Pleural & Peritoneal Tumors

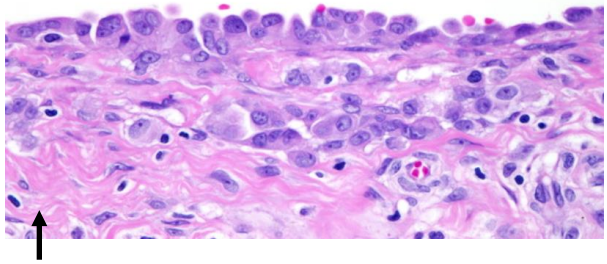
Non-neoplastic

Mesothelial markers: D2-40, Calretinin, WT-1, CK5/6 *(Not entirely specific)*
Pancytokeratin is positive too, but also gets epithelium, so much less specific.

Reactive Mesothelial Hyperplasia

"Activated" reactive mesothelial cells, often responding to inflammation/irritation, **can look very scary and *mimic* mesothelioma/carcinoma**.

Common scary findings: High cellularity, mitotic figures, cytologic atypia, papillary groups, and entrapment of mesothelial cells in fibrous tissue mimicking invasion.
Virtual Slide



Can see "layering" as additional layers of mesothelium and fibrous tissue organize over one another. *Think: sedimentary rock*

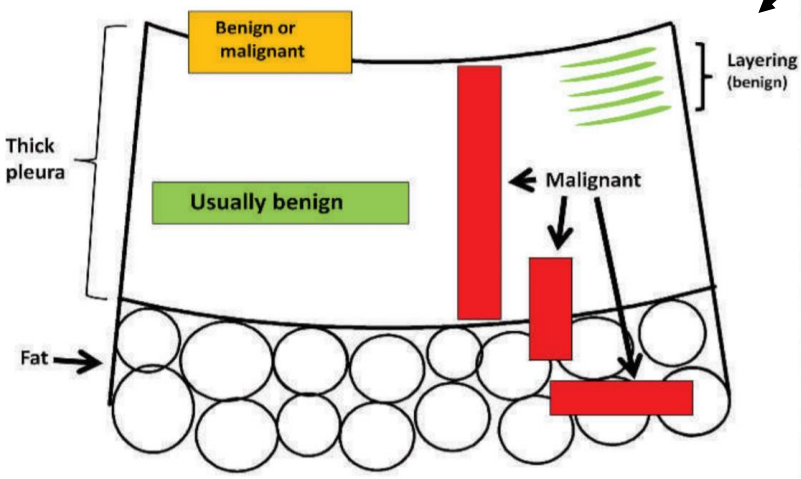
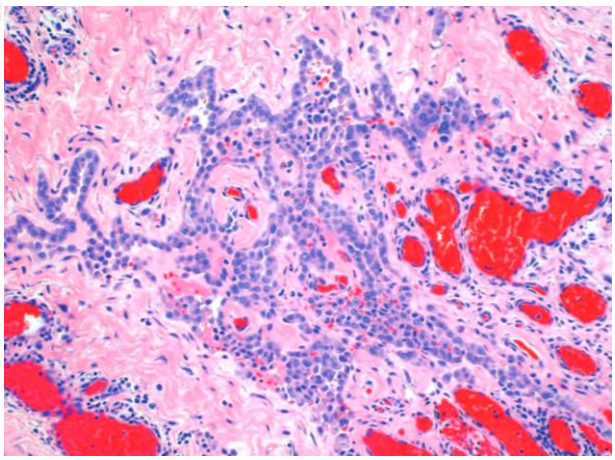


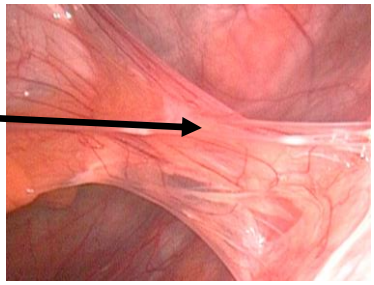
Figure from: Churg and Galateau-Salle. Arch Pathol Lab Med (2012) 136 (10): 1217–1226

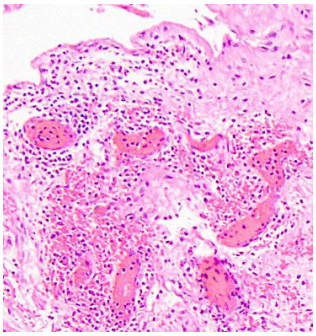


Reactive Mesothelial Hyperplasia	Mesothelioma
Absence of stromal invasion (beware of entrapment and tangential sectioning)	Stromal invasion usually apparent (highlight with pancytokeratin staining)
Cellularity may be prominent but is confined to the mesothelial surface/pleural space and is not in the stroma	Dense cellularity, including cells surrounded by stroma
Simple papillae; single cell layers	Complex papillae; tubules and cellular stratification
Loose sheets of cells without stroma	Cells surrounded by stroma (''bulky tumor'' may involve the mesothelial space without obvious invasion)
Necrosis rare	Necrosis occasionally present
Inflammation common	Minimal inflammation (usually)
Uniform growth (highlighted with cytokeratin staining)	Expansile nodules; disorganized growth (highlighted on cytokeratin staining)
Usually *Not* Helpful: Mitotic activity, Mild to moderate cellular atypia	

Modified from: Husain AN et al. Guidelines for Pathologic Diagnosis of Malignant Mesothelioma 2017 Update of the Consensus Statement From the International Mesothelioma Interest Group. Arch Pathol Lab Med. 2018 Jan;142(1):89-108.

Adhesions

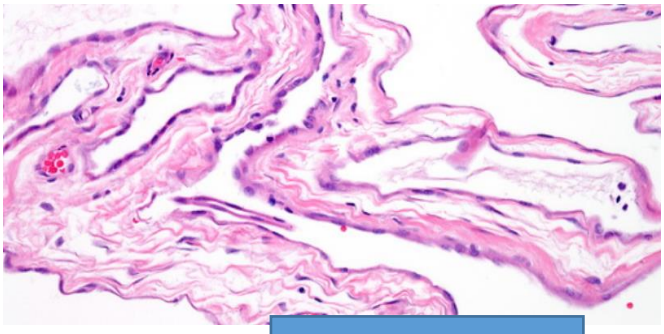




Extremely common!
Bands that form between tissues and organs
May result from surgery or inflammation.
Can cause bowel obstruction, pain, and dysfunction.

Inflammation → exudate → fibrin deposition → *fibrinous* adhesions → Can organize and become *fibrous* adhesions with **fibrovascular scar tissue**

Peritoneal Inclusion Cyst



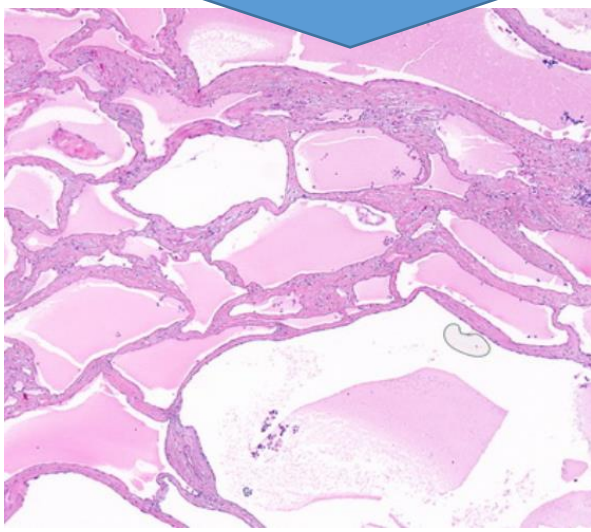
Often discovered incidentally. More common in women

Single or multiple, small, **thin-walled, translucent, unilocular cysts** attached or free in the peritoneal cavity.

Lined by a single layer of flattened, benign-appearing mesothelial cells

Multilocular Peritoneal Inclusion Cysts

If **large** and **multiloculated**



Old (confusing!) name: Benign Multicystic Peritoneal Mesothelioma

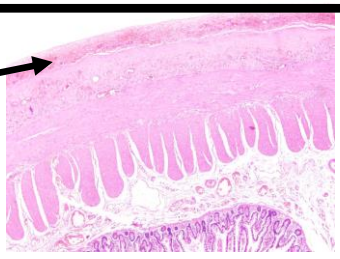
Occurs most frequently in young to middle-aged women in the peritoneum/pelvis.

Likely a hyperplastic reactive lesion (vs. a benign neoplasm). **Associated with previous abdominal surgery, pelvic inflammatory disease, and endometriosis**.
It has a **strong tendency to recur**.

Grossly: often **large, multiple** small, thin-walled, translucent, unilocular cysts that may be attached or free floating. Often fibrous tissue in septae with sparse inflammation.

Cysts are lined by a **single layer of flattened to cuboidal mesothelial cells** which occasionally have a "hob-nail" appearance.

Sclerosing Peritonitis



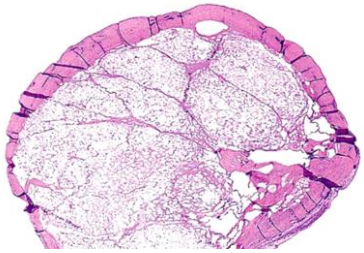
"**Cocoon abdomen**"

Rare. **Encasement of the bowel by fibrous tissue** causes bowel obstruction.

Can be idiopathic, or seen with intraperitoneal dialysis, VP shunts, and fibrothecomas of the ovary.

Infarcted epiploic appendages

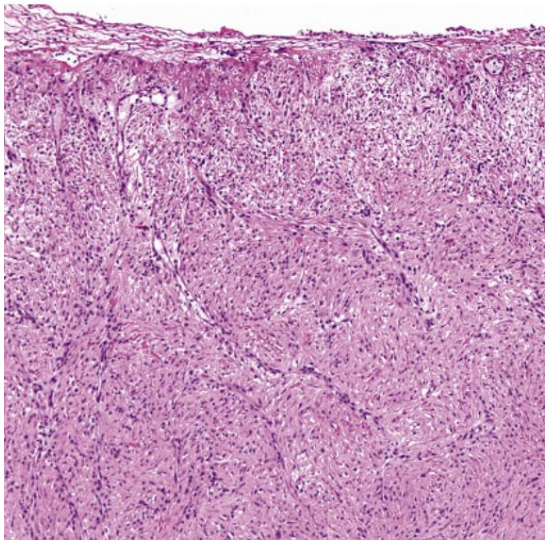
Aka "peritoneal loose body" or "peritoneal mouse"



Epiploic appendages (fat containing pouches of colonic peritoneum) *torse* → Infarction → **fat necrosis with fibrosis and calcifications.**

Can autoamputate and be loose in the peritoneum
Often incidental finding. Can grossly be egg-like.

Fibrous pleurisy



aka "Diffuse Pleural Fibrosis" or "Chronic fibrosing pleuritis"

Deposition of bland, hypocellular fibrous tissue in the pleura.

Often **involves the visceral pleura** and may produce apical fibrous "capping." Severe cases can obliterate pleural space.

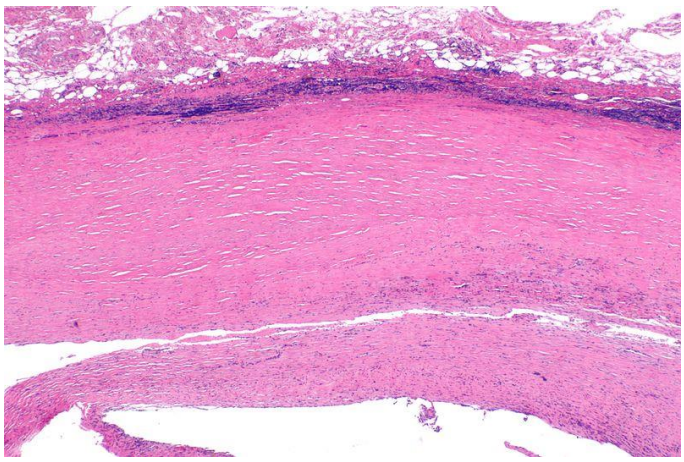
May be associated with connective tissue disorders, such as lupus erythematosus or rheumatoid arthritis, as well as chronic infections and asbestos exposure.

May mimic desmoplastic mesothelioma

Fibrous Pleurisy	Desmoplastic Mesothelioma
Storiform pattern not prominent	Storiform pattern often prominent
Absence of stromal invasion	Stromal invasion present (highlight with pancytokeratin staining)
Uniform thickness of the process	Disorganized growth, with uneven thickness, expansile nodules, and abrupt changes in cellularity
Perpendicularly oriented vessels	Paucity of vessels. No orientation.
Hypercellularity at the surface with maturation and decreased cellularity deep (so-called zonation)	Lack of maturation from the surface to the depths of the process
Necrosis, if present, is at the surface epithelioid mesothelial cells (where there is often associated acute inflammation)	Bland necrosis of paucicellular, collagenized tissue
Not helpful: Cellularity, Atypia (unless severe), Mitotic activity (unless numerous atypical mitotic figures)	

Modified from: Husain AN et al. Guidelines for Pathologic Diagnosis of Malignant Mesothelioma 2017 Update of the Consensus Statement From the International Mesothelioma Interest Group. Arch Pathol Lab Med. 2018 Jan;142(1):89-108.

Pleural Plaque



aka "hyaline pleural plaque"

Hypocellular, dense bundles of hyalinized collagen, often with a "basket weave" arrangement. Often dystrophic **calcifications**. Variable chronic inflammation.

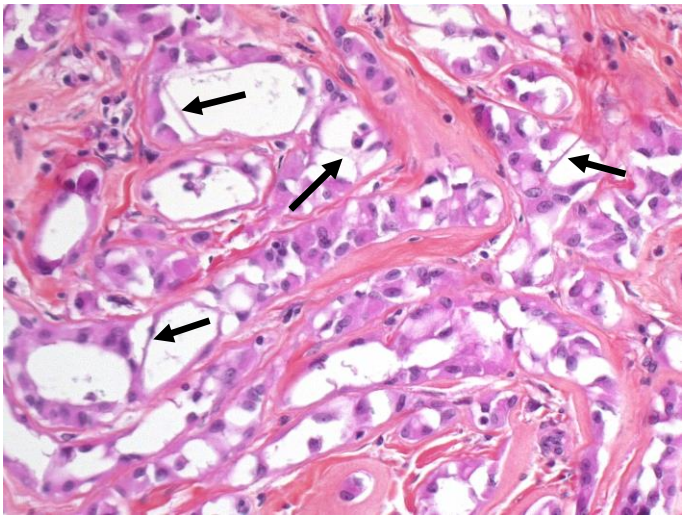
Mesothelial cells run *parallel* to surface (vs haphazard in desmoplastic mesothelioma).

Often on parietal pleura, particularly on diaphragm

Often a marker of asbestos exposure, but can be seen with other sources of chronic pleural irritation.

Benign/Indolent Mesothelial Tumors

Adenomatoid Tumor



Irregularly shaped gland-like microcystic spaces composed of flattened or cuboidal cells with associated fibrous stroma.
Bland cytologic features.

***Helpful feature*: "thread-like bridging strands"** (→)

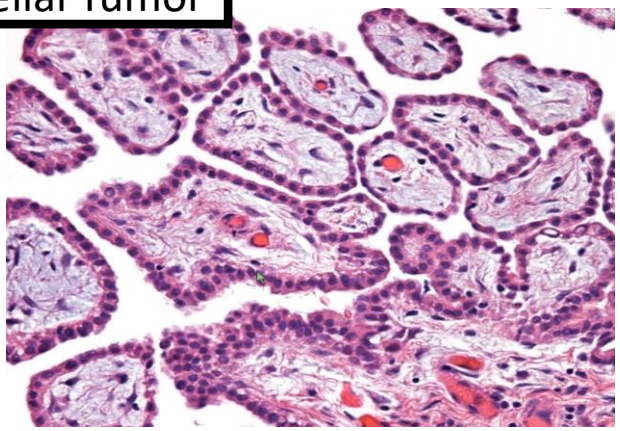
Sometimes signet ring-like vacuolated cells.

Solitary, localized.

TRAF7 missense mutations. Intact BAP1 staining.

Most commonly in the **female genital tract** (e.g., uterine or adnexal surface) or **genitourinary tract** (e.g., paratesticular), but can be pleural.
Virtual Slide

Well-Differentiated Papillary Mesothelial Tumor



Rare. Grossly **velvety** appearance.

Prominent papillary architecture with myxoid cores covered by a single layer of flattened to cuboidal bland epithelioid cells.

Nuclei are **bland**, round, and small without atypia.

Generally NO invasion. Often solitary and incidental.

TRAF7 missense mutations. Intact BAP1 staining.

Indolent tumors. Most cases cured by excision.
Very long survival. May recur.

Characteristic	Well-differentiated Papillary Mesothelioma	Malignant Mesothelioma with a Papillary Pattern
Growth feature- bulk of disease	Often incidental, solitary, focal area of velvety appearance	Diffuse or multinodular, grossly apparent
Morphology of papillae	Fibrous and stout cores, single-cell layer	Fibrous cores, lined by cells with stratification
Cytology	Flat cuboidal, no anisocytosis	Cuboidal cells with nucleoli and variable anisocytosis
Mitoses	Low	High
Other growth patterns	Absent	Tubular, solid, cribriform, complex papillae
Stroma invasion	Predominantly exophytic growth, Invasion usually absent or very focal/superficial	Present
Prognosis	Good, with local recurrence	Poor

Adapted from: WHO Classification of tumors of the lung, pleura, thymus, and heart. 2015.

Mesothelioma

Usually <u>diffuse</u> (circumferential, rind-like)→ <u>Poor prognosis.</u>
Rarely, localized (solitary, well-circumscribed)→ Better prognosis

Vast majority pleural location (~90%). Occasionally, peritoneal. Rarely, pericardial, paratesticular.
Most common in **elderly, often male. Often unilateral** at first. Most common cause is **<u>asbestos exposure</u>**.
Often insidious onset with chest pain and/or dyspnea.

Clinical information (either from imaging or intraoperative findings) can be very helpful with Dx:
<u>Circumferential pleural thickening</u> is highly suggestive of malignancy,
Nodular pleural thickening is also often malignant.

<u>Note</u>: Previously, the term "Malignant mesothelioma" was sometimes used, but with the renaming of other benign entities, the term "mesothelioma" <u>only</u> corresponds to malignant tumors.

Epithelioid Mesothelioma

Malignant proliferation of mesothelial cells with **<u>epithelioid</u>** morphology. **Most common subtype** (~75%)

Often relatively <u>bland cytologically</u> (but can be pleomorphic) with **eosinophilic cytoplasm in vesicular nuclei.**

Demonstration of **<u>tissue invasion</u>** (e.g., into chest wall or lung) is often key for diagnosis (see next page).
However, when a substantial amount of solid, malignant tumor (i.e., a mass) is identified, the presence of invasion is *<u>not</u>* required for diagnosis.

<u>Histologic patterns</u>: Solid and micropapillary→ worse prognosis
Tubulopapillary, trabecular, adenomatoid→ better prognosis

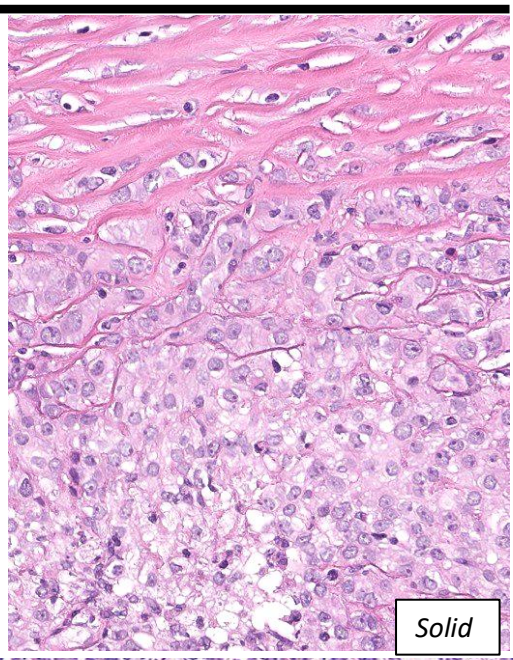
Can also have cytologic/stromal features, like: rhabdoid, myxoid, pleomorphic, small cell, lymphohistiocytoid, clear cell, deciduoid, etc.

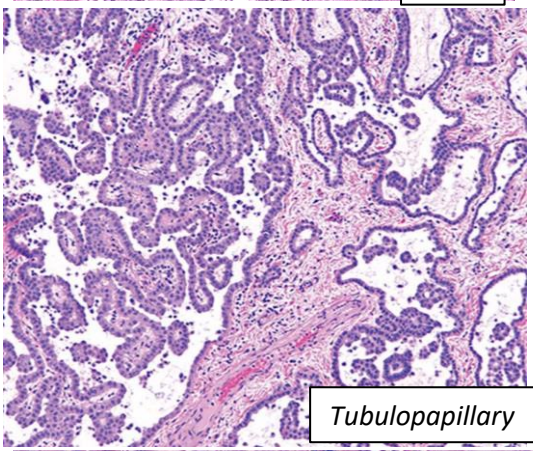
Can see psammoma bodies.

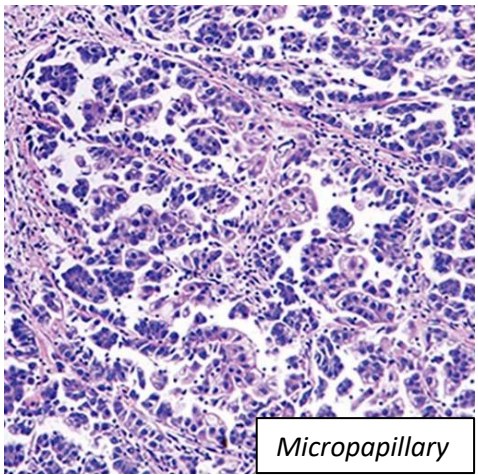
Essentially, mesothelioma can look like almost anything, so always keep it on your DDX!

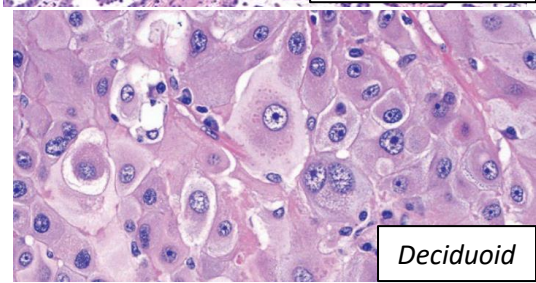
Molecular: Often multiple chromosomal alterations. Frequent loss of tumor suppressors CDKN2A, BAP1, TP53, and NF2.

<u>Virtual slide 1</u>
<u>Virtual slide 2</u>
<u>Virtual slide 3</u>

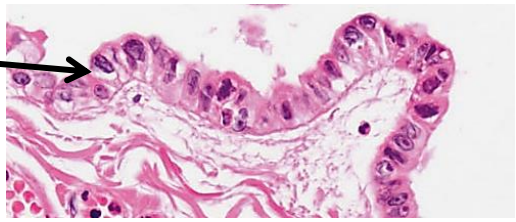

Solid


Tubulopapillary


Micropapillary


Deciduoid

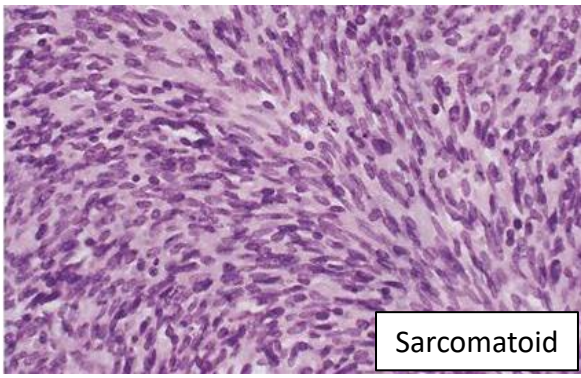
Mesothelioma in situ



Non-invasive **precursor to mesothelioma.**
Variable morphology: Flat to cuboidal cells with variable atypia.
Can have flat, papillary, or complex architecture.

Requires special studies to Dx: BAP1 loss by IHC or CDK2A homozygous deletion
By definition: **No invasion**, No clinical or radiographic mass or diffuse process.

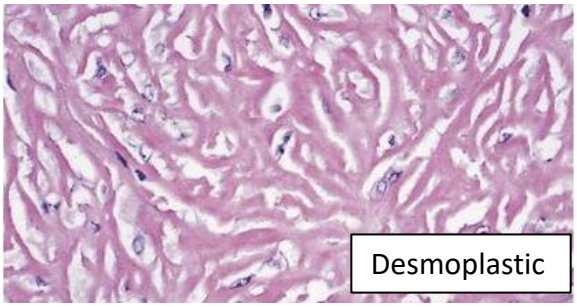
Sarcomatoid Mesothelioma



Spindle cell appearance. Arranged in fascicles or haphazard.
Can see heterologous elements (e.g., rhabdomyosarcoma).
Worse prognosis.
Virtual slide

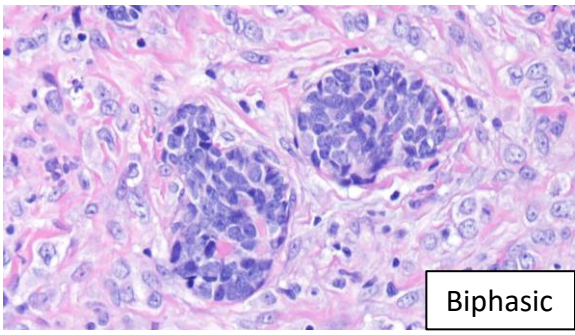
Subtypes:

Desmoplastic mesothelioma: Dense collagenized tissue with malignant mesothelial cells. Either patternless or storiform pattern. Must be ≥50% of tumor. Invasion into fat is most helpful feature to differentiate from organizing pleuritis.



Biphasic mesothelioma: Contains BOTH epithelioid and sarcomatoid patterns, each ≥10%. Intermediate prognosis.

Transitional mesothelioma: Sheetlike growth with cytomorphology between sarcomatoid and epithelial tumor.

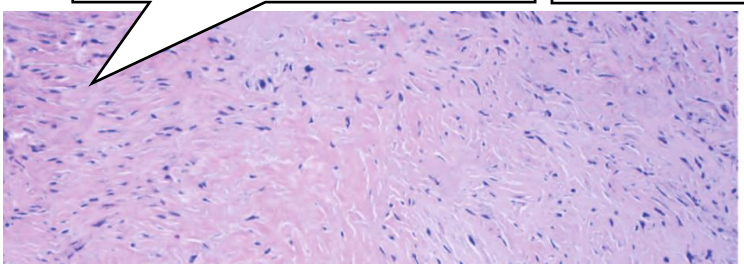


Stromal invasion is often more difficult to recognize in these spindle cell proliferations as the invasive malignant cells are often deceptively bland→ Use IHC liberally.

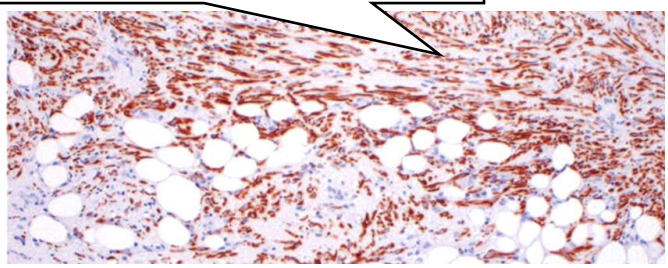
IHC: Usually stain, at least focally, with a broad spectrum pancytokeratin (can also help demonstrate invasion).
Loss of BAP1 is very uncommon in these types.

Poorer prognosis than epithelioid mesotheliomas.
Desmoplastic mesothelioma has a particularly dismal prognosis (often <6 months).

1 Hmm… that looks pretty bland, but the clinician said it's a mass.



2 Yikes! A cytokeratin stain shows that all of those bland spindled cells are actually invasion!



Useful Special Studies

Special studies are used for 2 main purposes:

1) Use IHC to **<u>confirm mesothelial differentiation</u>** (vs metastatic carcinoma) (see tables→) **<u>Always use a panel</u>!**

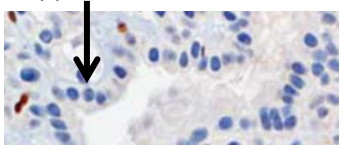
Frequent Mesothelial IHC:
<u>Least specific</u>: Broad spectrum cytokeratins (e.g., AE1/AE3), CK5/6
<u>More specific</u>: Calretinin, D2-40, WT-1, HEG1.
All >80% sensitive, but not specific (so, again, use a panel!!)

2) After mesothelial origin is confirmed, special studies can **<u>support the diagnosis of malignancy</u>** (if necessary)
<u>good specificity</u> (by definition, not found in benign mesothelial proliferations). Reasonable, but not perfect, sensitivity:

IHC: ***Loss of* <u>BAP1</u>** (nuclear stain) or **MTAP** (cytoplasmic stain)
FISH: **CDKN2A** (**<u>p16</u>**) ***deletion***
(MTAP is a surrogate marker for CDKN2A as it is a neighbor of CDKN2A and is often codeleted)

Normal BAP1 (intact nuclear) → supports benign mesothelium

Abnormal BAP1 (loss of nuclear) → supports mesothelioma



Metastatic Adenocarcinoma	Mesothelial cells
BerEP4	Calretinin
MOC31	D2-40
B72.3	WT-1
Claudin-4	CK5/6

Squamous cell carcinoma	Mesothelial cells
p40 & p63	Calretinin
MOC31	HEG1
Claudin-4	WT-1

Always remember:
Carcinoma stains that can also get mesos: PAX8, CK7, GATA-3, AE1/AE3

Meso stains that can also get some carcinomas: WT-1, CK5/6

Stains that get both mesos and SCC: CK5/6

Algorithm Approach to Mesothelial Proliferations

Arch Pathol Lab Med (2024) 148 (11): 1251–1271.

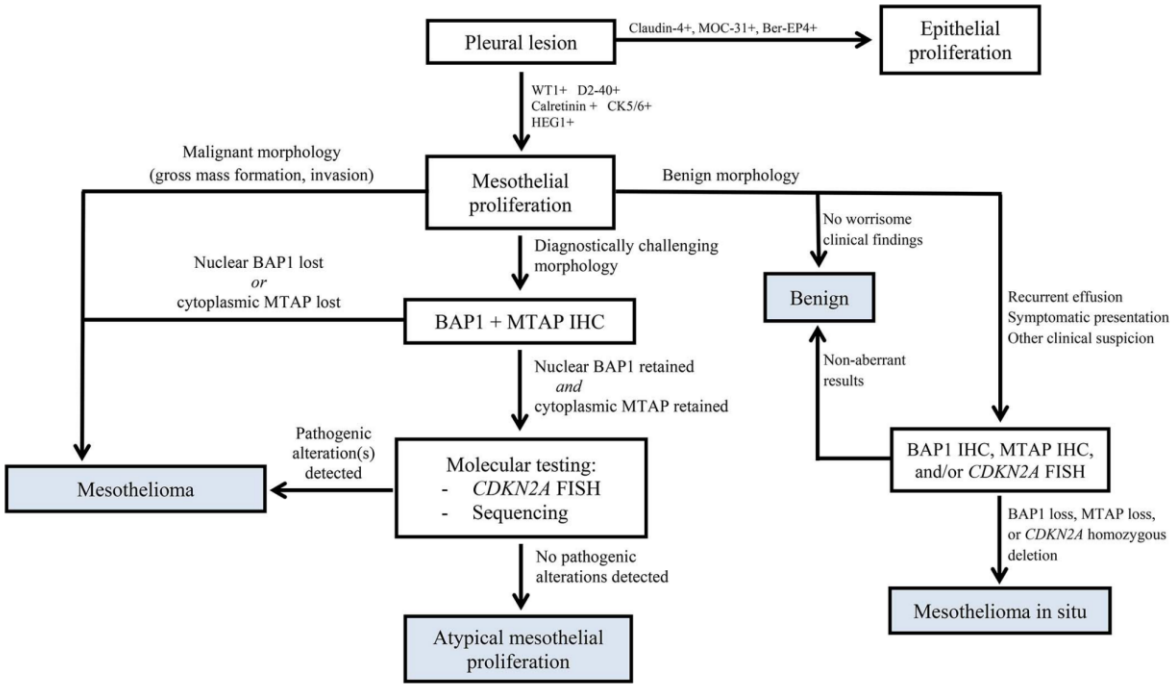


Figure 10. *Algorithm for tissue diagnosis of mesothelial proliferations. An immunopanel of 2 epithelial and 2 mesothelial markers is generally advisable for confirming mesothelial lineage. Abbreviations: CK, cytokeratin; D2-40, podoplanin; FISH, fluorescence in situ hybridization; IHC, immunohistochemistry; WT1, Wilms tumor-1.*

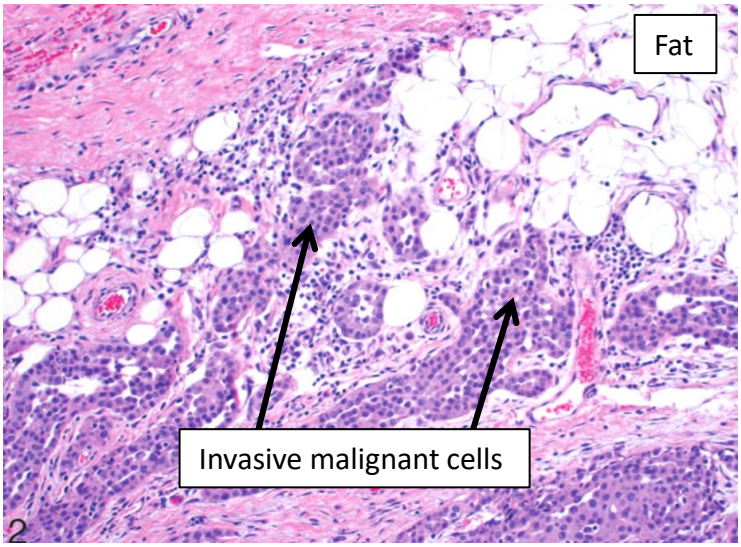
Is it really invasive?

Given that reactive mesothelial processes can look so atypical, **demonstrating tissue invasion is often required for the diagnosis of mesothelioma**, *unless* there is a significant solid tumor mass.

Tip: Use of IHC stains (e.g., Pancytokeratin or Calretinin) can highlight infiltrative cells, helping confirm invasion.

Look for cytokeratin-positive malignant cells in regions in which they would not normally be present: adipose tissue, skeletal muscle deep to the parietal pleura, or lung tissue (or other extrapleural structures).

Caution: Sometimes the biopsy process can create fake empty fat-like spaces. When in doubt, do an S100 to see if it is real fat. Also, vimentin will be negative as this fake fat does not have any cellular lining.



Benign processes→ Tend to be well-circumscribed (only a few glands evident beneath the pleural surface, or a sharp line beyond which no mesothelial cells are found)

Malignant processes→ Poorly-circumscribed, invasive

Warning: On small biopsies, it can be very hard to evaluate for invasion. In such cases where invasion is not definite, it is recommended that you simply say "***atypical mesothelial hyperplasia***" or "***atypical mesothelial proliferation***," with a comment that another larger biopsy (likely surgical), may be appropriate if the clinician is suspicious for mesothelioma.

	Mesothelial Hyperplasia	Mesothelioma
Major criteria		
Stromal invasion	Absent	Present (the deeper the more definitive)
Cellularity	Confined to the pleural surface	Dense, with stromal reaction
Papillae	Simple, lined by a single layer of cells	Complex, with cell stratification
Growth Pattern	Surface growth	Expansile nodules, complex, disorganized
Zonation	Process becomes less cellular towards chest wall	No zonation of process, often more cellular away from effusion
Vascularity	Capillaries perpendicular to surface	Irregular, haphazard
Minor criteria		
Cytologic atypia	Confined to areas of organizing effusion	Present in any area, but often deceptively bland
Necrosis	Rare	More common
Mitoses	May be plentiful	Often rare (but atypical favors malignancy)

Adapted from: WHO Classification of tumors of the lung, pleura, thymus, and heart. 2015.

Other Tumors

Synovial Sarcoma

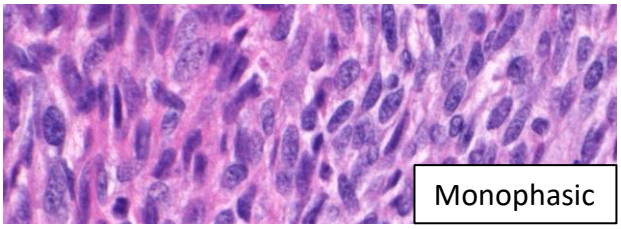
Malignant. Usually young adults.

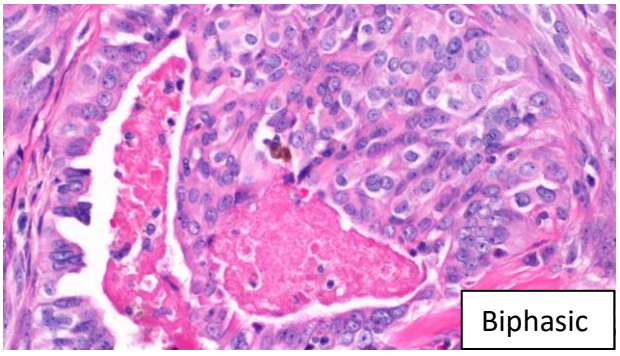
Monophasic SS→ Just spindled component.
Biphasic SS→ Spindled and epithelioid components.

Fairly uniform spindled cells with relatively little cytoplasm. Ovoid, "stubby," nuclei with hyperchromatic granular chromatin and small nucleoli. Can see "Stag-horn" vessels. Epithelial cells arranged in nests and glands with paler cytoplasm and vesicular nuclei.

IHC: Patchy EMA and CK (particularly strong in epithelial areas). Usu. CD99 (+). TLE-1 (+)

Molecular: **SS18-SSX gene fusions t(X;18)** Virtual slide


Monophasic


Biphasic

Solitary Fibrous Tumor ("SFT")

Old name: Hemangiopericytoma
(referred to cellular tumors on a spectrum with SFT)

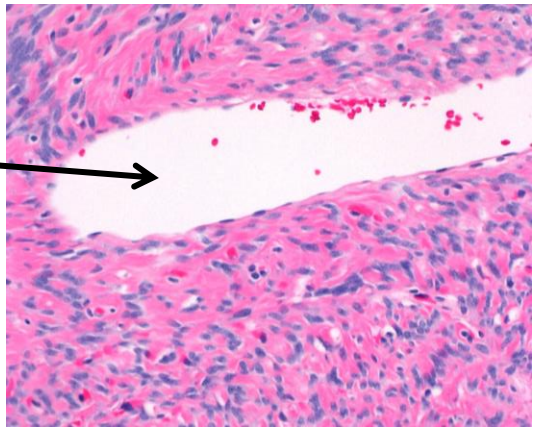
Usually benign.

"Patternless pattern" of varying cellularity of bland spindled cells with varying amounts of collagenized stroma. Prominent "Staghorn vessels" (dilated, thin-walled, branching vessels). Can be hyalinized or myxoid.

IHC: **STAT6 (+)**. Also, CD34, CD99 (+, but variable).

Molecular: NAB2/STAT6 gene fusion

Factors associated with malignant behavior:
Numerous mitoses (esp. >4/10 HPF), Large size (esp. >15 cm), and tumor necrosis. Virtual slide



Desmoplastic Small Round Cell Tumor

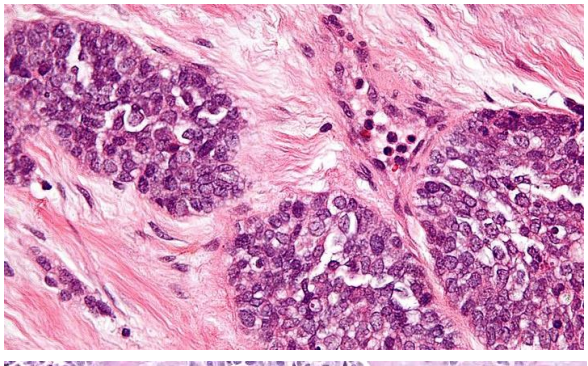
Malignant tumor of uncertain histogenesis often found in the **peritoneal** cavity; often in **young men**.

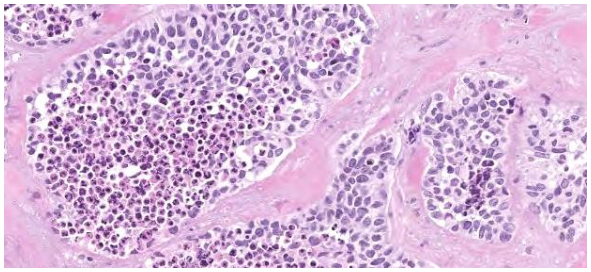
Basaloid **nests of small, round, uniform tumor cells that are surrounded by desmoplastic stroma**.
Tumor cells have hyperchromatic nuclei and scant cytoplasm. Mitoses and apoptoses are frequent.

IHC: Express **Cytokeratins**, EMA, **Desmin** (perinuclear dot-like pattern), WT-1 (but C-terminus—opposite of the WT-1 in Wilms!), and NSE

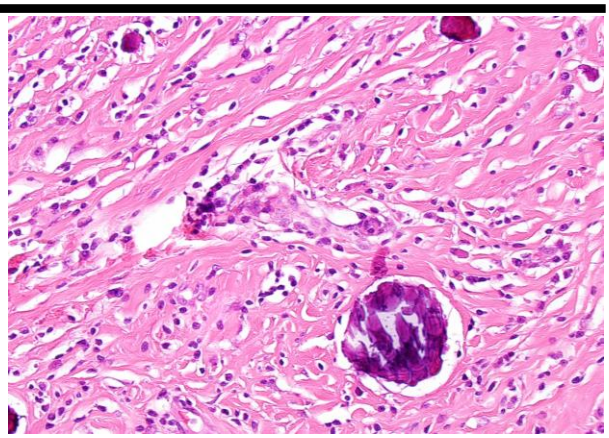
Molecular: Characteristic **EWSR1–WT-1 translocation**

Poor prognosis (although may respond at first)
Virtual slide





Calcifying Fibrous Tumor



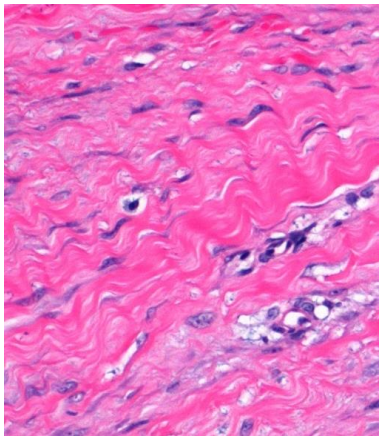
Rare. **Benign**. Occurs on visceral pleura/peritoneum.
More common in **women**, often **younger**.

Paucicellular collagenized fibrous tissue with associated psammomatous or dystrophic calcifications.
Scattered chronic inflammation.
Circumscribed, but not encapsulated.

Confined to pleura and does not invade underlying tissue.

IHC: (+) CD34. (-) STAT6, ALK1, β-catenin Virtual slide

Desmoid-type Fibromatosis



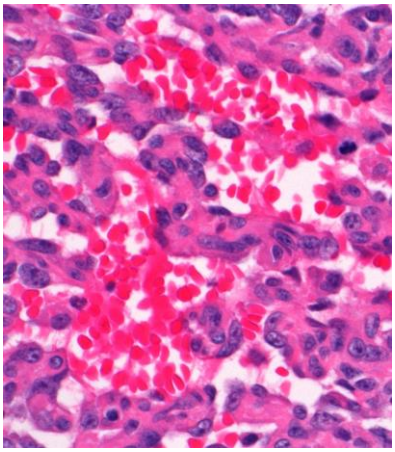
Benign (never metastasize), but infiltrative with high-recurrence rate (>50%).

Infiltrative growth into surrounding structures (esp. skeletal muscle).
Broad, sweeping fascicles.
Uniform spindled cells with small, pale nuclei with pinpoint nucleoli.
Moderate amounts of collagen, surrounding cells, in slightly myxoid background. Virtual slide

IHC: Nuclear β-catenin. Some actin (+)

Molecular: Associated with FAP and mutations in the APC/β-catenin (CTNNB1) pathway

Angiosarcoma



Malignant. Very aggressive. Typically elderly.

Variable degrees of vascular differentiation.
Some areas show well-formed anastomosing vessels, while other areas may show solid sheets of high-grade cells. Can be epithelioid or spindled.
Often extensive hemorrhage.

Unlike benign lesions: significant cytologic atypia, necrosis, endothelial cells piling up, and mitotic figures (although mitoses can be seen in some benign tumors)

IHC: CD31, ERG, FLI1, often CD34

Lymphoproliferative Disorders

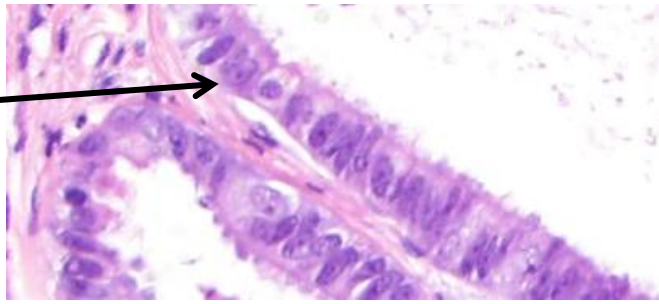
Primary Effusion Lymphoma:
Rare. Presents as an effusion without solid tumor masses. Usually in immunocompromised patients (e.g., HIV-positive). Proliferation of large, atypical B cells with an immunoblastic appearance. Positive for HHV8, often with coinfection with EBV. IHC: CD45(+), but usually lack pan-B-cell markers like CD20, CD19, PAX5, CD79a. Usually express CD30 CD138, CD38, EMA. Poor prognosis.

Diffuse Large B Cell Lymphoma associated with chronic inflammation:
Occurs in patients with long-standing pyothorax or other chronic inflammatory processes, usually in body cavities. EBV-associated. Morphologically resembles other forms of DLBCL with large vesicular nuclei with prominent nucleoli. Express B-cell markers. Aggressive.

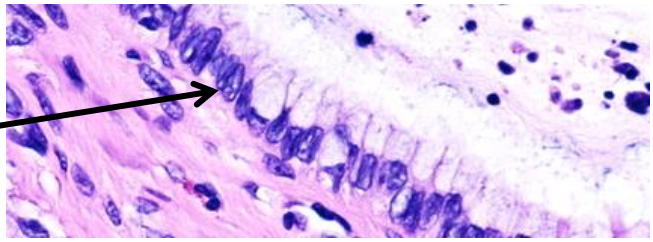
Müllerian Lesions

The pelvic and lower abdominal mesothelium can be primarily or secondarily involved by many Müllerian lesions.

Müllerianosis



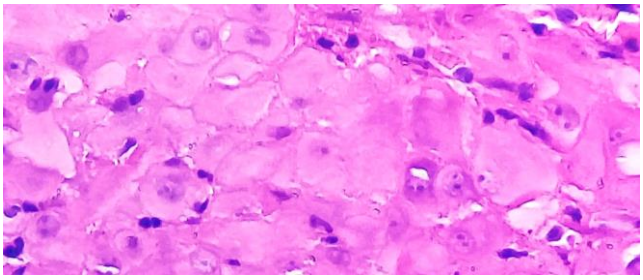
Endosalpingiosis: Glands lined by benign tubal-type (ciliated) epithelium involving the peritoneum or pelvic or para-aortic lymph nodes. Likely secondary as associated with salpingitis. Can have associated psammoma bodies.



Endometriosis: Benign endometrial glands and stroma. Often accompanying hemosiderin-laden macrophages.
Virtual slide

Endocervicosis: Benign endocervical-type epithelium.

Deciduosis



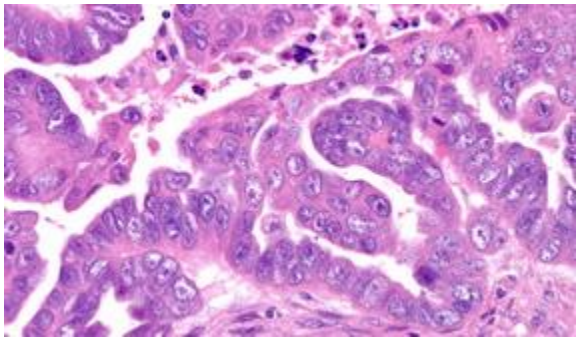
Ectopic decidual cells (epithelioid cells with abundant pale pink granular cytoplasm and bland nuclei) arranged individually, in nodules, or in plaques.
Seen during pregnancy.
May have associated hemorrhage/inflammation.

Primary Peritoneal Serous Borderline Tumors

Morphologically identical to the noninvasive peritoneal implants of ovarian serous borderline tumors.
Diagnosis of exclusion: only when the ovaries are uninvolved or there only minimal surface involvement.
Likely arises from endosalpingiosis.
Generally good prognosis. Can get primary peritoneal low-grade serous carcinomas, so sample well!

Primary Peritoneal High-Grade Serous Carcinoma

Morphologically identical to the primary tuboovarian high-grade serous carcinoma.
Diagnosis of exclusion: Both tubes and both ovaries grossly and microscopically uninvolved (when examined entirely).
Dx can only be made at primary surgery prior to any chemotherapy.



Otherwise, looks and behaves like peritoneal carcinomatosis from high-grade serous carcinoma

Other lesions:
Walthard rests (Transitional metaplasia)
Peritoneal leiomyomatosis
(and pretty much anything arising from Müllerianosis!)