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METHOD

From "Form" to "Essence": Guiding Students to Achieve Deep Cognitive Transition in Morphological Experiments

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Introduction: Within the basic medical education system, morphological experiment courses constitute the cornerstone for building students' medical cognitive framework. However, the traditional "see-and-memorize" teaching model readily traps students in the cognitive dilemma of "seeing the trees but not the forest.".

Methods: Based on years of teaching practice and reflection, this paper proposes a systematic teaching reform plan centered on the "Three-Tier Observation Method." This scheme aims, through progressive training in "macroscopic localization → microscopic identification → logical reasoning", to resolve the issue of passive student learning and guide them through a cognitive upgrade—from static morphological recognition to the interpretation of dynamic pathological processes. This article presents this approach as a descriptive educational innovation, detailing its theoretical rationale, operational procedures, and illustrative case analyses.

Results: This paper presents the "Three-Tier Observation Method" as a descriptive educational innovation. It details the method's theoretical rationale, operational procedures, and illustrative case analyses to demonstrate its potential to help students construct a solid bridge between basic medical science and clinical practice.

Discussion: We aim to provide educators with a practical and replicable teaching framework that fosters deeper cognitive integration, thereby contributing to the pedagogical toolkit for enhancing clinical reasoning skills in basic medical education.

Keywords: morphological experiments, teaching reform, three-tier observation method, pathological thinking, medical education

Introduction

Upon entering any medical school morphology laboratory, one can readily observe a series of characteristic scenes: students gather around microscopes, their hands adjusting the knobs while their eyes dart across the field of view. The air is often filled with murmurs—"Where is the hepatic lobule?" or "Has anyone found the glomerulus?" A triumphant "I found it!" draws glances of both admiration and anxiety from peers. Attention then shifts to meticulously reproducing the image on the slide, translating sight into a detailed laboratory drawing.

Throughout this exercise, students' cognitive energy is funneled almost entirely into searching and replicating. They become adept at "pattern matching," yet rarely progress to deeper inquiry about what they see. When asked, "Why is this hepatocyte swollen?" or "How does this change explain the patient's symptoms?" we are often met with puzzled looks or rehearsed textbook fragments. This points to a fundamental problem: for many students, critical thinking stops at the moment of "finding." Unwittingly, the morphology lab risks becoming a passive "visual treasure hunt"—a task that demands little beyond visual recognition.

The underlying causes of this pedagogical dilemma are multifaceted. Firstly, a fragmented knowledge structure is evident: students often perceive earlier courses such as Histology and Embryology as separate from subsequent disciplines like Pathology, rather than as a logical continuum that traces the transition from normal physiology to pathological abnormality.[1] For instance, while students may memorize the "classic" architecture of a normal hepatic lobule, they frequently fail to comprehend the

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dynamic process through which cirrhotic pseudolobules form and the destructive consequences this entails. Secondly, the inertia of examination-oriented education plays a significant role.[2] The heavy emphasis on image-based identification in examinations inadvertently reinforces a reductive mindset that equates "morphology with the correct answer." In this context, learners are conditioned to rapidly identify "exam points" rather than to understand the pathophysiological mechanisms underlying the morphological changes. Thirdly, traditional teaching methods remain predominantly unilateral. The conventional cycle of "demonstration by the instructor – image searching by students – drawing and reporting" lacks effective scaffolding to stimulate higher-order thinking.[3] Within this model, instructors often assume the role of "answer providers" rather than "facilitators of critical inquiry." Lastly, there exists a disconnect from clinical relevance.[4] Learning in the foundational stages often fails to be consistently and meaningfully linked to clinical problems. As a result, morphological knowledge remains abstract and decontextualized, losing the practical significance that justifies its essential role in medical education.

To break this impasse, we must fundamentally reframe the instructional objectives of morphological laboratory training. The core goal should no longer be limited to "enabling students to recognize specific morphological patterns," but should shift towards "cultivating their ability to reconstruct and reason through the story of a disease based on morphological evidence." This paradigm shift calls for a systematic approach to redirect students' observational focus—from isolated, static forms ("the shape") toward interconnected, dynamic processes ("the essence")—that is, the intrinsic logic and underlying mechanisms of disease pathogenesis and progression. To achieve this, we have proposed and implemented a reformed pedagogical pathway centered on the "Three-Tiered Observational Approach."[5]

Theoretical Framework: Construction and Explanation of the "Three-Tier Observation Method"

The "Three-Tier Observation Method" is a progressive thinking training framework that deconstructs a complete morphological observation into three interconnected, deepening tiers.

Tier 1: Macroscopic Localization – Cultivating the "Architect's" Holistic View

In the practice of histopathological examination, microscopic structures must be interpreted within their macroscopic organ context, as isolated observation without reference to the whole may lead to fragmented and misleading interpretations. Thus, prior to placing a tissue section under the microscope, it is essential to perform a thorough gross inspection of the slide. This includes assessing staining uniformity and identifying any abnormal discolorations—such as the dark red of hemorrhage, gray-yellow of necrosis, or pallor indicative of fatty tissue. Additionally, the observer should determine whether fundamental organ architectures, like the renal cortex and medulla or the cortical and medullary regions of a lymph node, are distinguishable and evaluate the clarity of structural layering. Any raised or depressed lesions should be noted, with attention to their size, shape, distribution, and demarcation from adjacent tissue. To cultivate this integrative approach, guiding questions may be posed—for instance, "What might account for the diffuse dark brown pigmentation of this lung tissue, and what underlying etiology, such as anthracosis related to smoking or environmental exposure, could be inferred?" or "Why does the liver specimen exhibit a loss of normal gloss and a nodular surface, and what does this suggest about underlying fibrotic change and structural remodeling?" The overarching pedagogical objective is to instill a "see the forest before the trees" mindset, enabling trainees to achieve preliminary lesion localization and characterization at the macroscopic level before proceeding to high-power microscopic analysis.[6]

Tier 2: Microscopic Identification – Training the "Detective's" Evidence-Gathering Skills

Foundational Principle: From Recognition to Discernment

The microscopic examination represents a pivotal phase for evidence gathering at the cellular level, analogous to analyzing a "crime scene." This stage requires a fundamental shift in observation strategy—moving beyond merely identifying structures ("finding something") to actively detecting significant pathological deviations ("seeing what is different"). This transition entails advancing from basic recognition to systematic, precise description and comparison, thereby establishing a objective basis for morphological diagnosis.

Standardized Operational Workflow

A rigorous, stepwise protocol is essential for effective microscopic evaluation. This begins with strict adherence to an observation sequence from low-power (4×, 10×) to high-power (40×) magnification, where low power provides architectural overview and navigational context, while high power permits detailed cytological assessment.[7] Furthermore, observations must be articulated through comparative description using precise morphological terminology. Key analytical dimensions include: architectural integrity (eg, disorganization of tissue arrangement, loss of cellular polarity); quantitative alterations (eg, increase or decrease in specific cell types); cellular and nuclear features (eg, variations in cell volume, nuclear size and shape, presence of atypia); and changes in staining properties (eg, enhanced cytoplasmic eosinophilia, stromal pallor).[8]

Guided Analytical Reasoning and Pedagogical Objective

To cultivate this analytical approach, instruction should incorporate targeted, comparative questions that bridge observation and interpretation. For instance, "Compared to the adjacent normal glomerulus, is this one enlarged or shrunken, and is cellularity increased or decreased?" guides the observer toward identifying proliferative or sclerotic changes relevant to glomerulonephritis. Similarly, "What do these round vacuoles in the hepatocyte cytoplasm represent, what cellular structures are they displacing, and what functional implications might this imply?" directs reasoning toward the structural and functional consequences of fatty change. The overarching pedagogical goal is to instill objective and precise observational skills, enabling students to systematically accumulate robust morphological evidence—much like a detective gathering physical clues—which forms a reliable foundation for subsequent pathological reasoning and diagnostic formulation.[9,10]

Tier 3: Logical Reasoning – Achieving the "Judge's" Comprehensive Adjudication

Core Concept: Integrating Morphological Evidence Into Dynamic Disease Pathways

The essence of this advanced training lies in synthesizing previously acquired "location information" and "morphological evidence" within the dynamic continuum of disease progression. This tier focuses on uncovering the intrinsic causal relationships that connect structural alterations to functional deficits and clinical manifestations, thereby translating static microscopic observations into a coherent pathophysiological narrative.

Operational Framework for Pathological Reasoning

A systematic approach is required to construct meaningful diagnostic linkages. For each key morphological change, the observer should pursue causal explanation by asking "Why did this occur?" and infer significance by addressing "So what are the functional consequences?" This process necessitates active integration of foundational knowledge from disciplines such as Biochemistry, Physiology, and Immunology. Subsequently, logical extrapolation should be made from the pathological process to potential clinical correlates—including symptoms, signs, and laboratory abnormalities. The overall reasoning model thus forms a complete diagnostic loop: "Morphological change → Functional impairment → Underlying pathological process → Clinical manifestation."[11]

Educational Objective: Cultivating Dynamic Diagnostic Mindset

The ultimate teaching goal is to empower students to transcend static morphological snapshots and mentally simulate disease processes as dynamic, evolving entities. By truly understanding morphology as the "language" of disease, learners acquire the ability to not only interpret microscopic findings within their functional and clinical context but also to develop preliminary diagnostic reasoning and clinically predictive capabilities.

Teaching in Action: In-Depth Analysis of Classic Cases Using the Three-Tier Method

The following two classic pathological changes illustrate the application of the "Three-Tier Observation Method."

Portal Cirrhosis (Pseudolobule Formation)

Macroscopic Evaluation: Architectural Remodeling of the Liver

Gross examination reveals a reduction in liver volume with firm consistency. The surface and cut sections exhibit diffuse, relatively uniform nodules measuring 0.1–0.5 cm in diameter, surrounded by prominent gray-white fibrous tissue. This

nodular transformation signifies the destruction of the normal hepatic lobular architecture and its replacement by regenerative nodules encircled by fibrous septa—a morphological hallmark of advanced chronic liver disease.[12]

Microscopic Analysis: Histopathological Reorganization

At low magnification, the normal lobular architecture is entirely effaced and replaced by regenerative pseudolobules—isolated hepatocyte nodules demarcated by broad fibrous septa. High-power examination demonstrates disorganized hepatic cords with loss of radial orientation toward central veins, which are either absent, displaced, or multiplied. Hepatocytes display degenerative changes including swelling, fatty metamorphosis, and focal necrosis. Within the fibrous septa, proliferated collagen fibers, bile ductule proliferation, and chronic inflammatory cell infiltration are evident. These features collectively reflect the core pathological process: excessive extracellular matrix deposition driven by activated hepatic stellate cells in response to recurrent parenchymal injury and persistent inflammatory stimulation.[13,14]

Pathophysiological Integration: From Structural Alterations to Clinical Sequelae

The widespread collagen deposition represents scar tissue formation resulting from repeated cycles of hepatic injury and repair. Fibrous septa function as internal barriers, compressing and distorting the vascular and biliary networks. Portal vein compression leads to impaired portal blood flow and portal hypertension, manifesting as splenomegaly, portosystemic collaterals, and ascites. Hepatic venous outflow obstruction exacerbates intrahepatic congestion, while bile ductule compression disrupts biliary excretion, potentially leading to jaundice. Simultaneously, hepatocyte isolation within fibrotic compartments impairs metabolic exchange, synthetic function, and detoxification capacity. These alterations culminate in hepatic insufficiency, evidenced by hypoalbuminemia, coagulopathy, hormonal dysregulation, and jaundice. Thus, each pseudolobule embodies the morphological endpoint of cirrhotic transformation, linking recurrent injury, fibrogenesis, and multiorgan dysfunction into a coherent pathophysiological narrative that informs both diagnostic assessment and therapeutic intervention.[15,16]

Atherosclerosis (Aortic Atheromatous Plaque)

Macroscopic Evaluation: Structural Alterations of the Aortic Intima

Gross examination of the aortic intima reveals multiple scattered yellow streaks and raised gray-white plaques with firm consistency. The cut surface demonstrates a characteristic architecture: a firm white fibrous cap overlying a soft, yellow, gruel-like core. These elevated lesions represent a fundamental deviation from the normal thin, smooth intimal surface, indicating accumulation of lipids and fibrous tissue within the vessel wall—the hallmark of advanced atherosclerosis.[17]

Microscopic Analysis: Histopathological Composition

At low magnification, lesions are predominantly localized to the intima, exhibiting focal thickening and luminal protrusion. The plaque architecture consists of a superficial fibrous cap overlying a deep necrotic core containing amorphous debris, cholesterol clefts (needle-shaped voids), and lipid-laden foam cells, accompanied by inflammatory infiltrates. High-power examination reveals foam cells with cytoplasm distended by lipid vacuoles, characteristic cholesterol clefts within the necrotic core, and the cellular components of the fibrous cap. These features reflect the essential pathological elements: extracellular lipid deposition, necrotic debris, and chronic inflammatory response, originating primarily from infiltrated blood-derived low density lipoprotein (LDL) that has been internalized by monocyte-derived macrophages and smooth muscle cells.[18,19]

Pathophysiological Integration: From Plaque Formation to Clinical Sequelae

Atherosclerosis represents a chronic inflammatory and proliferative process initiated by endothelial dysfunction, permitting subendothelial LDL accumulation. Monocyte recruitment and differentiation into macrophage-derived foam cells form the early fatty streak. Subsequent smooth muscle cell migration, proliferation, and collagen deposition stabilize the lesion through fibrous cap formation. Progressive lipid accumulation and necrotic core expansion drive plaque growth. Clinically, lumen stenosis causes chronic ischemia (eg, angina, claudication), while plaque instability—characterized by fibrous cap thinning from inflammatory enzyme activity—predisposes to rupture. Thrombus formation upon exposure of the thrombogenic lipid core leads to acute vascular occlusion (myocardial or cerebral infarction) or distal embolism.

Concurrently, medial destruction by advanced plaques predisposes to aneurysm formation and potential rupture. Therefore, plaque vulnerability—determined by cap thickness, lipid burden, and inflammation—rather than stenosis severity alone, dictates acute risk. This pathophysiological continuum underscores therapeutic strategies targeting both lipid reduction and plaque stabilization to prevent catastrophic clinical events.[20]

Evaluation Reform

To enhance the educational outcomes in pathology training and to directly measure the cognitive skills targeted by the Three-Tier Observation Method, a comprehensive restructuring of the assessment framework has been implemented. While a full quantitative study of the method's long-term impact on clinical reasoning remains an important avenue for future research, the following modifications have been introduced to align assessment with our pedagogical objectives and to provide formative and summative evaluation of the targeted skills. Formative assessment now constitutes a significant portion of the evaluation, emphasizing continuous skill development and clinical reasoning. It incorporates class participation and responsiveness to questioning (10%), rigorous evaluation of structured "Lesion Detective" worksheets (30%), and performance in CBL group presentations (20%). This multi-faceted approach ensures ongoing feedback and reinforces analytical habits throughout the course. Concurrently, summative assessment has been reformed to align with higher-order cognitive objectives. In final examinations, the proportion of questions requiring pure image identification has been substantially reduced. These have been replaced by more intellectually demanding formats, such as "Image Description & Interpretation"—where students are presented with a pathological slide and must describe salient morphological features and explain their clinical relevance—and comprehensive case analysis questions. In the latter, students are provided with a clinical scenario and corresponding microscopic images, and are required to establish a diagnosis while articulating a complete logical chain that connects morphological evidence to pathophysiological mechanisms and eventual clinical manifestations.

Discussion and Conclusion: Becoming the "Navigator" of Student Thinking

Fundamental Shift in Teacher Role

Implementing the "Three-Tier Observation Method" necessitates a profound shift in the teacher's role: from a "disseminator" of knowledge and "direction-giver" at the microscope, to a "navigator" of student thinking and a "designer" of learning. The core task is no longer telling students "where the answer is," but guiding them to explore "the path to the answer" through carefully designed question chains, cases, and activities. This demands broader knowledge integration skills (bridging basic and clinical sciences), stronger classroom facilitation techniques, and more creative instructional design capabilities from teachers.

Impact on Student Cognitive Processes

The implementation of the Three-Tier Observation Method fundamentally reshapes the student's cognitive journey in the laboratory. Instead of being confined to visual search and rote recall, students are guided through a structured progression. They first establish a holistic context through Macroscopic Localization, then cultivate meticulous Microscopic Identification skills akin to gathering forensic evidence, and finally engage in synthetic Logical Reasoning to construct a coherent disease narrative. This scaffolded process actively promotes the development of "pathological thinking"—the ability to interpret static morphological findings within the dynamic continuum of a disease process.

To preliminarily evaluate the cognitive impact of this method, we analyzed assessment data from two consecutive academic years (2023–2024, n=128; 2024–2025, n=132). Following implementation, students'performance on comprehensive case-analysis questions—which require integrating morphological evidence with pathophysiological reasoning—showed marked improvement. The mean score increased from 75.5% (SD=10.3) to 81.9% (SD=9.8), representing a statistically significant gain ($p<0.01$, independent *t*-test). Notably, the proportion of students achieving high-level reasoning scores (defined as ≥90%) rose from 18% to 34%. Concurrently, the average score on traditional image-identification items remained stable (82.4% vs 83.1%, $p=0.42$), indicating that foundational recognition skills were maintained while higher-order analytical abilities were enhanced.

Challenges and Responses

Challenge 1

Time Constraints. Deep thinking training requires more time. Response: Fully utilize online resources for pre-class preparation, front-loading knowledge transfer, reserving class time for high-order thinking training and discussion.

Challenge 2

Student Inertia. Some students are accustomed to passive reception and find active thinking daunting. Response: Use engaging "detective" scenarios, group collaboration, and timely positive feedback to gradually stimulate the joy and sense of achievement derived from thinking.

Challenge 3

Teacher Capacity. Not all teachers naturally possess facilitative teaching skills. Response: Organize teaching workshops, collaborative lesson planning, share excellent teaching cases and question designs, promoting the teaching team's collective growth.

Conclusion

The ultimate goal of morphological experiment courses is not to train skilled "microscope operators" or "atlas copiers," but to cultivate medical talents who can see the essence through the phenomenon, possessing scientific thinking, clinical potential, and humanistic care. The "Three-Tier Observation Method" provides a systematic, operable framework to help students break down disciplinary barriers, weaving isolated morphological knowledge points into a cognitive network for understanding disease and serving clinical practice.

The Three-Tier Observation Method proposed in this study aims to address a cognitive gap in current morphological experiment teaching that has not yet received sufficient attention. Although problem-based learning (PBL) and case-based learning (CBL) have proven effective in promoting clinical problem-solving and knowledge integration, their application in the specific skill-training context of microscopic morphological observation is often indirect.[21–23] These approaches emphasize macro-level clinical decision-making rather than the cognitive restructuring of the observation process itself. On the other hand, traditional "image recognition and memorization" drills can quickly enhance pattern recognition but tend to keep students at the level of "what it is," making it difficult for them to spontaneously advance to the reasoning stages of "why" and "what it means".

The Three-Tier Observation Method is precisely designed to bridge this gap. It does not seek to replace PBL or CBL but rather provides a structured, observation-centric cognitive scaffold embedded within the routine laboratory workflow. It directly intervenes in every step of students' microscope use, systematically training them to transition from passive morphological identifiers into active "evidence gatherers" and "pathological process reasoners." Therefore, this method can be regarded as a dedicated bridge connecting traditional skill training with higher-order clinical reasoning, offering a concrete and actionable pathway to achieve the cognitive leap from morphological "form" to pathological "essence" within integrated curricula.When our future students, standing in clinical roles, can discern the patient's overall picture from a pathology report and understand the pathological basis behind treatment strategies, they will appreciate that cognitive baptism from "form" to "essence" experienced long ago in the laboratory. The pointer in our hands should aim not merely at a structure under the microscope, but at the essential path in the depths of student thinking leading to the medical. Let us work together to make every morphological experiment session an engaging "disease story session," allowing every silent slide to resonate rationally within students' minds.

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Disclosure

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