The Pap Test
The Pap Test

Richard Mac DeMay, MD
Professor of Pathology
Director of Cytology
University of Chicago

ASCP Press
American Society for Clinical Pathology
Chicago
Publishing Team

Jeffrey Carlson (senior designer)
Erik Tanck (production manager/designer)
Joshua Weikersheimer (publisher)
Adam Fanucci and Temi Horning (production)
Table of Contents

Introduction ............................................. 1

Historical Perspective ................................. 2

Anatomy and Embryology of the Female Genital Tract ... 8

I. Cytology of the Squamous Epithelium .............. 11

A Simplifying Synopsis of Pap Test Interpretation .......... 12

Introduction to Interpretation ........................ 12

Two Basic Concepts: Squamous Differentiation & Carcinogenesis . 13

Squamous Differentiation ............................. 14

The Cells .............................................. 14

Basal Cells ............................................ 14

Parabasal Cells ........................................ 16

Intermediate Cells ..................................... 17

Superficial cells ....................................... 17

Hormonal Cytology .................................. 18

Parabasal Predominant Maturation Index (Atrophy) ......... 19

Intermediate Predominant Maturation Index ............... 20

Superficial Predominant Maturation Index ................ 21

Summary of Changes During Menstrual Cycle, Menopause, Pregnancy ... 22

Barr Bodies .......................................... 23

Carcinogenesis ....................................... 23

Benign Proliferative Reactions .......................... 24

Metaplastic Reactions .................................. 24

Keratotic Reactions .................................... 27

Summary of Benign Proliferative Reactions ................ 28

Dysplasia and Carcinoma In Situ (CIN, SIL) .............. 28

Morphogenesis ........................................ 30

Morphology of Dysplasia and Carcinoma In Situ .......... 30

Dysplasia ............................................. 31

Carcinoma In Situ ..................................... 32

Metaplastic and Keratinizing Lesions ..................... 32

Metaplastic Lesions .................................... 33

Keratinizing Lesions ................................... 36

Microinvasive Squamous Cell Carcinoma .................. 37

Clinical Features ..................................... 38

Histology ............................................. 38

Cytology .............................................. 39

Differential ........................................... 40

Biology ................................................ 41

Therapy ............................................... 41

Squamous Cell Carcinoma .............................. 41

Cytology ............................................. 42

Small Cell Squamous Carcinoma .......................... 44

Nonkeratinizing Squamous Cell Carcinoma ................. 44

Keratinizing Squamous Cell Carcinoma .................. 45

Rare Variants of Squamous Cell Carcinoma ................. 47

Verrucous (Squamous Cell) Carcinoma ................... 47

Warty (Condylomatous) Carcinoma ....................... 47

Papillary Squamous Cell Carcinoma ....................... 47

 Transitional Cell (Urothelial) Carcinoma ................. 47

Lymphoepithelioma-like Squamous aplas Cell Carcinoma .. 48

Spindle Squamous Cell Carcinoma ....................... 48

Condylomata Acuminata (Genital Warts) .................. 49

Condyloma in the Pap Test ................................ 49

Koilocytes ............................................. 49

Dyskeratocytes ........................................ 50

Macrocyes ............................................. 50

Minor Cytologic Criteria for Condyloma ................... 50

Atypical Immature Metaplasia ........................... 52

Differential of Condyloma ............................... 52

Condyloma Redux ...................................... 52

A Final (?) Word on Nomenclature ........................ 53

Histology and Cytology: Yin and Yang .................... 55

Definitions ............................................ 55

Carcinoma In Situ ..................................... 55

Dysplasia ............................................. 55

Justification Sola Fide .................................. 55

Histology ............................................. 55

Cytology .............................................. 56

Cellularity, Nucleus, Cytoplasm, and N/C Ratio .......... 56

The Secret of Dysplasia Revealed ......................... 58

The Secret of Carcinoma In Situ Revealed ................. 58

Histo-Cyto Correlations ................................ 59

Atypical Squamous Cells ................................ 59

Minimal Dysplasia: Squamous Atypia & Atypical Squamous Metaplasia .............................................. 59

Squamous Atypia ....................................... 59

Atypical Squamous Metaplasia ........................... 60

Significance of Minimal Dysplasia ......................... 60

Atypical Squamous Cells: Undetermined Significance & Cannot Exclude H SIL .............................. 61

Atypical Squamous Cells-Undetermined Significance (ASC-US) ............... 61

ASC–Cannot Exclude High-Grade Squamous Intraepithelial Lesion (ASC–H) 62

Included in ASC ........................................ 62

Not Included in ASC .................................... 63
# Cervical Adenocarcinoma
- **Introduction**: 124
- **Histology of Cervical Adenocarcinoma**: 126
- **Cytology of Cervical Adenocarcinoma**: 126
  - Differential: Endocervical vs Endometrial Adenocarcinoma: 129
- **Variants of Cervical Adenocarcinoma**: 130
  - Villoglandular Adenocarcinoma: 131
  - Minimal Deviation Adenocarcinoma ("Adenoma Malignum"): 131
  - Intestinal-type Adenocarcinoma: 132
  - Endometrioid Cervical Adenocarcinoma: 133
  - Clear Cell Carcinoma: 133
  - Serous Adenocarcinoma: 133
  - Meseonephric Adenocarcinoma: 133
  - Adenosquamous Carcinoma: 134
  - Glassy Cell Carcinoma: 134
  - Adenocystic Carcinoma: 134
  - Adenoid Basal Cell Carcinoma: 135
  - Adenosquamous Carcinoma: 135
  - Glassy Cell Carcinoma: 134
  - Adenocystic Carcinoma: 134
  - Adenoid Basal Cell Carcinoma: 135

# Early Endocervical Glandular Neoplasia
- **Cervical Adenocarcinoma In Situ**: 135
- **Histology of Adenocarcinoma In Situ**: 137
- **Cytology of Adenocarcinoma In Situ**: 137
- **Variants of Adenocarcinoma In Situ**: 138
- **Differential of Adenocarcinoma In Situ**: 140
- **Endocervical Glandular Dysplasia**: 140
  - Morphologic Criteria for Endocervical Glandular Dysplasia: 141
- **Microinvasive Cervical Adenocarcinoma**: 143
- **Differential of Early Endocervical Glandular Neoplasia**: 143

# Atypical Glandular Cells
- **Differential of Atypical Glandular Cells**: 146
  - High Endocervical Cells: 147
  - Reactive Endocervical Cells: 147
  - Endocervical Brush Artifact: 148
  - Endocervical Repair: 148
  - Endocervical Polyps: 148
  - Directly Sampled Endometrium: 148
  - Endometriosis: 148
  - Lower Uterine Segment: 148
  - Cone Biopsy Artifact: 150
  - Tubal Metaplasia: 150
  - Microglandular Endocervical Hyperplasia: 152
  - Intrauterine Contraceptive Device Effect: 152
  - Postpartum Atypia: 152
  - Arias-Stella Reaction: 152
  - Squamous Carcinoma In Situ: 152
  - Invasive Squamous Cell Carcinoma: 152
  - Neoplastic Endocervical Cells: 152
  - Metastatic Adenocarcinoma: 152
  - Other Conondromas: 152

# III. Cytology of Iatrogenic Conditions

## Radiation Cytology
- **Radiation Effect**: 156
  - Acute Radiation Change: 157
  - Chronic Radiation Change: 158
- **Residual Carcinoma**: 158
  - Persistent vs Recurrent Carcinoma: 159
- **Postradiation Dysplasia**: 160

## Chemotherapy Cytology
- **Immunosuppressive Drugs**: 160

## Surgery, Electrodiathermy, Laser, and Cryotherapy
- **Hormone Therapy-Related Cytology**: 161
  - Diethylstilbestrol: 161
    - Vaginal Adenosis: 161
  - Hormone Replacement Therapy: 162
  - Oral Contraceptives: 162
  - Long-Acting Hormonal Contraception: 162
  - Megace®: 162
  - Tamoxifen: 162
- **Intrauterine Contraceptive Device (IUD) Changes**: 163

# IV. Cytology of Pregnancy

## Hormonal Cytology of Pregnancy
- **The Cells of Pregnancy**: 166
  - Arias-Stella Reaction: 166
  - Decidual Cells: 167
  - Trophoblasts: 168
  - Cytotrophoblasts: 168
  - Syncytiotrophoblasts: 168
  - Cocklebur: Pseudoactinomycotic Radiate Granules: 168

## Cervical Neoplasia During Pregnancy
- **Miscellaneous Pregnancy Findings**: 170
  - Puerperal Endometritis: 170
  - Vitamin Deficiency in Pregnancy: 170
  - Cells of Fetal Origin: 170
    - Fetal Squamous Cells: 170
    - Fetal Erythrocytes: 170
V. Cytology of the Rare and Sundry . . . . 171

Non-Neoplastic Conditions ............... 172
Vitamin Deficiency Cytology ................ 172
Pemphigus Vulgaris ......................... 172
Malakoplakia ................................ 172

Neoplastic Conditions ....................... 173
Neuroendocrine Carcinomas ................ 173
Small Cell Neuroendocrine Carcinoma .... 173
Other Neuroendocrine Tumors .............. 174
Mesenchymal Tumors ....................... 175
General Cytologic Features of Sarcomas  .. 175
Leiomyoma and Leiomyosarcoma .......... 175
Endometrial Stromal Sarcoma ............. 176
Rhabdomyosarcoma ......................... 177
Primitive Neuroectodermal Tumor ......... 177
Other Sarcomas ................................ 177
Mixed Mullerian Tumors .................... 177
Carcinosarcoma (Malignant Mixed Mullerian Tumor) 177
Adenosarcoma ................................ 178
Carcinosarcoma ________________________ 178
Gestational Trophoblastic Disease ....... 178
Hydatidiform Mole ......................... 178
Choriocarcinoma ............................ 178
Placental Site Trophoblastic Tumor ...... 179
Germ Cell Tumors ......................... 179
Melanoma .................................. 179
Lymphoma and Leukemia ................. 179
Hodgkin Lymphoma ......................... 180
Extramedullary Myeloid Tumor .......... 180
Plasmacytoma ................................ 180
Differential ................................ 180
Metastases ................................ 181

Odds & Ends ................................. 182
Hyperchromatic Crowded Groups (HCGs) 182
Fallopian Tube Cells ....................... 188
Carcinoma of the Fallopian Tube ........... 188
Benign Glandular Cells Posthysterectomy 188
Ferning of the Cervical Mucus ............ 189
Curschmann Spirals ....................... 189
Fistulae .................................. 190
Rectovaginal Fistula ...................... 190
Vesicovaginal Fistula ..................... 190
Neovagina ................................ 190
Spermatozoa ................................ 190
Seminal Vesicle Cells ..................... 190
Psammoma Bodies .......................... 190
Benign Associations ....................... 192
Malignant Associations ................... 192
Ciliocystophthoria, Detached Ciliary Tufts 192
Collagen Balls ............................ 192
Other Artifacts ............................ 192

VI. Clinical Considerations .............. 195

Clinical Management ...................... 196
Detect .................................. 196
Delineate ................................ 196
Diagnose ................................ 196
Destroy .................................. 197
Cryotherapy ................................ 197
Laser Ablation ........................... 197
Lap Electrosurgery Excision Procedure 197
Pap Test Basics ........................... 197
Screening ................................ 198
ACS Pap Test Screening Recommendations 199
Sample Collection ........................ 199
General Instructions ........................ 199
Technique ................................ 199

Pap Test Management Guidelines ....... 200
Inflammatory Change and Repair ......... 200
Atypical Squamous Cells of Undetermined Significance (ASC-US) 200
Atypical Squamous Cells, High-Grade Squamous Intraepithelial Lesion Cannot Be Excluded (ASC-H) 201
Low-Grade Squamous Intraepithelial Lesion (L SIL) .. 201
High-Grade Squamous Intraepithelial Lesion (H SIL) ... 201
Atypical Glandular Cells (AGC) ........ 201
Summary of Management Guidelines .... 201

VII. Failure of the Pap Test ............ 203

Factors Related to Failure of Pap Test Screening ........... 206
Patient-Related Errors ................... 206
Clinical Errors .......................... 207
Instrument and Sample Errors .......... 207
Cytopreparation and Interpretive Errors 207
Lesion-Related Errors ................. 211

Standard of Practice .................... 211
This book began life as a chapter in *The Art & Science of Cytopathology*. But the contents of that original chapter have been greatly revised, updated, and expanded to include liquid-based cytology, new concepts of human papillomavirus in cervical carcinogenesis, HPV-DNA testing, the latest Bethesda System changes, new management guidelines from the ASCCP, lessons from litigation over the past 10 years, and much more. Even the title, *The Pap Test*, recognizes a “paradigm shift” from predominance of the conventional Pap smear to liquid-based cytology, which now accounts for most cervicovaginal cytology in America. Some may want this book for the atlas of liquid-based cervicovaginal cytology alone....

The audience for this book is students, residents, fellows, cytotechnologists, pathologists, gynecologists, and in fact, anyone involved with Pap testing. Obviously, this will include a wide range of readers, from beginners in the field to advanced practitioners to those subjected to mandatory proficiency testing. Therefore, the work is offered as something of a smorgasbord, with a good helping of something for everyone. Acknowledging that not everyone will read the book “cover-to-cover,” each section is a complete discussion—those who do read all of it, bless them, will naturally find some redundancies in the text. The presentation is comprehensive, but mindful of providing practical information useful in daily practice. Liquid-based cytology is compared and contrasted with conventional Pap smears throughout the text. In addition, a synoptic *Liquid-Based Cytology Atlas* (aka LBC Fun Park) is included in chapter VIII for your viewing pleasure. Of course, most of the information about cervical disease applies to both technologies.

All together, there are well over 500 images, all but 1 in full color. Important criteria for cytologic interpretation are emphasized at every useful turn in the text. Synoptic lists, tables, and illustrations are applied liberally to summarize key information and make it easier to remember. Clinical correlation is stressed because it is vital in formulating a cytologic interpretation. References are included as an academic exercise, and boy-howdy there sure are a lot of them (>4000). In addition, the history of the Pap test and the discovery of the role of human papillomavirus in cervical carcinogenesis, as well as other historical tidbits, are offered for the reader’s enjoyment. The reader might also get a kick out of the new DeMay Classification System, which really gets down to brass tacks. Philosophically, a spoon full of sugar helps the medicine go down.

Finally, chapters on the *Failure of the Pap Test* and *Lessons from Litigation* are included, in recognition that the Pap test is not perfect. But, it’s still the best test ever invented for cancer prevention! And we all thank Dr Papanicolaou every time we mention it by name.

Mac DeMay
Author
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>AdCA</td>
<td>adenocarcinoma</td>
</tr>
<tr>
<td>αFP</td>
<td>alpha-fetoprotein</td>
</tr>
<tr>
<td>AGC</td>
<td>atypical glandular cells</td>
</tr>
<tr>
<td>AGUS</td>
<td>atypical glandular cells of undetermined significance</td>
</tr>
<tr>
<td>AIDS</td>
<td>acquired immunodeficiency syndrome</td>
</tr>
<tr>
<td>AIS</td>
<td>adenocarcinoma in situ</td>
</tr>
<tr>
<td>ALTS</td>
<td>ASCUS/L SIL triage study</td>
</tr>
<tr>
<td>ASC</td>
<td>atypical squamous cells</td>
</tr>
<tr>
<td>ASC-H</td>
<td>atypical squamous cells—cannot exclude H SIL</td>
</tr>
<tr>
<td>ASCUS</td>
<td>atypical squamous cells of undetermined significance (pre 2001)</td>
</tr>
<tr>
<td>ASC-US</td>
<td>atypical squamous cells—undetermined significance (post 2001)</td>
</tr>
<tr>
<td>ASCCP</td>
<td>American Society for Colposcopy and Cervical Pathology</td>
</tr>
<tr>
<td>BCC</td>
<td>benign cellular changes</td>
</tr>
<tr>
<td>BCP</td>
<td>birth control pill</td>
</tr>
<tr>
<td>βHCG</td>
<td>beta–human chorionic gonadotropin</td>
</tr>
<tr>
<td>[C]</td>
<td>conventional Pap smear, see also CPS</td>
</tr>
<tr>
<td>CA</td>
<td>carcinoma</td>
</tr>
<tr>
<td>CD</td>
<td>cluster designation</td>
</tr>
<tr>
<td>CDC</td>
<td>Centers for Disease Control</td>
</tr>
<tr>
<td>CEA</td>
<td>carcinoembryonic antigen</td>
</tr>
<tr>
<td>CGIN</td>
<td>cervical glandular intraepithelial neoplasia</td>
</tr>
<tr>
<td>CIN</td>
<td>cervical intraepithelial neoplasia</td>
</tr>
<tr>
<td>CIS</td>
<td>carcinoma in situ</td>
</tr>
<tr>
<td>CK</td>
<td>cytokeratin</td>
</tr>
<tr>
<td>CLIA</td>
<td>Clinical Laboratory Improvement Act</td>
</tr>
<tr>
<td>CMV</td>
<td>cytomegalovirus</td>
</tr>
<tr>
<td>CPS</td>
<td>conventional Pap smear, see also [C]</td>
</tr>
<tr>
<td>CT</td>
<td>cytotecnologist</td>
</tr>
<tr>
<td>DDx</td>
<td>differential interpretation</td>
</tr>
<tr>
<td>DES</td>
<td>diethylstilbestrol</td>
</tr>
<tr>
<td>DNA</td>
<td>deoxyribonucleic acid</td>
</tr>
<tr>
<td>EBV</td>
<td>Epstein-Barr virus</td>
</tr>
<tr>
<td>EC</td>
<td>endocervical</td>
</tr>
<tr>
<td>EC/TZ</td>
<td>endocervical cell/ transformation zone</td>
</tr>
<tr>
<td>eg</td>
<td>exempli gratia</td>
</tr>
<tr>
<td>EGD</td>
<td>endoglandular dysplasia</td>
</tr>
<tr>
<td>EGN</td>
<td>endocervical glandular neoplasia</td>
</tr>
<tr>
<td>EM</td>
<td>endometrial</td>
</tr>
<tr>
<td>etc</td>
<td>et cetera</td>
</tr>
<tr>
<td>FDA</td>
<td>Food and Drug Administration</td>
</tr>
<tr>
<td>FLC</td>
<td>funny looking cell</td>
</tr>
<tr>
<td>FN</td>
<td>field number</td>
</tr>
<tr>
<td>FNA</td>
<td>fine needle aspiration</td>
</tr>
<tr>
<td>FSH</td>
<td>follicle stimulating hormone</td>
</tr>
<tr>
<td>GI</td>
<td>gastrointestinal</td>
</tr>
<tr>
<td>H SIL</td>
<td>high-grade squamous intraepithelial lesion</td>
</tr>
<tr>
<td>H&amp;E</td>
<td>hematoxylin and eosin</td>
</tr>
<tr>
<td>HCGs</td>
<td>hyperchromatic crowded groups</td>
</tr>
<tr>
<td>HG</td>
<td>high grade</td>
</tr>
<tr>
<td>HIV</td>
<td>human immunodeficiency virus</td>
</tr>
<tr>
<td>HK</td>
<td>hyperkeratosis</td>
</tr>
<tr>
<td>HLA</td>
<td>human leukocyte antigen</td>
</tr>
<tr>
<td>HPV</td>
<td>human papilloma virus</td>
</tr>
<tr>
<td>HRT</td>
<td>hormone replacement therapy</td>
</tr>
<tr>
<td>HSV</td>
<td>herpes simplex virus</td>
</tr>
<tr>
<td>ICL</td>
<td>intracytoplasmic lumen</td>
</tr>
<tr>
<td>IE</td>
<td>id est</td>
</tr>
<tr>
<td>ISH</td>
<td>in situ hybridization</td>
</tr>
<tr>
<td>IUD</td>
<td>intrauterine device</td>
</tr>
<tr>
<td>K SCC</td>
<td>keratinizing squamous cell carcinoma</td>
</tr>
<tr>
<td>[L]</td>
<td>liquid-based cytology, see also LBC</td>
</tr>
<tr>
<td>L SIL</td>
<td>low-grade squamous intraepithelial lesion</td>
</tr>
<tr>
<td>LBC</td>
<td>liquid-based cytology, see also [L]</td>
</tr>
<tr>
<td>LCA</td>
<td>leukocyte common antigen</td>
</tr>
<tr>
<td>LCR</td>
<td>long control region</td>
</tr>
<tr>
<td>LEEP</td>
<td>loop electrosurgical excision procedure</td>
</tr>
<tr>
<td>LG</td>
<td>low grade</td>
</tr>
<tr>
<td>LH</td>
<td>luteinizing hormone</td>
</tr>
<tr>
<td>LHA</td>
<td>lymphohistiocytic aggregates</td>
</tr>
<tr>
<td>LLETZ</td>
<td>large loop excision transformation zone</td>
</tr>
<tr>
<td>LN</td>
<td>lymph node</td>
</tr>
<tr>
<td>MG bodies</td>
<td>Michaelis-Gutmann bodies</td>
</tr>
<tr>
<td>MI</td>
<td>maturation index</td>
</tr>
<tr>
<td>MicroCA</td>
<td>microinvasive carcinoma</td>
</tr>
<tr>
<td>MMTT</td>
<td>malignant mixed müllerian tumor</td>
</tr>
<tr>
<td>MSBR</td>
<td>multiple slide blinded rescreening</td>
</tr>
<tr>
<td>N/C</td>
<td>nuclear/cytoplasmic</td>
</tr>
<tr>
<td>N-C</td>
<td>nucleocytoplasmic</td>
</tr>
<tr>
<td>NCR</td>
<td>noncoding region</td>
</tr>
<tr>
<td>NILM</td>
<td>negative for intraepithelial lesion or malignancy</td>
</tr>
<tr>
<td>NOS</td>
<td>not otherwise specified</td>
</tr>
<tr>
<td>ORF</td>
<td>open reading frame</td>
</tr>
<tr>
<td>PAS</td>
<td>periodic acid–Schiff</td>
</tr>
<tr>
<td>PBC</td>
<td>pale bland cell</td>
</tr>
<tr>
<td>PC</td>
<td>politically correct</td>
</tr>
<tr>
<td>PCR</td>
<td>polymerase chain reaction</td>
</tr>
<tr>
<td>pg</td>
<td>page</td>
</tr>
<tr>
<td>PK</td>
<td>parakeratosis</td>
</tr>
<tr>
<td>PPK</td>
<td>pseudoparakeratosis</td>
</tr>
<tr>
<td>PMNs</td>
<td>polymorphonuclear neutrophils</td>
</tr>
<tr>
<td>PNET</td>
<td>primitive neuroectodermal tumor</td>
</tr>
<tr>
<td>RB</td>
<td>retinoblastoma</td>
</tr>
<tr>
<td>RBC</td>
<td>red blood cell</td>
</tr>
<tr>
<td>RCH</td>
<td>reserve cell hyperplasia</td>
</tr>
<tr>
<td>RNA</td>
<td>ribonucleic acid</td>
</tr>
<tr>
<td>RV</td>
<td>recto-vaginal</td>
</tr>
<tr>
<td>Rx</td>
<td>therapy</td>
</tr>
<tr>
<td>SBLB</td>
<td>satisfactory but limited by</td>
</tr>
<tr>
<td>SCC</td>
<td>squamous cell carcinoma</td>
</tr>
<tr>
<td>SIADH</td>
<td>syndrome of inappropriate antidiuretic hormone secretion</td>
</tr>
<tr>
<td>SIL</td>
<td>squamous intraepithelial lesion</td>
</tr>
<tr>
<td>SRC</td>
<td>sarcoma</td>
</tr>
<tr>
<td>TBS</td>
<td>the Bethesda System</td>
</tr>
<tr>
<td>TGF</td>
<td>transforming growth factor</td>
</tr>
<tr>
<td>TM</td>
<td>tubal metaplasia</td>
</tr>
<tr>
<td>TTF1</td>
<td>thyroid transcription factor one</td>
</tr>
<tr>
<td>TZ</td>
<td>transformation zone</td>
</tr>
<tr>
<td>URR</td>
<td>upstream regulatory region</td>
</tr>
<tr>
<td>VCE</td>
<td>vaginal cervical endocervical</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>WBC</td>
<td>white blood cell</td>
</tr>
<tr>
<td>WNL</td>
<td>within normal limits</td>
</tr>
<tr>
<td>YY1</td>
<td>ying yang one</td>
</tr>
</tbody>
</table>
Acknowledgements

Joan Hives, factotum and library researcher extraordinaire, without whom this work would not be possible.

Gregory Spiegel, for careful review of manuscript and numerous helpful suggestions.

Jim Linder, for generous contribution of glass slides.

Joshua Weikersheimer, because he’s the best.

Also wish to acknowledge bureaucratic red tape, busy work, and meetings, without which this work would have been completed a lot sooner.
To my Father, Richard, my Sister, Laurie, and the memory of my Mother, Gloria.
The Pap Test

Richard Mac DeMay, MD