indicated due to tumor extent to visceral pleura; Unknown; Unknown.

**Raw Report Example 2:** REVISED REPORT (Revised information underlined). TISSUE DESCRIPTION: Tissue from the left kidney (partial nephrectomy, 3.76. grams, 2.2 X. 2.0 X 1.9 cm). . DIAGNOSIS: Kidney, left, partial nephrectomy: Grade 1 (of 4) renal. cell. carcinoma, papillary type, forms a 1.9 X 1.7 x 1.7 cm. mass. The tumor is confined to the kidney. Coagulative. tumor. necrosis is absent. Sarcomatoid differentiation is. absent. The. surgical margins are negative for tumor (free by 0.2 cm). AMENDMENTS. Revision Description: Review of permanent sections reveals the tumor to be a. grade 1 (of. 4) renal cell carcinoma, papillary type. Original Diagnosis. Kidney, left, partial nephrectomy: Grade 1 (of 4) renal. cell. carcinoma, clear cell type, forms a 1.9 X 1.7 X 1.7 cm. mass. The. tumor is confined to the kidney. Coagulative tumor. necrosis is. absent. Sarcomatoid differentiation is absent. The. surgical. margins are negative for tumor (free by 0.2 cm).

**Answer Example 2:** Lesion is grade 1 (of 4), indicating well-differentiated; Unknown; Unknown; Unknown; The lesion is confined to the kidney, indicating no invasion of adjacent tissues or organs; Margins of the excised tissue are clear of disease (free by 0.2 cm).

**Raw Report Example 3:** TISSUE DESCRIPTION: Right lower lobe lung (305 grams) superior (right upper and

lower. paratracheal) and inferior (subcarinal, inferior pulmonary ligament). mediastinal lymph nodes and N1 (right interlobar) lymph nodes. DIAGNOSIS: Lung, right lower lobe, lobectomy : Grade 3 (of 4) squamous cell. carcinoma forming a subpleural mass measuring 5 X 4.5 X 2.6 cm,. extending into but not through the pleura. Bronchial margin is. negative for tumor. Multiple (6) intrapulmonary peribronchial lymph. nodes are negative for tumor. Lymph nodes, superior and inferior mediastinal, N1, excision: Multiple superior (2 right lower and 2 right upper paratracheal) and. inferior (6 subcarinal, 1 inferior pulmonary ligament) mediastinal. lymph nodes and N1 (3 right interlobar) lymph nodes are negative for. tumor.

**Answer Example 3:** Lesion differentiation is poorly differentiated (G3 of 4); Unknown; Unknown; Pleural invasion by the lesion is present, as the carcinoma extends into but not through the pleura; Unknown; Margins of the excised tissue are clear of disease (R0).

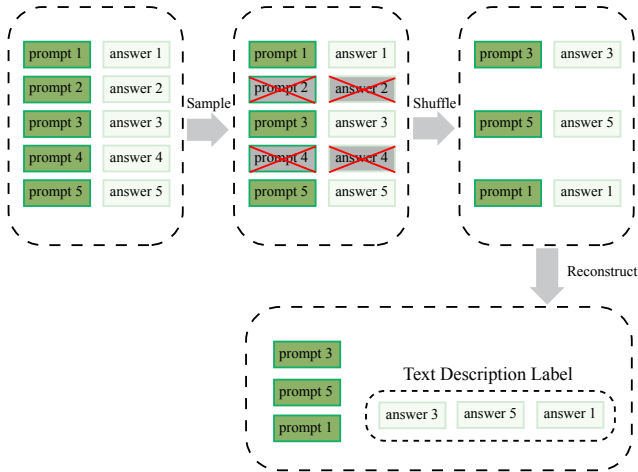


Figure 5. Fine-grained guidance construction pipeline.

### D. Fine-grained Guidance Construction Pipeline

As depicted in Fig. 5, we partition the original fine-grained text descriptions into several parts based on manually designed prompts. Next, we perform random sampling and remove “Unknown” tags from the answers. Afterward, we shuffle the retained pairs and reconstruct the answers into a unified and complete sequence.. This approach enables our model to undergo a wider range of description transformations, with changes in granularity providing diverse perspectives on the visual image. Aligning visual images with text descriptions of varying granularities enriches the training data, offering more descriptive perspectives and semantic information for visual patterns. This enhances the semantic richness of the model’s features and facilitates model transfer to downstream tasks.