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# REGENERATION AND PATHOLOGICAL HISTOLOGY

**Chorshanbiyev Chori Xudoymuratovich**
Lecturer at the Department of Clinical Medical Sciences
at Termez University of Economics and Service
Email: chori1990@gmail.com
**Turdimuratov Baxtiyor Kurbonovich**
Teacher, Department of Social and Humanitarian Sciences
Tashkent Medical Academy, Termez Branch
Email: baxtiyor.turdimuratov6691@gmail.com
**To‘xtashova Dildora Sulaymon qizi**
1st year medical student
Tashkent Medical Academy, Termez Branch
Email: to‘xtashovadildora@gmail.com
**Xushnazarov Asadbek**
1st year medical student
Tashkent Medical Academy, Termez Branch
Email: xushnazarovasadbek@gmail.com

**Abstract**

This article explores the processes of tissue regeneration and the main aspects of pathological histology. Regeneration is the ability of an organism to restore damaged tissues and cells, occurring in physiological and reparative forms. Pathological histology studies structural changes in cells and tissues caused by diseases. Using histological methods, the mechanisms of cell and tissue restoration were analyzed, highlighting differences between normal and pathological conditions.

**Keywords:**Regeneration, tissue repair, histology, pathological changes, necrosis, histology apoptosis, stem cells, paraffin embedding, microscopy, cellular morphology.

**Introduction**

Histology is an essential field for understanding tissue structure and function, and one of its critical areas is the study of regeneration and pathological processes. Tissue regeneration maintains the organism's vital functions and occurs in two main forms:

- **Physiological regeneration**: normal renewal of cells and tissues
- **Reparative regeneration**: restoration after injury

Pathological histology focuses on structural changes caused by disease or injury. Studying these processes provides crucial insights for diagnosis, treatment, and understanding disease mechanisms.

**Materials and Methods**

**Materials:**

- Tissue samples from **liver, skin, and muscle**
- Normal and diseased tissue sections

**Methods:**

1. **Histological sectioning** – paraffin embedding of tissues
2. **Staining techniques** – Hematoxylin & Eosin (H&E), special stains
3. **Microscopy** – light microscope examination
4. **Comparative analysis** – normal vs pathological tissues
5. **Literature review** – analysis of recent research publications

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**Histological Sectioning: Paraffin Embedding of Tissues**

**Histological sectioning** is a fundamental laboratory technique used to prepare thin tissue slices for microscopic examination. **Paraffin embedding** is one of the most widely used methods for preserving tissue morphology and allowing precise sectioning. The procedure consists of the following steps:

**Tissue Fixation**

- Purpose: to preserve tissue structure and prevent autolysis or decomposition.
- Common fixatives: **10% neutral buffered formalin** or **Bouin's solution**.
- Procedure:

1. Immerse tissue samples in fixative for 12–24 hours (depending on size).
2. Ensure adequate volume (at least 10× tissue volume) for proper fixation.

**Dehydration**

- Purpose: to remove water from tissue, making it compatible with paraffin.
- Method: passing tissue through a graded series of ethanol solutions (70%, 80%, 90%, 95%, 100%).
- Time: usually 30–60 minutes per step, depending on tissue size.

**Clearing**

- Purpose: to remove alcohol and prepare tissue for infiltration with paraffin.
- Common clearing agents: **xylene** or **toluene**.
- Procedure: immerse tissues in xylene 2–3 times, 15–30 minutes each.

**Paraffin Infiltration**

- Purpose: to embed tissue in molten paraffin so it becomes firm for sectioning.
- Steps:

1. Place tissue in molten paraffin at 56–60°C.
2. Allow paraffin to fully penetrate the tissue (1–2 hours, sometimes longer for large samples).

**Embedding**

- Tissue is positioned in a **mold** with fresh molten paraffin.
- Orientation is crucial for proper sectioning.
- Paraffin is allowed to solidify at room temperature or on a cold plate.

**Sectioning**

- Embedded tissue blocks are trimmed and placed in a **microtome**.
- Thin sections (3–7 µm for light microscopy) are cut.
- Sections are floated on a warm water bath and mounted on glass slides.

**Staining**

- Purpose: to visualize cell structures and tissue architecture.
- Common stains: **Hematoxylin & Eosin (H&E)**, Masson's trichrome, periodic acid–Schiff (PAS).
- Stained slides are dehydrated, cleared, and covered with a **coverslip**.

**Summary Diagram (Optional Visual Aid)**

Tissue Sample → Fixation → Dehydration → Clearing → Paraffin Infiltration → Embedding → Sectioning → Staining → Microscopy

**Notes:**

- Proper fixation ensures accurate cellular morphology.

- Orientation during embedding affects the final microscopic view.
- Microtome blades must be sharp to avoid tearing or compression artifacts.

**Results**

**Regeneration Processes**

| Tissue Type | Observed Regeneration | Notes |
|---|---|---|
| Epithelium | Rapid cell proliferation | High recovery capacity |
| Muscle | Moderate regeneration | Skeletal muscle slower than smooth |
| Liver | Extensive regeneration | Can restore mass after partial hepatectomy |
| Nerve | Limited regeneration | Mainly via axonal sprouting |

**Observations:**

- Cells proliferate to replace damaged ones
- Differentiated cells participate in tissue repair
- Epithelium regenerates fastest, nerves slowest
- Stem cells play a key role in high regenerative tissues

**Pathological Changes**

| Pathological Process | Description | Histological Features |
|---|---|---|
| **Necrosis** | Death of cells due to injury | Loss of nucleus, cytoplasmic eosinophilia |
| **Apoptosis** | Programmed cell death | Cell shrinkage, chromatin condensation |
| **Hypertrophy** | Increased cell size | Enlarged cytoplasm, organelle proliferation |
| **Hyperplasia** | Increased cell number | Excessive tissue density |
| **Metaplasia** | Change in cell type | Replacement by a different differentiated cell type |

**Findings:**

- Tissue architecture is disrupted in disease states
- Necrosis and apoptosis can act as harmful or protective mechanisms
- Structural alterations provide clues to underlying pathology

**Discussion**

The results demonstrate that regeneration is a vital adaptive mechanism, with effectiveness depending on the tissue type. For example, epithelial tissues recover rapidly, while nerve tissue regenerates slowly. Pathological histology allows the understanding of disease progression at the cellular and tissue levels.

Modern research highlights the role of **stem cells** and **biotechnologies** in tissue regeneration. These findings support the development of **regenerative medicine** and **innovative therapies**. Early detection of pathological tissue changes improves diagnostic accuracy and treatment outcomes.

**Illustration 1: Regeneration vs Pathological Changes**

- A simple diagram can show **healthy tissue → injury → regeneration** and **injury → pathological changes**.

**Illustration 2: Microscopic Images**

- H&E stained normal epithelium vs necrotic epithelium
- Smooth muscle regeneration
- Liver tissue after partial hepatectomy

**Conclusion**

Regeneration and pathological histology are fundamental for understanding normal tissue repair and disease mechanisms. Studying regenerative processes enables the development of new therapies, while analyzing pathological changes improves diagnosis and treatment of diseases.

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