
THYROID CARCINOMAS

A clinicopathologic framework

Cell of origin · molecular drivers · morphology · clinical behavior

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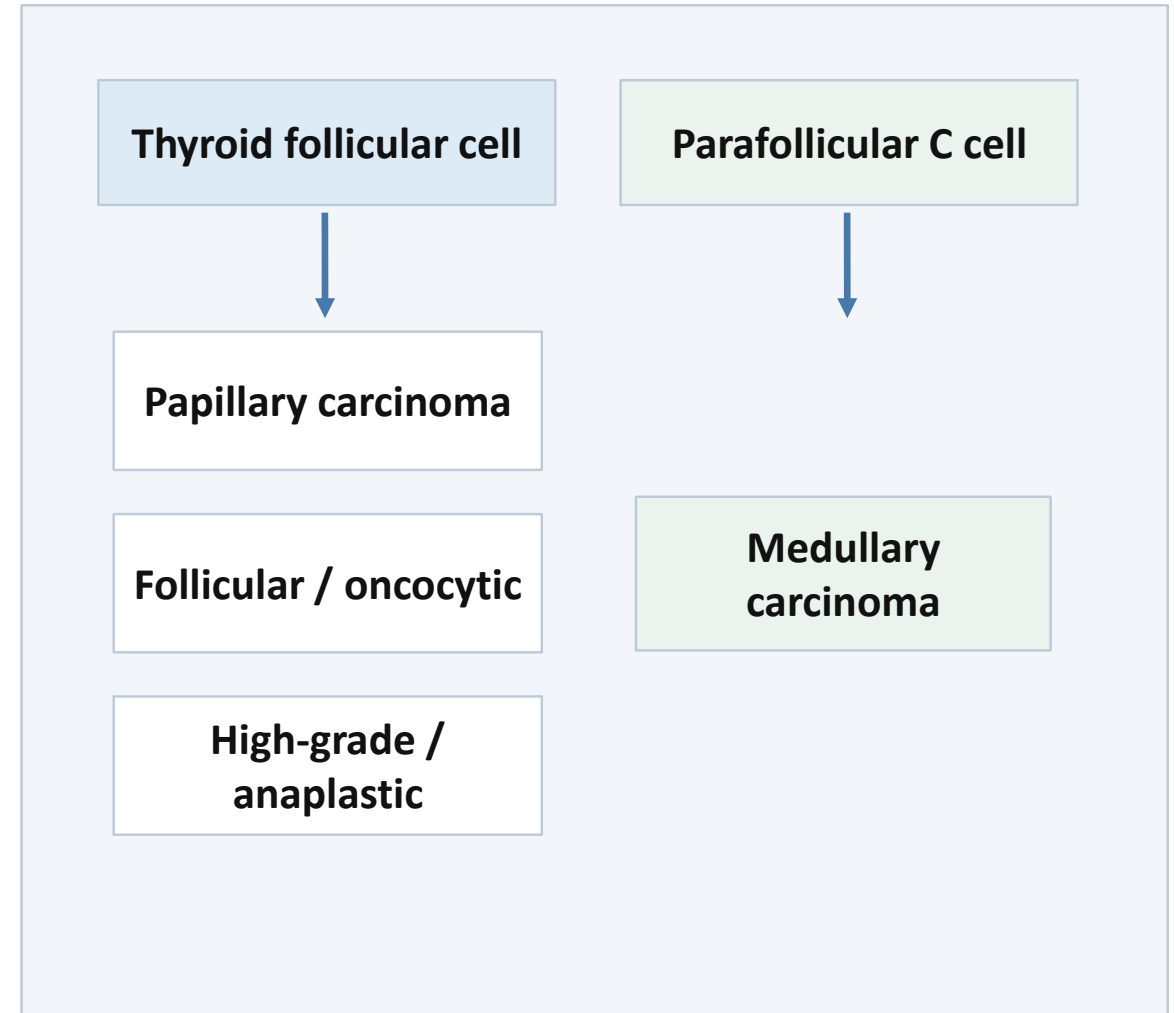
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Learning outcomes: Recognize and distinguish thyroid cancers

- Classify major carcinomas by cell of origin and differentiation.
- Connect MAPK, PI3K/AKT, and RET alterations with tumor phenotype.
- Recognize the decisive morphologic findings in papillary, follicular, and medullary carcinoma.
- Explain why invasion, dissemination route, and molecular progression matter.

Cell of origin defines two fundamentally different groups

- Follicular epithelium gives rise to most thyroid carcinomas.
- Papillary, follicular/oncocytic, and aggressive high-grade carcinomas belong to this lineage.
- Parafollicular C cells give rise to medullary thyroid carcinoma.



Increasing detection does not imply parallel lethality

- Small, localized carcinomas are frequently detected incidentally by palpation or ultrasonography.
- The textbook documents substantial historical increases in diagnosis after ultrasound screening programs.
- Overall mortality remained low because many detected tumors, especially papillary carcinomas, have excellent outcomes.

Relative frequency is strongly dominated by papillary carcinoma

Subtype	Approximate share in textbook	Interpretation
Papillary	~85%	Commonly differentiated; often incidental
Follicular / oncocytic	~5–15%	Follicular lineage; invasion-based diagnosis
High-grade differentiated / PDTC	~5%	Less frequent; clinically aggressive
Anaplastic	~1%	Uncommon; disproportionately lethal
Medullary	~5%	Distinct C-cell lineage

Well-differentiated and aggressive carcinomas behave differently

- Most follicular-derived cancers are well differentiated.
- Poorly differentiated or anaplastic tumors may acquire additional molecular alterations during progression.
- Aggressive follicular-derived and medullary carcinomas account for a substantial share of thyroid cancer mortality.

Differentiated carcinoma

Generally favorable

High-grade differentiated / PDTC

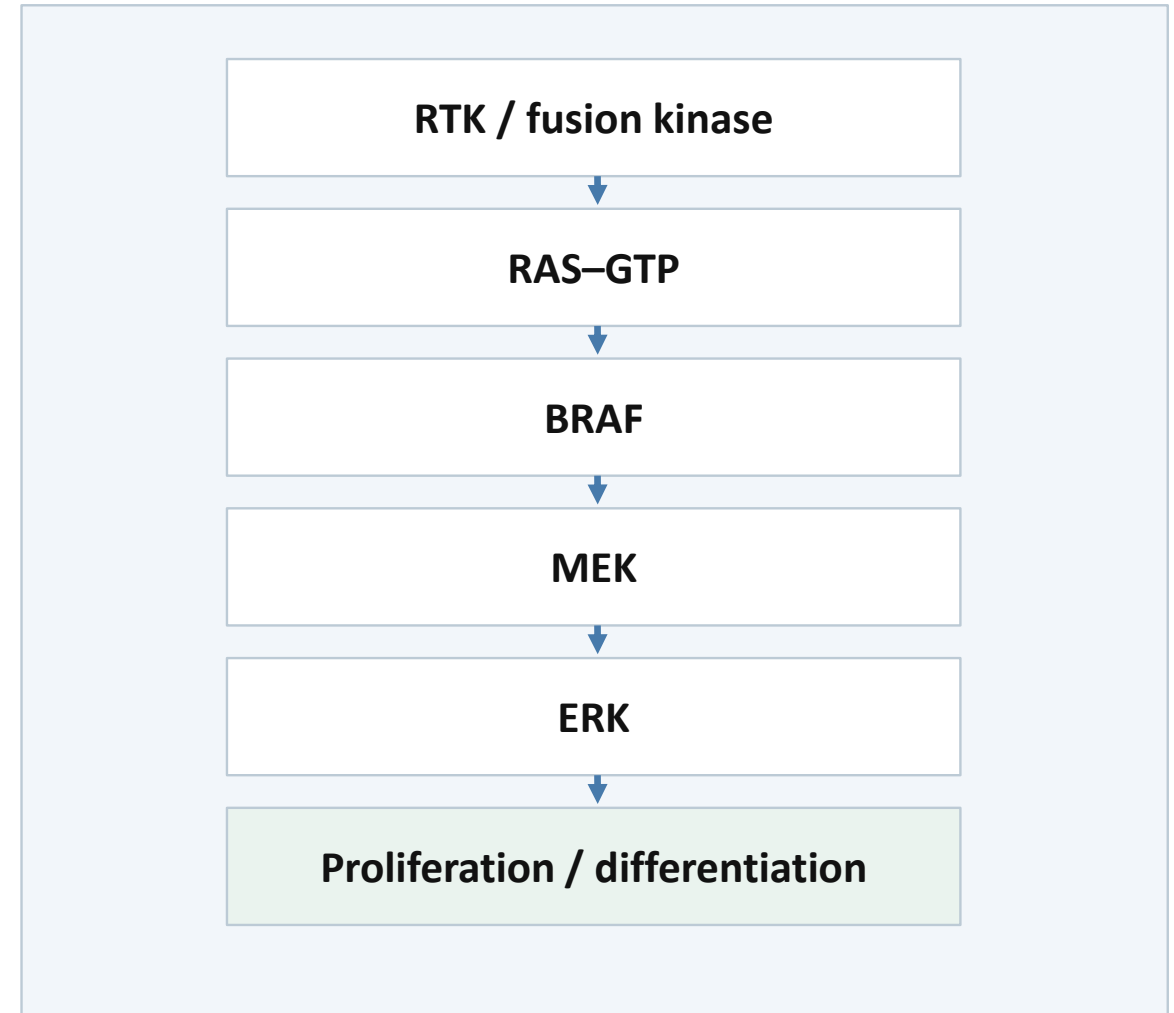
More aggressive

Anaplastic carcinoma

Very poor prognosis

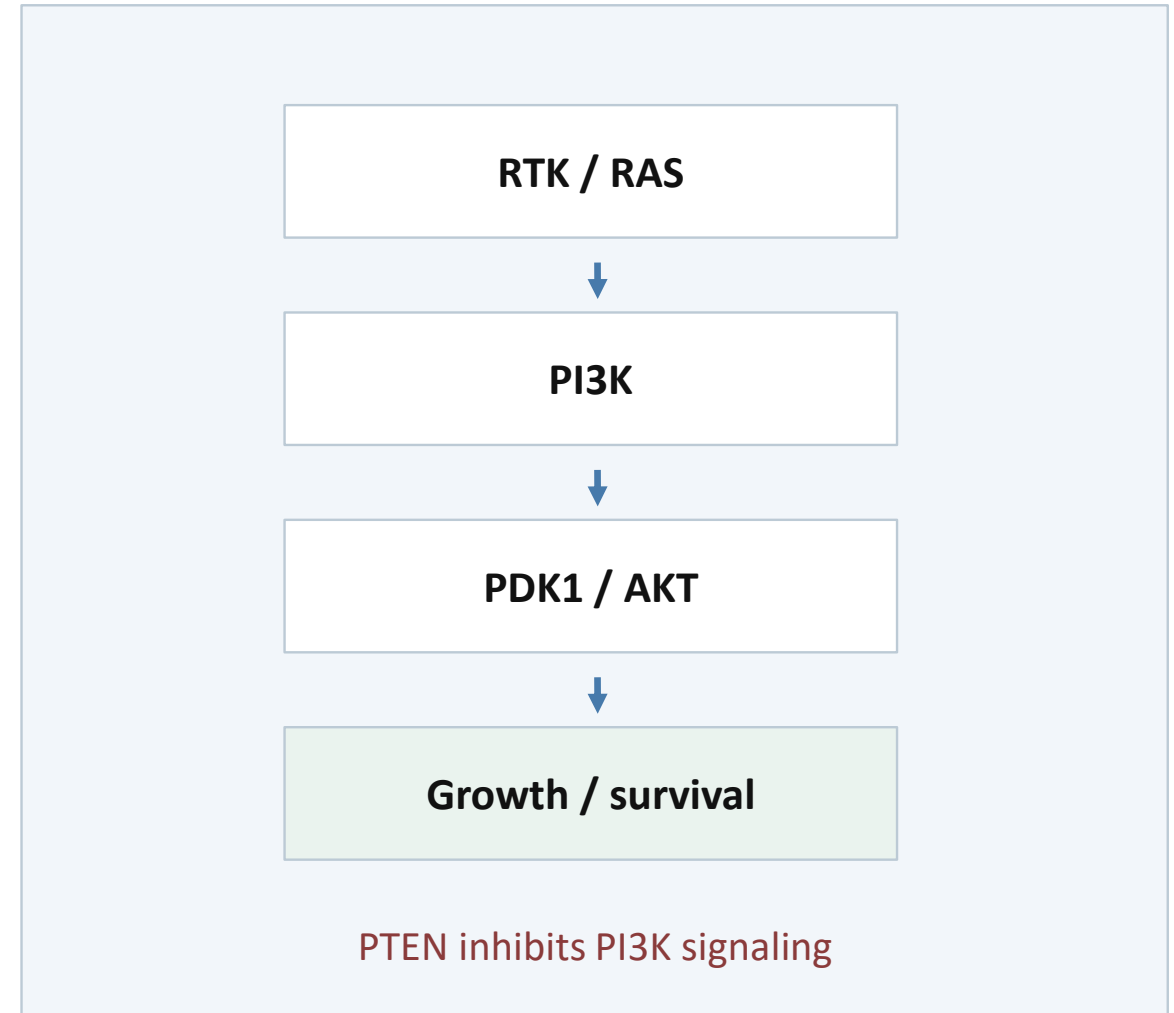
MAP-kinase signaling is a central oncogenic axis

- RTK activity engages downstream RAS and BRAF signaling.
- MEK and ERK transmit growth-factor signals to the nucleus.
- Mutations or fusion kinases can drive constitutive signaling without normal upstream control.



The PI3K/AKT axis provides a second growth program

- PI3K/AKT pathway alterations occur in a subset of follicular carcinomas.
- PTEN normally restrains PI3K pathway signaling.
- Activating PIK3CA or inactivating PTEN lesions release growth/survival signaling.

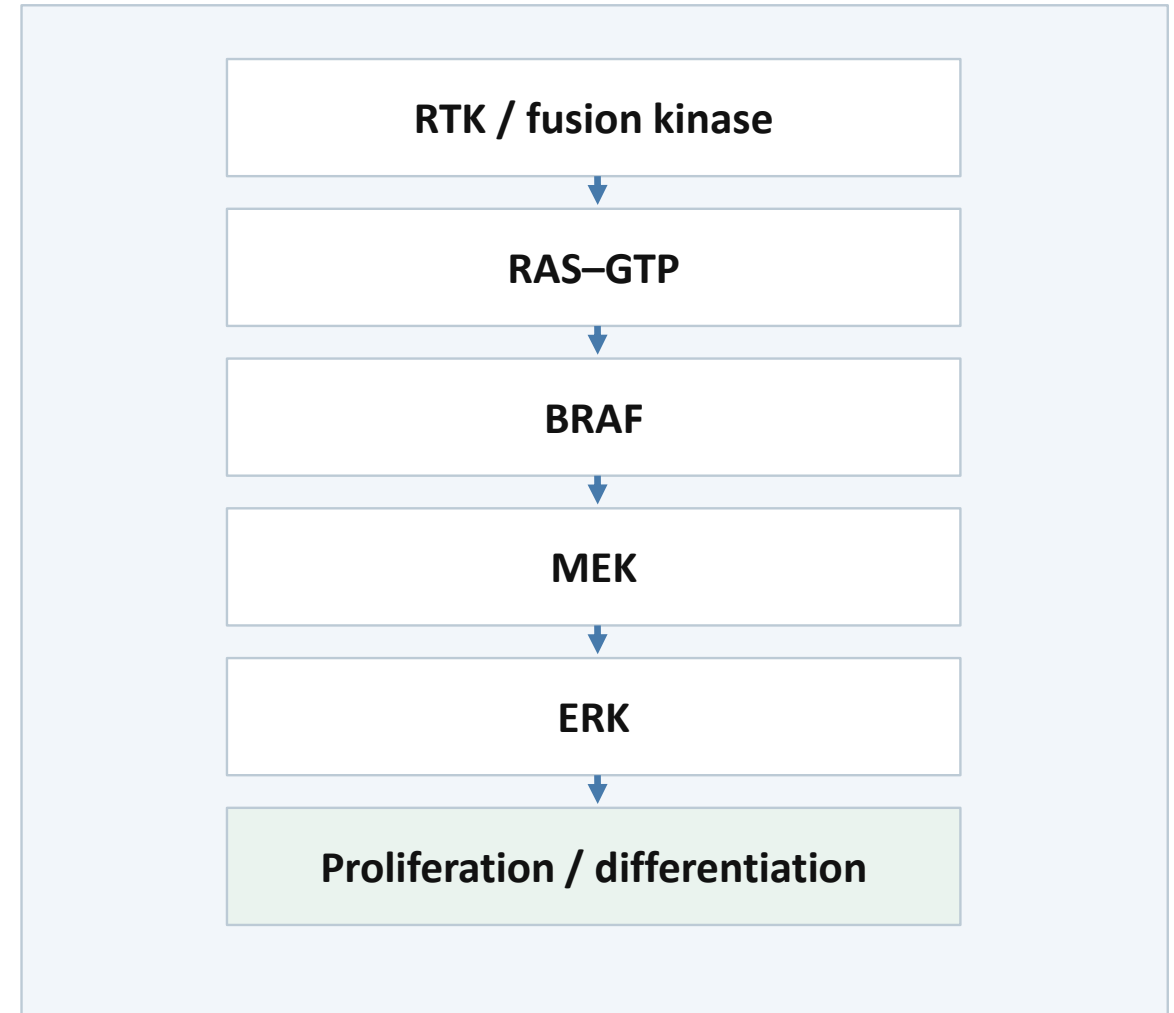


Driver patterns differ across major thyroid tumor classes

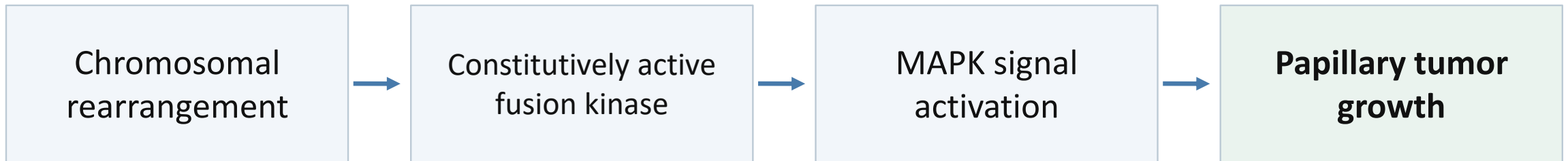
Tumor context	Characteristic molecular alterations	Conceptual consequence
Conventional PTC	BRAF V600E; RET, NTRK, BRAF fusions	MAPK-pathway activation
Follicular-pattern neoplasms	RAS mutations; PAX8::PPARG fusion	Follicular/RAS-like phenotype
Progressed high-grade tumors	Additional TP53; TERT promoter lesions	Dedifferentiation / aggressiveness
Medullary carcinoma	RET activating point mutations	C-cell oncogenesis

BRAF V600E promotes constitutive MAPK activation

- BRAF encodes a serine/threonine kinase downstream of RAS.
- V600E substitutes glutamate for valine at codon 600 and produces gain of function.
- The textbook associates this alteration with reduced expression of thyroid differentiation markers and possibly higher recurrence risk.



RET and NTRK fusions activate receptor kinases in PTC



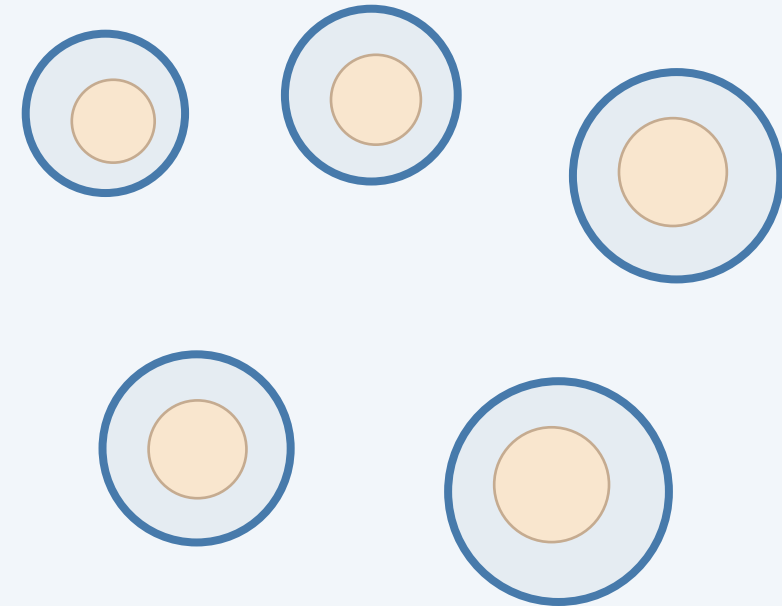
Schematic mechanism; Arrows indicate conceptual sequence

Radiation-associated PTC often has gene fusions

- Ionizing radiation is a major thyroid-cancer risk factor, especially during childhood or adolescence.
- Radiation can induce DNA double-strand breaks and structural rearrangements.
- Fusion kinases are particularly relevant in radiation-associated and some childhood papillary carcinomas.

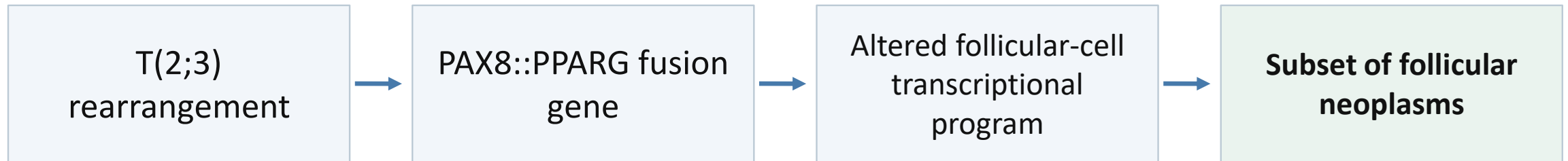
RAS alterations characterize many follicular neoplasms

- RAS mutations occur across follicular adenoma, carcinoma, and NIFTP-related lesions.
- RAS-like tumors often preserve expression of follicular differentiation markers.
- A follicular architectural phenotype does not establish benignity or malignancy.



Colloid-containing follicles (schematic)

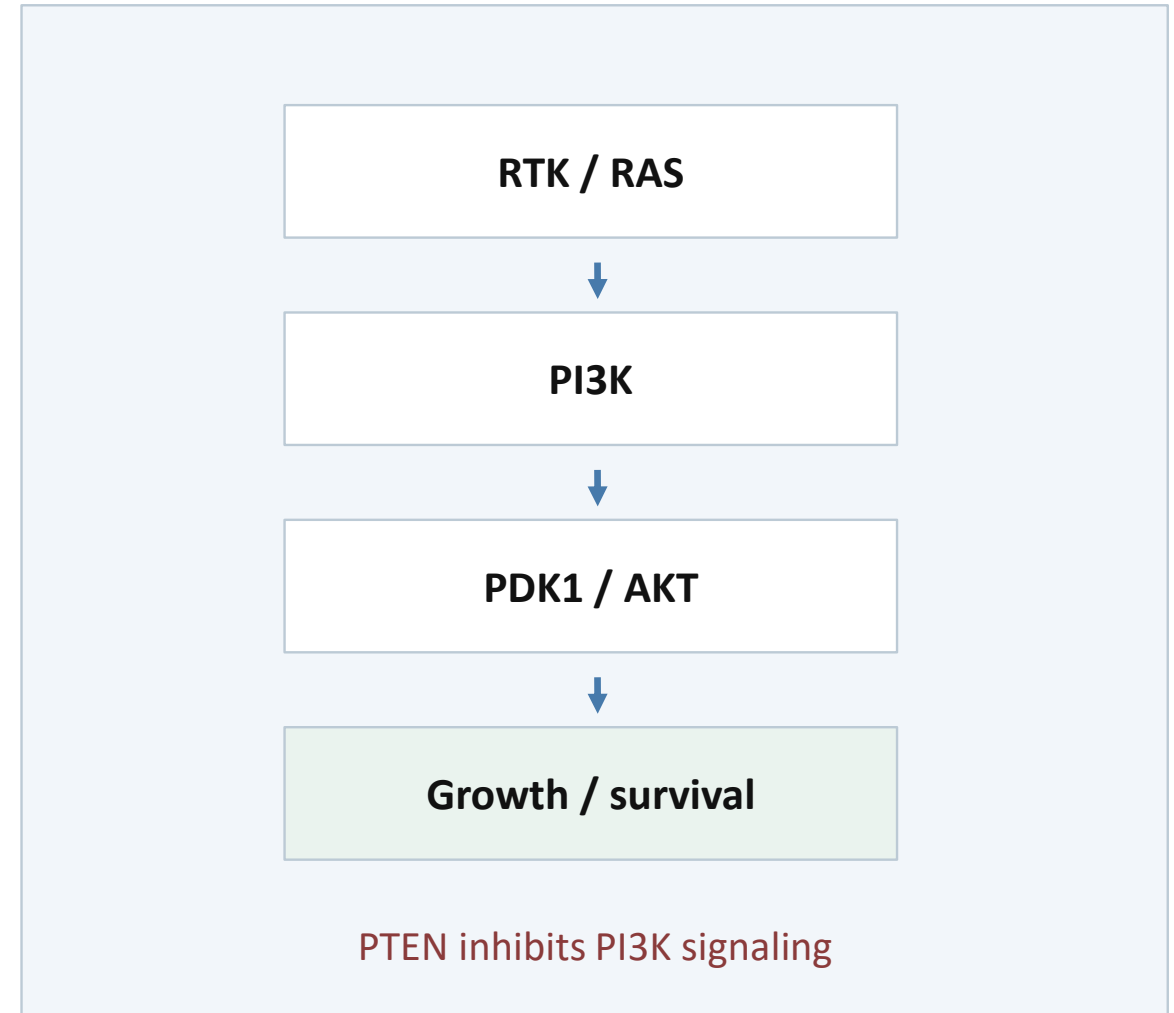
PAX8::PPARG rearrangement characterizes a follicular subset



Schematic mechanism; Arrows indicate conceptual sequence

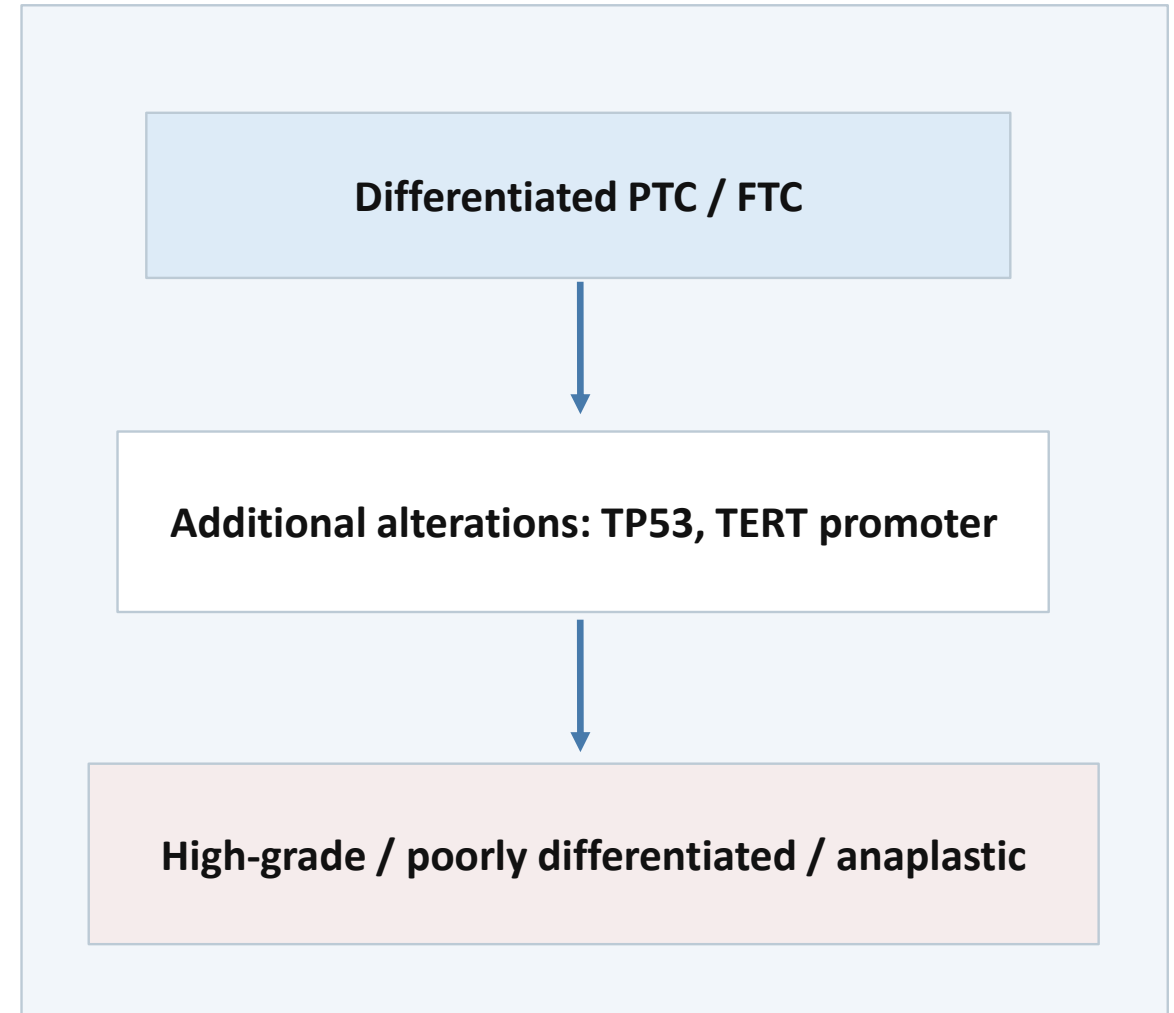
PIK3CA activation or PTEN loss occurs in follicular carcinoma

- PIK3CA encodes a catalytic component of PI3K.
- PTEN is a tumor suppressor antagonizing the PI3K signaling pathway.
- Alterations in a subset of follicular carcinomas, not in every case.



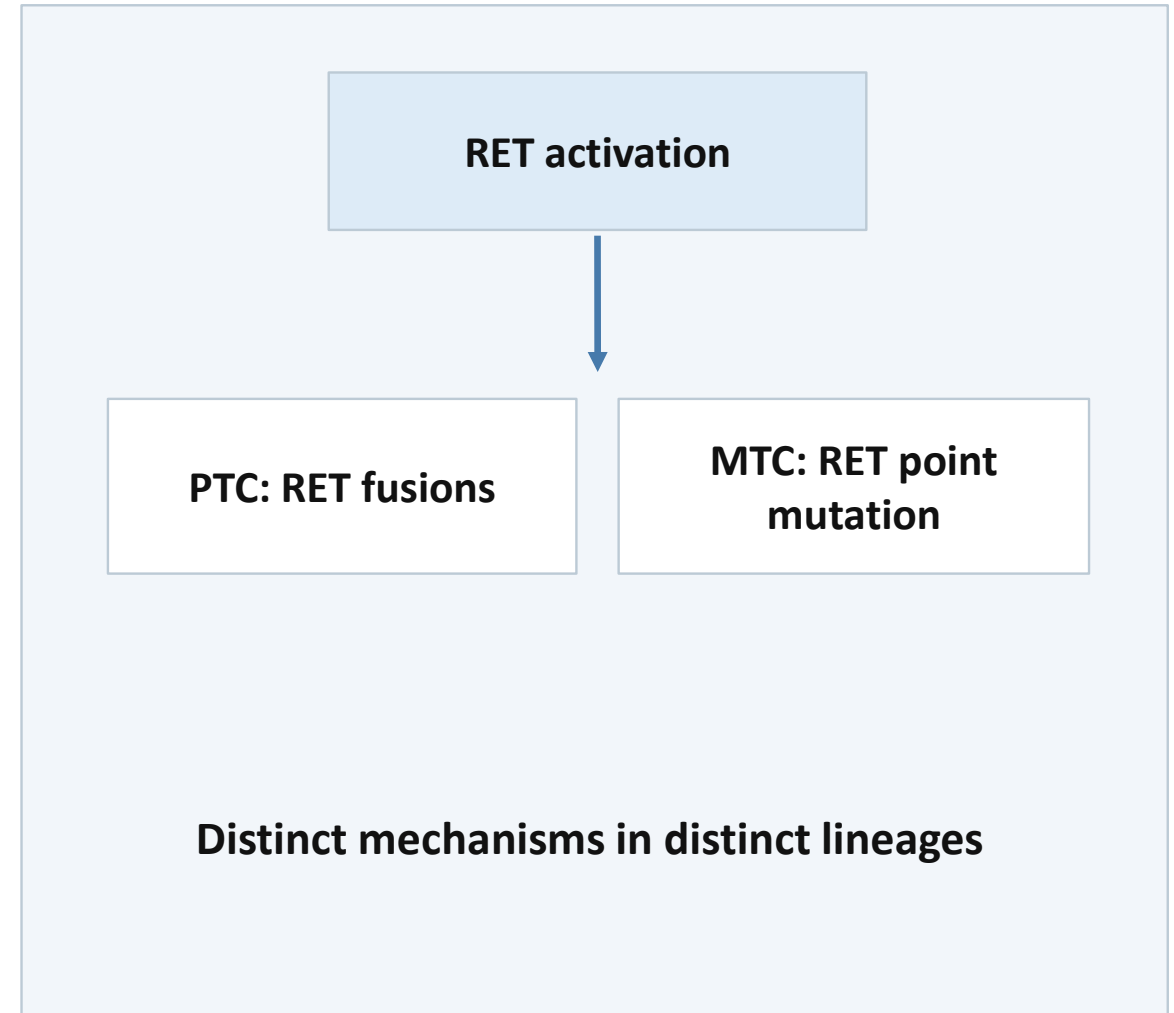
High-grade evolution involves acquisition of additional hits

- High-grade, poorly differentiated, and anaplastic cancers often share earlier drivers with well-differentiated cancers.
- Additional TP53 and TERT promoter mutations are enriched in aggressive lesions.
- Progression is possible, not inevitable, for a differentiated carcinoma.



RET alterations have lineage-specific mechanisms

- RET fusions in papillary carcinoma differ from RET activating point mutations in medullary carcinoma.
- Familial medullary carcinoma is associated with germline activating RET mutations.
- Somatic RET mutations are found in many sporadic medullary carcinomas.



Environmental risk factors have subtype associations

Ionizing radiation

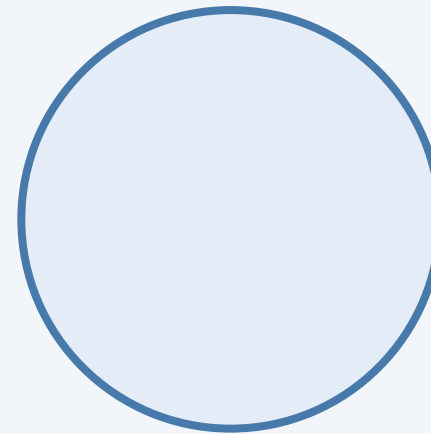
- Exposure during the first two decades is particularly important.
- Papillary carcinomas predominate after such exposure.
- Fusion-generating chromosomal breaks are implicated.

Dietary iodine deficiency

- Associated with greater frequency of follicular neoplasms.
- Follicular carcinomas comprise a larger relative share in deficient regions.
- Association does not identify the histologic diagnosis.

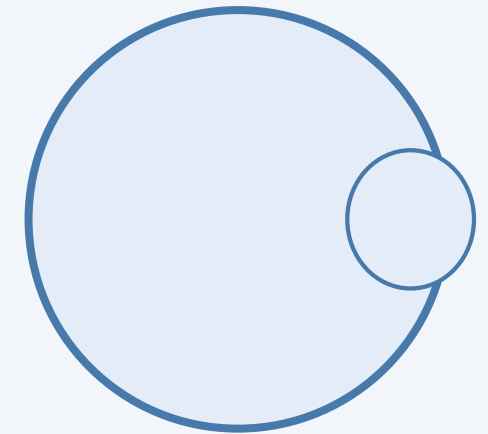
NIFTP is deliberately not classified as invasive cancer

- NIFTP was formerly termed noninvasive encapsulated follicular variant of PTC.
- It has a follicular pattern and PTC-like nuclear features but lacks invasion under strict diagnostic criteria.
- Histologic assessment after surgery is required to make the definitive designation.



Intact capsule

NIFTP (requires strict criteria)



Invasive growth

Invasive EFV-PTC

Most thyroid carcinomas first present as nodules

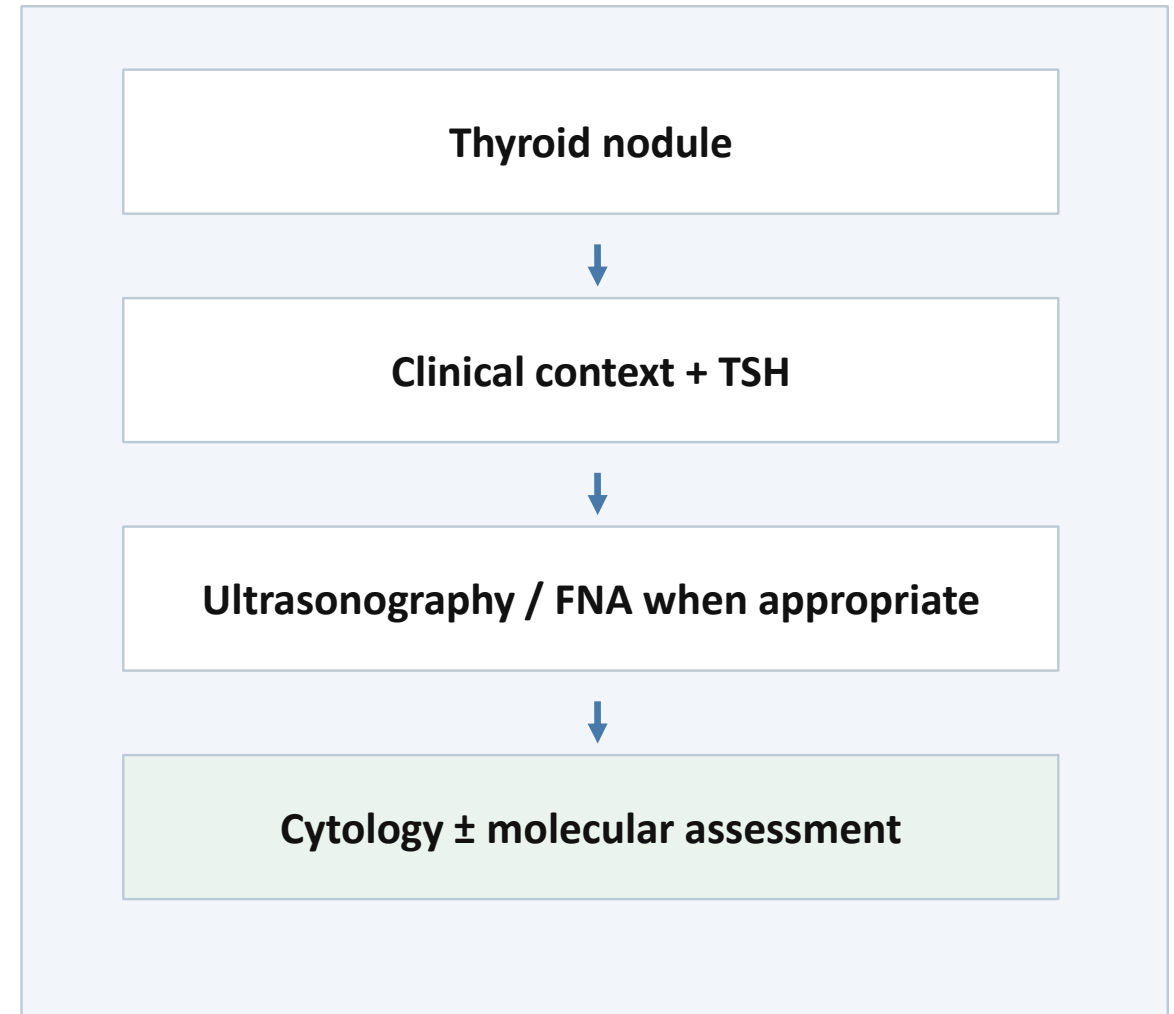
- An asymptomatic thyroid mass is a common initial presentation.
- A cervical lymph node can be the first manifestation of papillary carcinoma.
- Clinical palpation alone usually cannot reliably separate benign from malignant nodules.

Voice and airway symptoms signal possible advanced disease

- Hoarseness raises concern for local invasion or involvement of structures controlling vocal-fold motion.
- Dysphagia, cough, or dyspnea can reflect compressive or infiltrative growth.
- Rapid enlargement with obstructive symptoms is especially concerning for anaplastic carcinoma.

Nodule evaluation combines clinical, biochemical, and cytologic data

- TSH is relevant to the decision to use radionuclide scintigraphy.
- Ultrasonography helps characterize nodules and guides sampling when indicated.
- Fine-needle aspiration cytology is important, with molecular tests useful for indeterminate results.

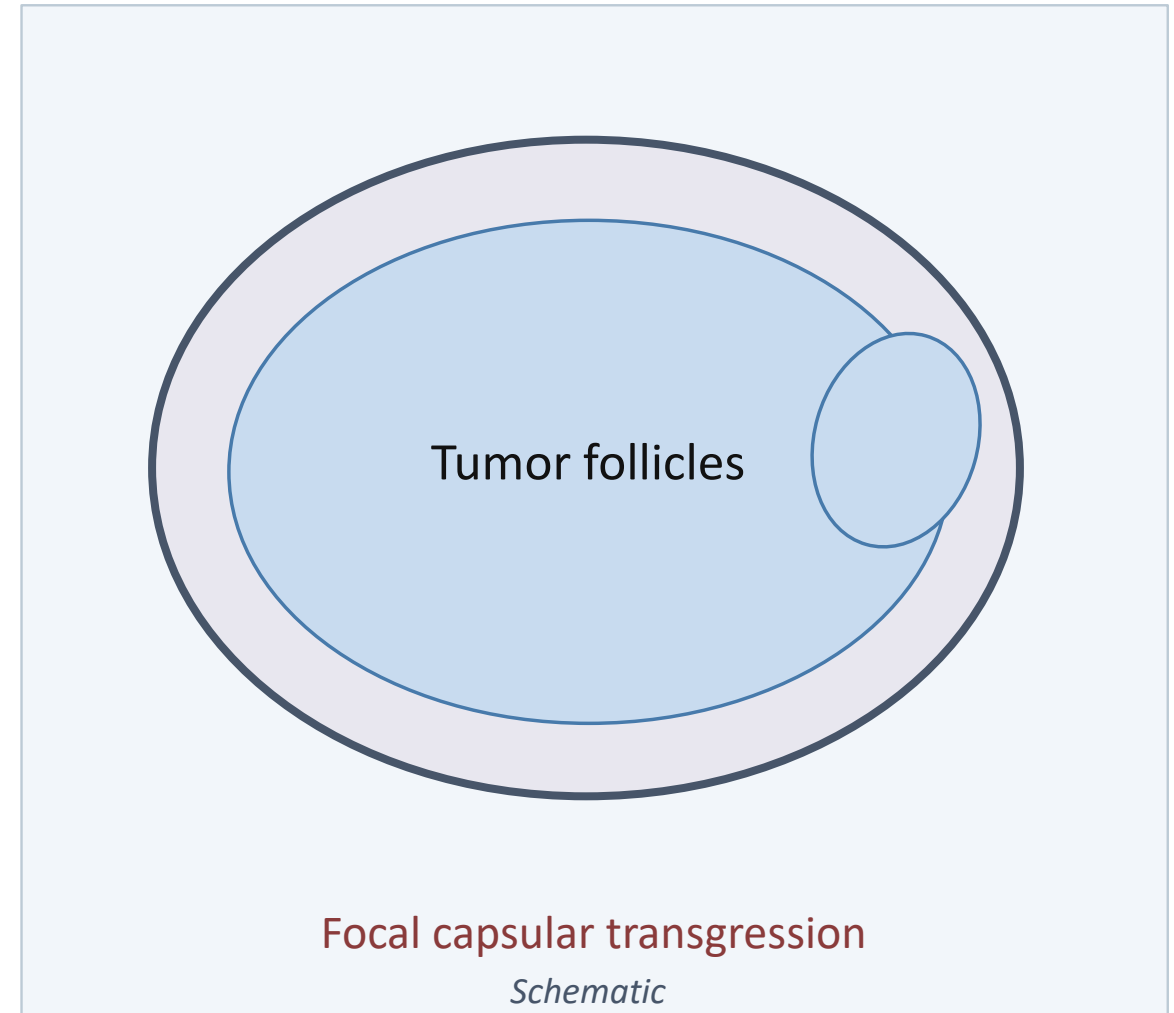


A “hot” nodule is usually not malignant

- Papillary carcinomas as usually scintigraphically “cold.”
- Hyperfunctioning “hot” nodules are almost never malignant.
- Scintigraphy is generally reserved for a low TSH rather than ordered for every thyroid nodule.

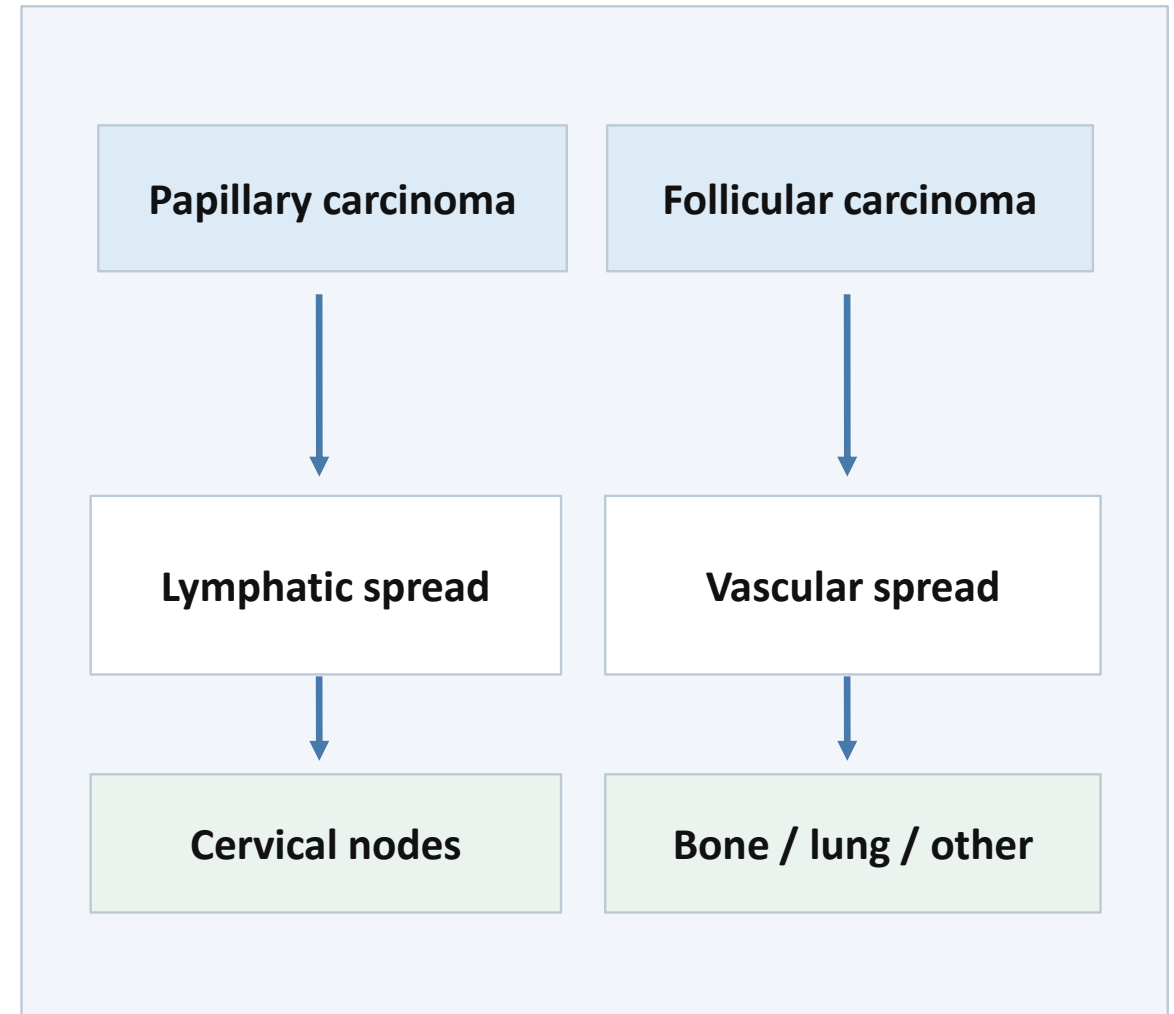
Fine-needle aspiration cannot prove follicular invasion

- Follicular adenoma and minimally invasive follicular carcinoma are cytologically indistinguishable.
- The malignant criterion is capsular and/or vascular invasion in histologic sections.
- Surgical tissue and extensive capsule sampling are therefore essential for classification.



Dissemination patterns provide a mechanistic diagnostic clue

- Conventional papillary carcinomas frequently invade lymphatics and spread to cervical lymph nodes.
- Follicular carcinomas prefer hematogenous dissemination to distant organs.
- The pattern reflects differences in invasive behavior, not an absolute rule.



Papillary carcinoma dominates the clinical workload

- Papillary thyroid carcinoma is the most common primary thyroid malignancy.
- Presentation most often between ages 25 and 50.
- Prior ionizing radiation exposure is a particularly relevant association.

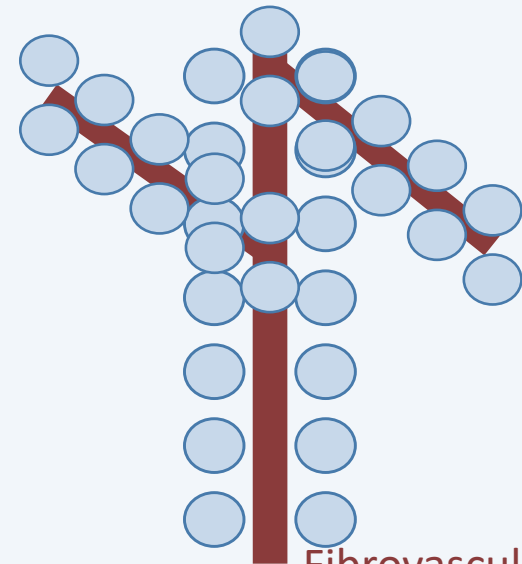
Papillary carcinoma may be solitary or multifocal

- Grossly, some lesions are well circumscribed; Others infiltrate surrounding parenchyma.
- Fibrosis, calcification, cystic change, and papillary cut-surface foci may occur.
- Gross appearance alone does not replace microscopic nuclear evaluation.

True papillae have fibrovascular cores

- Branching papillae contain a vascular connective-tissue stalk.
- Cuboidal neoplastic epithelium covers the cores in one or more layers.
- Architecture is useful, but papillary-type nuclear morphology remains essential.

Epithelial lining

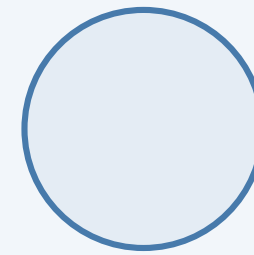


Fibrovascular core

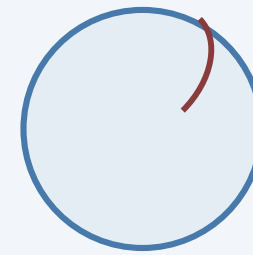
Schematic branching papilla

Papillary carcinoma nuclei display chromatin clearing

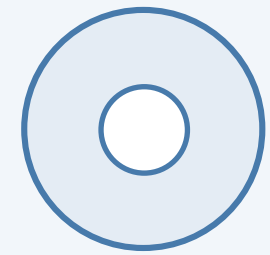
- Finely dispersed chromatin produces a pale or optically empty nuclear appearance.
- The classic descriptor is “Orphan Annie eye” nucleus.
- A constellation of nuclear findings is more reliable than one isolated feature.



Cleared
chromatin



Nuclear groove

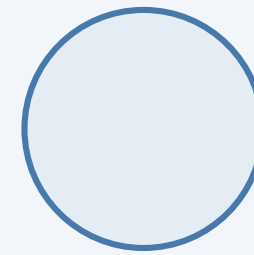


Pseudoinclusio
n

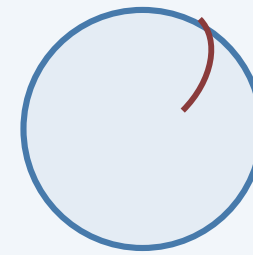
Schematic nuclear appearances; Not a histologic specimen

Nuclear grooves and pseudoinclusions are diagnostic clues

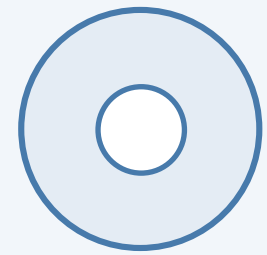
- Nuclear membrane irregularities may produce grooves or wrinkling.
- Intranuclear cytoplasmic pseudoinclusions represent invagination of cytoplasm.
- These are cytomorphologic findings—not evidence of a separate viral inclusion process.



Cleared
chromatin



Nuclear groove

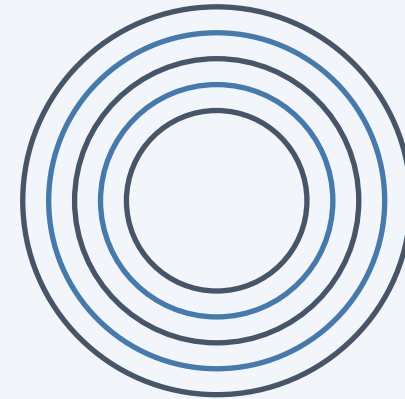


Pseudoinclusion
n

Schematic nuclear appearances; Not a histologic specimen

Psammoma bodies are lamellated calcifications

- Concentric calcified bodies may occur in papillary cores or adjacent stroma.
- Psammoma bodies strongly suggest papillary thyroid carcinoma when found in FNA material.
- They are uncommon in typical follicular and medullary carcinomas.

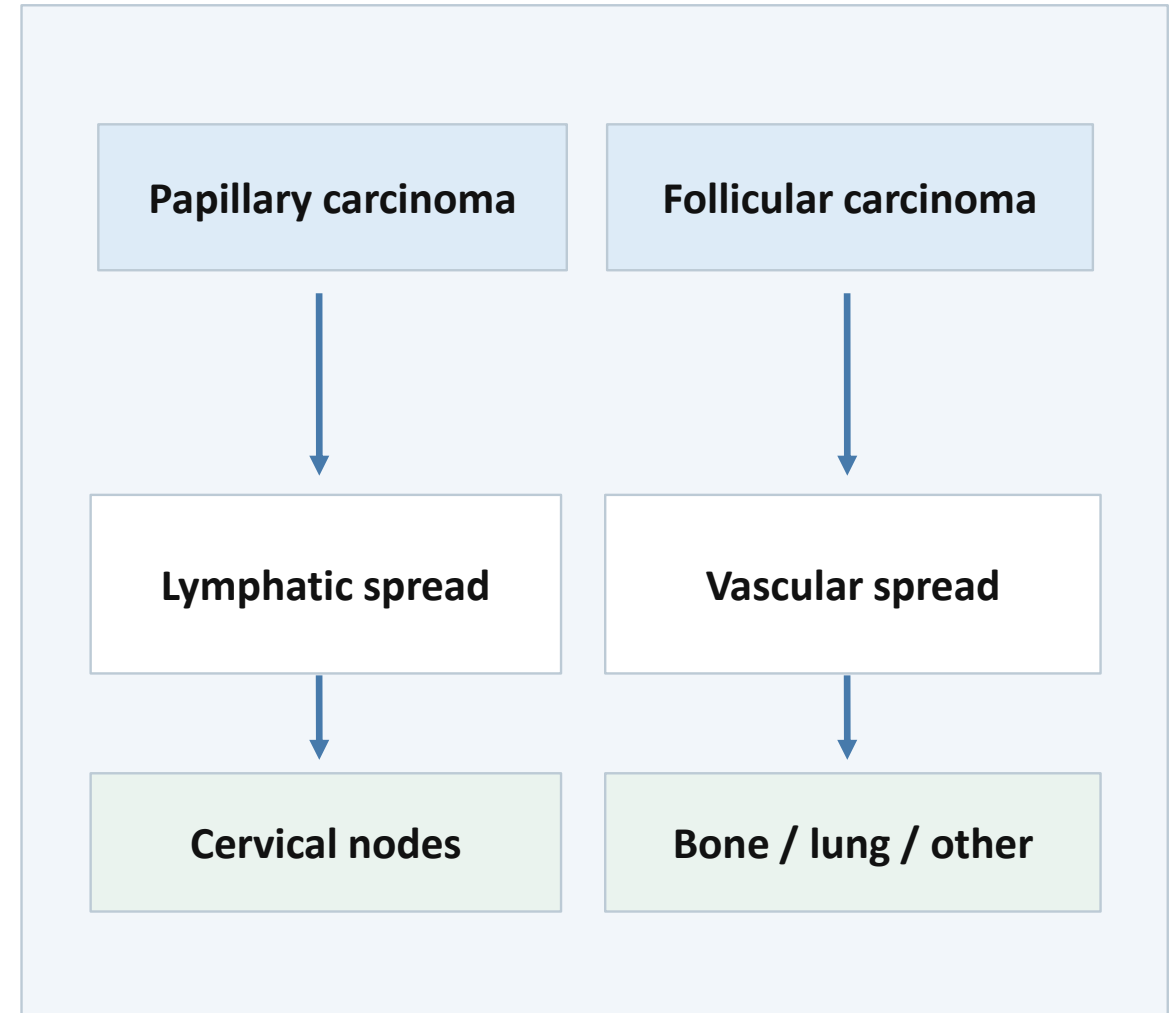


Concentric lamellated calcification

Schematic; Not an H&E image

Papillary carcinoma favors lymphatic dissemination

- Lymphatic tumor invasion is often present microscopically.
- Regional cervical lymph node metastases are relatively common.
- Lymph node involvement must be interpreted in the context of overall stage and recurrence risk.



PTC clinical course often remains favorable

- Many tumors present as asymptomatic nodules or incidentally detected small masses.
- A 10-year survival exceeding 95% in PTC.
- Long-term surveillance remains relevant because recurrence may occur despite favorable mortality.

Papillary carcinoma prognosis depends on extent and host factors

- Older age is associated with less favorable prognosis in the source.
- Extrathyroidal extension indicates invasion beyond the thyroid.
- Distant metastasis is an important determinant of stage and outcome.

Treatment intensity follows recurrence-risk profile

Selected lower-risk disease

- Lobectomy alone may provide excellent outcomes in appropriate patients.
- Preservation of endocrine function can be advantageous.
- Avoiding unnecessary surgical morbidity matters.

Higher recurrence-risk disease

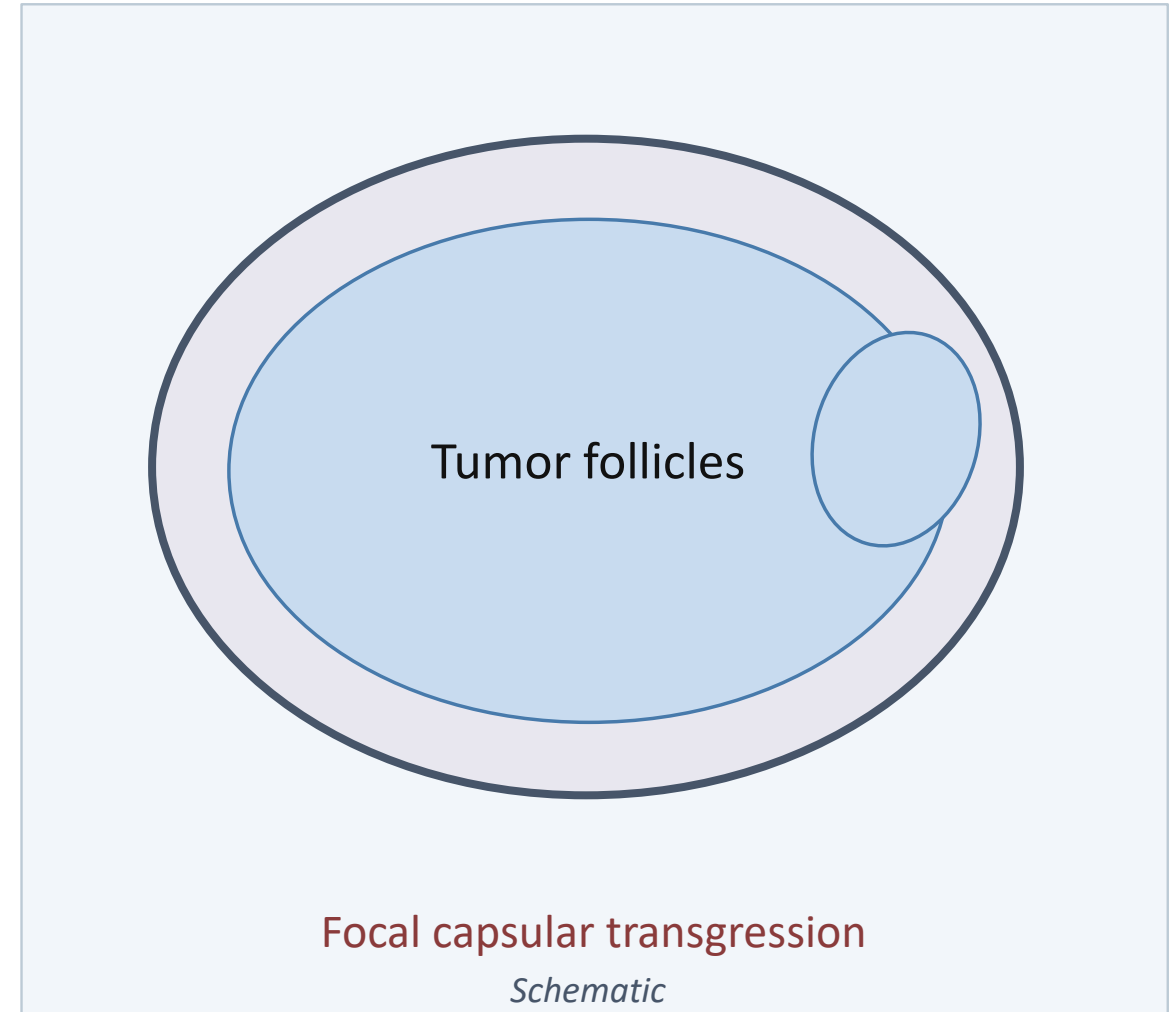
- May require total thyroidectomy.
- Radioactive iodine is used in appropriately selected patients.
- Risk stratification precedes treatment choice.

Thyroid surgery involves functional trade-offs

- Lobectomy preserves contralateral thyroid tissue.
- More extensive thyroid surgery may increase risks such as vocal cord palsy from recurrent laryngeal nerve injury.
- Pathology and recurrence risk help determine the appropriate extent of surgery.

Follicular carcinoma is defined by invasion

- Cells may form well-differentiated follicles resembling normal thyroid.
- Capsular penetration and/or vascular invasion differentiates carcinoma from adenoma.
- Bland nuclei and follicle formation do not guarantee benign behavior.

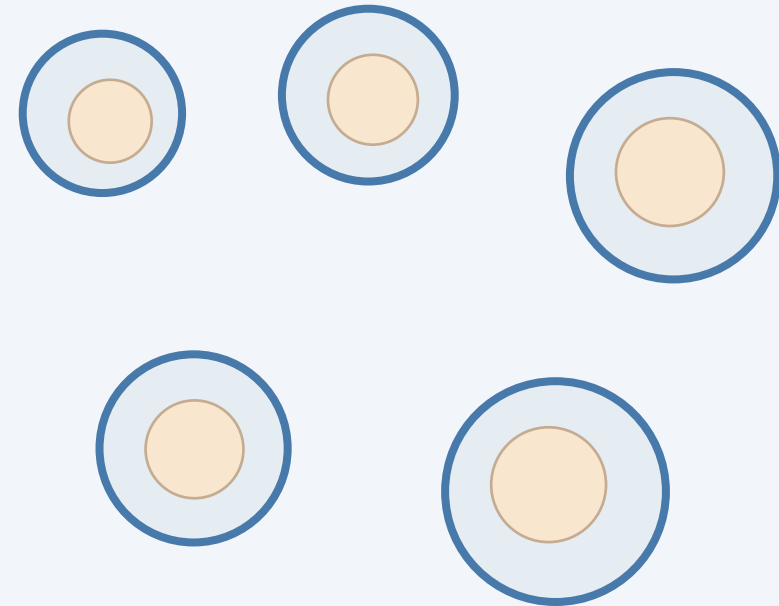


Follicular carcinoma often forms a solitary mass

- Nodules may be sharply circumscribed or widely infiltrative.
- Cut surfaces range from gray/tan to pink and may be colloid-rich.
- Large cancers can penetrate the capsule and invade the surrounding neck.

Follicular carcinoma may resemble ordinary thyroid tissue

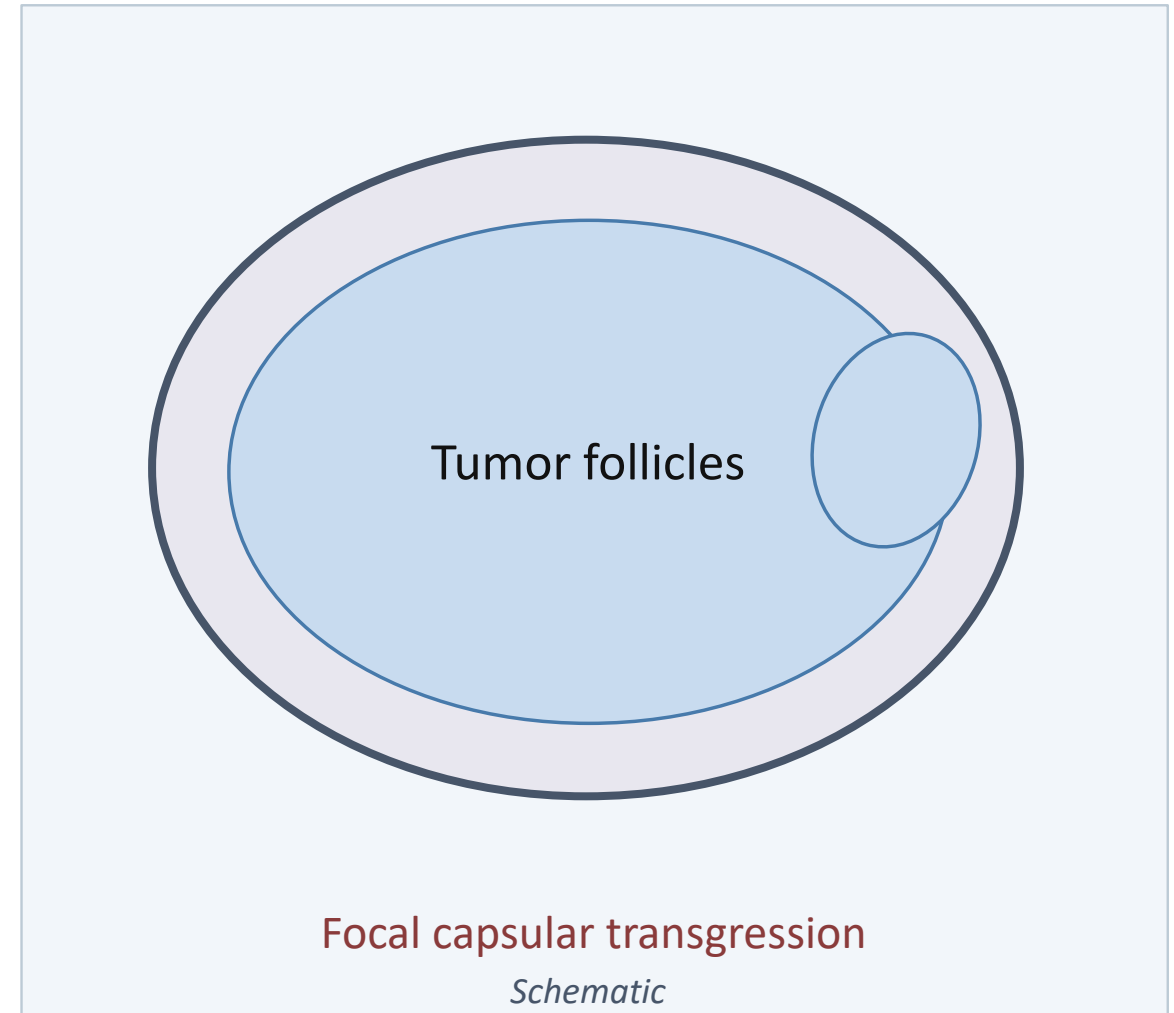
- Uniform follicular cells often surround lumina containing colloid.
- Typical PTC nuclear features are absent in conventional follicular carcinoma.
- Psammoma bodies are not expected.



Colloid-containing follicles (schematic)

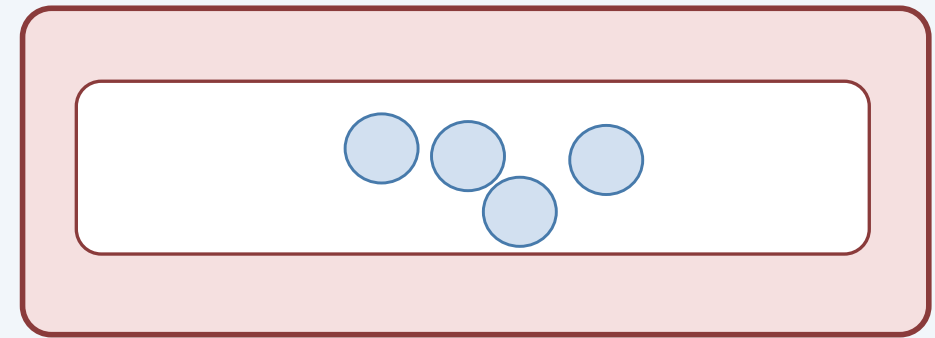
Capsular invasion requires careful histologic scrutiny

- The critical observation is complete transgression of the tumor capsule by neoplastic tissue.
- Sampling must distinguish true invasion from an irregular but intact capsule.
- Adequate capsule examination is necessary to avoid underdiagnosis.



Vascular invasion establishes follicular malignancy

- Tumor infiltration into venous channels within or immediately beyond the capsule is significant.
- Its identification cannot be made with aspirated free cells alone.
- Vascular access explains the preference for hematogenous metastasis.



Tumor cells within capsular vessel

Schematic; Histologic confirmation required

Minimal versus extensive invasion changes prognosis

Minimally invasive carcinoma

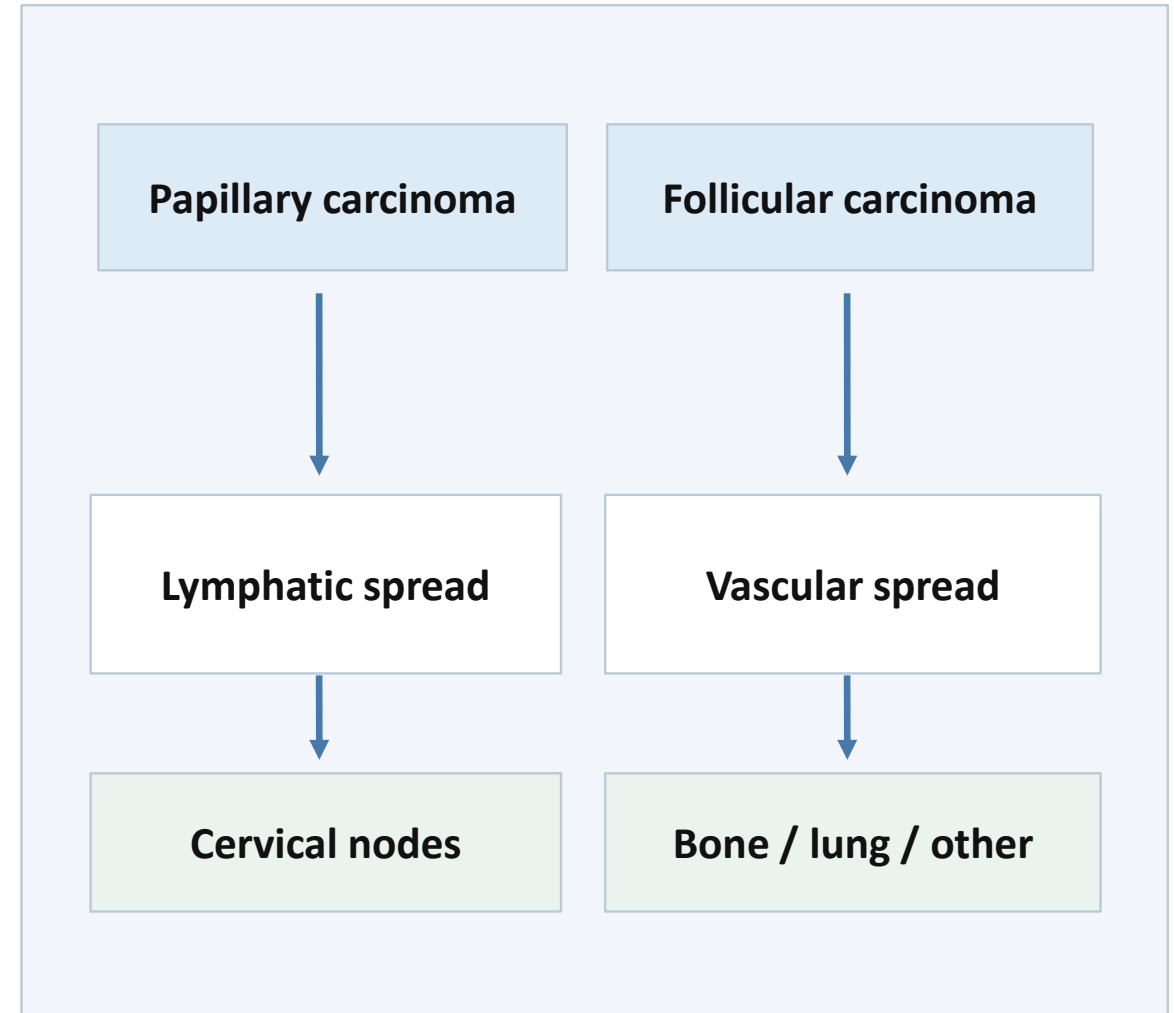
- May have low recurrence risk.
- 10-year survival exceeding 90%.
- Extent of invasion and stage require histologic assessment.

Widely invasive carcinoma

- Frequently demonstrates extension into thyroid or beyond.
- May present with distant metastatic disease.
- Associated with substantially worse long-term outcome.

Follicular carcinoma spreads predominantly through blood

- Regional lymphatic nodal involvement is typically less conspicuous than in PTC.
- Distant sites include bone, lung, liver, brain, and others.
- Clinical staging must consider remote organs, not just cervical nodes.



Iodine handling and thyroglobulin inform follow-up

- Differentiated follicular-derived tumor deposits may take up radioactive iodine.
- TSH suppression with thyroid hormone is described to limit trophic stimulation of residual tumor.
- After total thyroidectomy, circulating thyroglobulin can help monitor persistent or recurrent differentiated disease.

Oncocytic carcinoma is a follicular-lineage variant

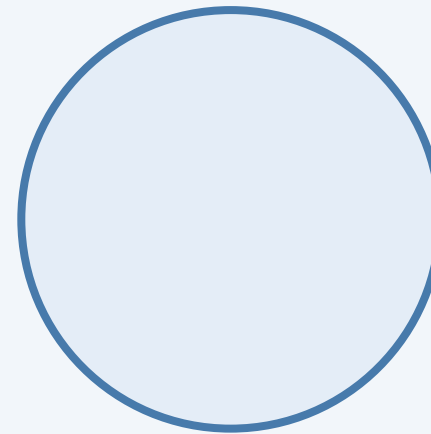
- Oncocytic tumor cells have abundant granular eosinophilic cytoplasm.
- Oncocytic cytology alone does not establish malignant behavior.
- The distinction between oncocytic adenoma and carcinoma still depends on invasive features.

NIFTP arose from outcome-driven reclassification

- Historically, encapsulated noninvasive follicular-variant tumors were labeled carcinomas.
- With strict absence of invasion, their risk of recurrence or metastasis is extremely low.
- The NIFTP label avoids treating all such lesions as biologically equivalent to invasive carcinoma.

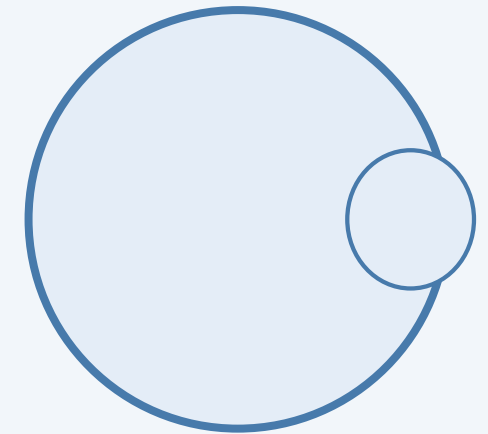
NIFTP retains a follicular pattern with PTC-like nuclei

- Follicles form the dominant architecture rather than conventional branching papillae.
- Nuclei show enlargement, clearing, and membrane abnormalities reminiscent of PTC.
- The decisive distinction is strict absence of invasion after tissue sampling.



Intact capsule

NIFTP (requires strict
criteria)

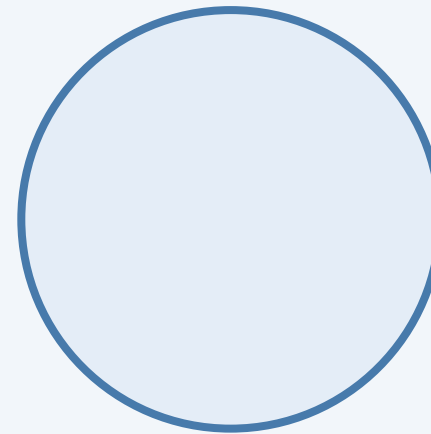


Invasive growth

Invasive EFV-PTC

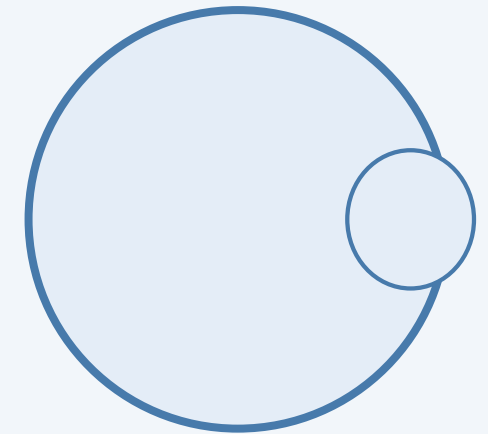
Invasive encapsulated follicular variant PTC is malignant

- Invasive EFV-PTC shares some nuclear and molecular similarities with NIFTP.
- Capsular, vascular, or intrathyroidal invasion invalidates a NIFTP diagnosis.
- Vascular invasion explains potential hematogenous dissemination.



Intact capsule

NIFTP (requires strict criteria)



Invasive growth

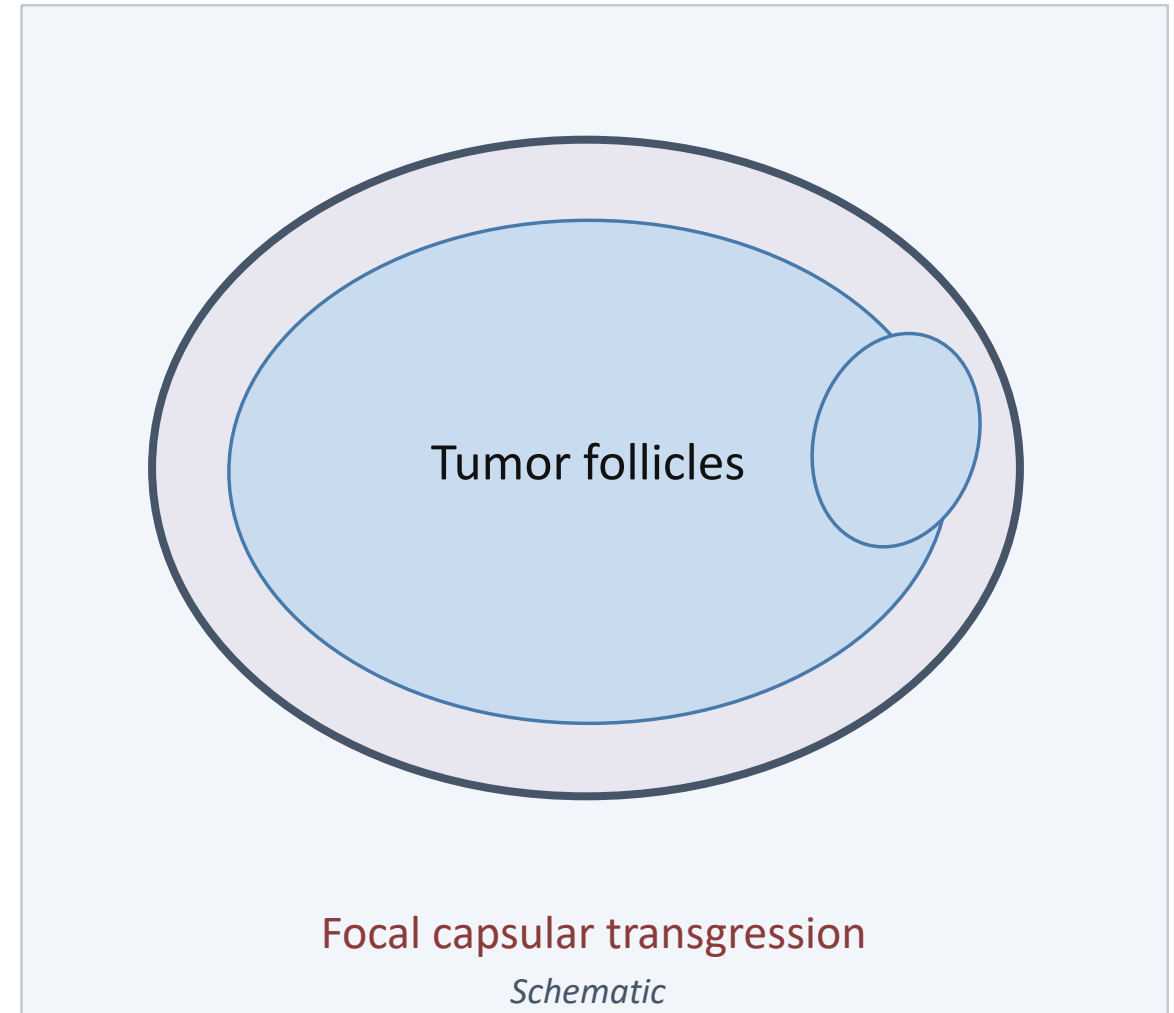
Invasive EFV-PTC

Follicular-pattern lesions require a structured differential

Entity	Nuclear phenotype	Invasion
Follicular adenoma	No characteristic PTC-type nuclear features	Absent
Follicular carcinoma	Usually lacks PTC-type nuclear features	Capsular / vascular
NIFTP	PTC-like nuclear features	Absent under strict criteria
Invasive EFV-PTC	PTC-like nuclear features	Present

The capsule is both an anatomic and diagnostic boundary

- An intact capsule around a follicular neoplasm does not prove carcinoma.
- Transcapsular or vascular invasion provides decisive malignant evidence.
- The distinction influences terminology, prognosis, and treatment intensity.



Some thyroid tumors lose follicular differentiation

- High-grade differentiated and poorly differentiated carcinomas show aggressive histologic features.
- Anaplastic carcinoma largely loses recognizable thyroid follicular morphology.
- The source associates progressive aggressiveness with acquired molecular alterations.

Differentiated carcinoma

Generally favorable

High-grade differentiated / PDTC

More aggressive

Anaplastic carcinoma

Very poor prognosis

High-grade thyroid tumors may show necrosis and mitoses

- Tumor necrosis and increased mitotic activity are high-grade features.
- Poorly differentiated carcinomas may grow as solid, insular, or trabecular nests.
- These appearances warrant careful distinction from ordinary well-differentiated carcinoma.

Poorly differentiated carcinoma has insular growth

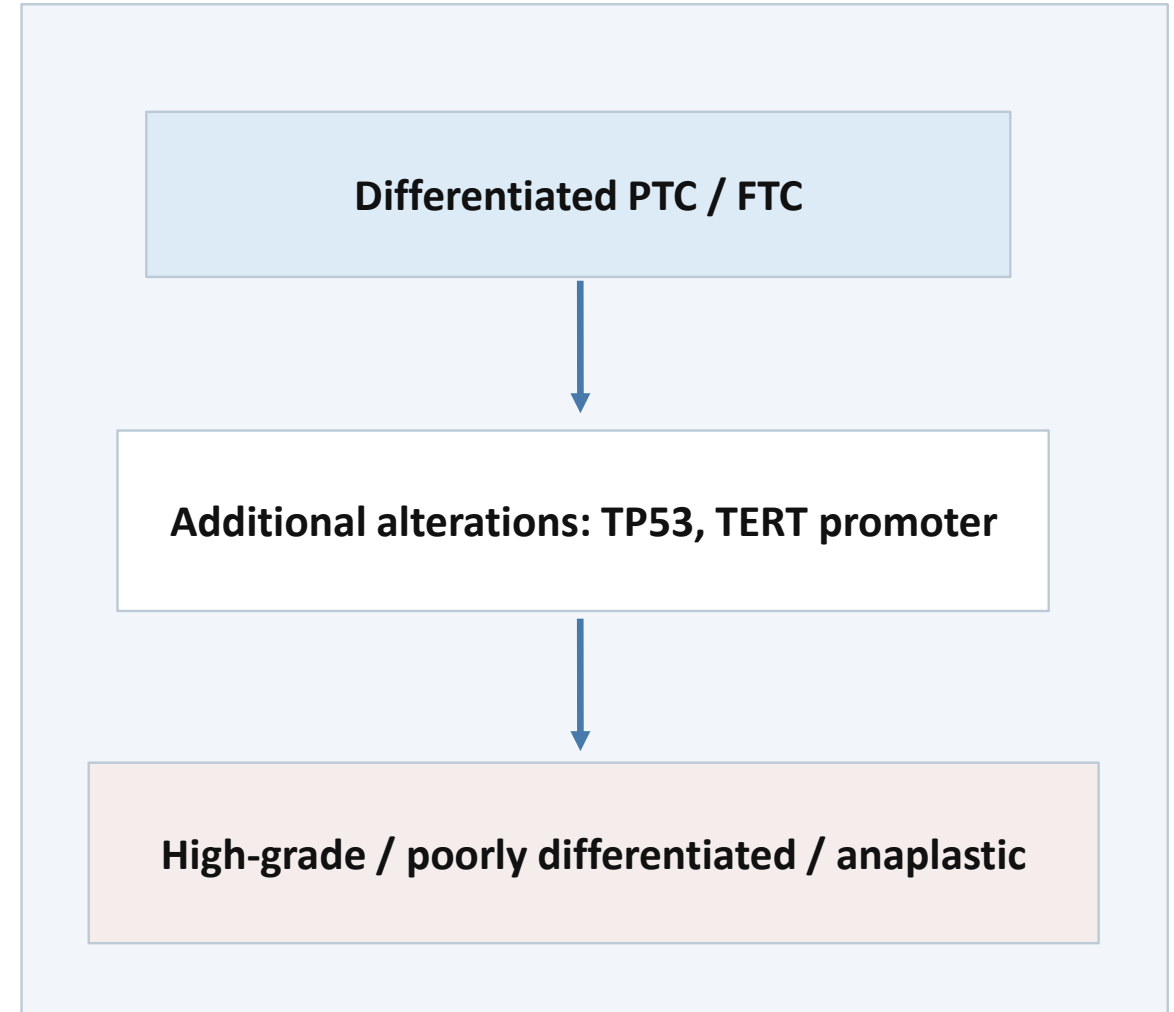
- Solid, insular (nested), and trabecular arrangements replace many familiar follicles.
- A patient may present like a lower-grade thyroid cancer until histology reveals aggressive features.
- The extent of necrosis or mitotic activity informs pathologic interpretation.

Anaplastic carcinoma has marked morphologic heterogeneity

- Cells can appear epithelioid, spindle-shaped, markedly pleomorphic, or giant-cell rich.
- Some tumors mimic squamous carcinoma or a mesenchymal malignancy.
- Foci of differentiated thyroid carcinoma may coexist and support progression.

Anaplastic tumors often lose follicular lineage markers

- Dedifferentiation may remove expression of follicular thyroid differentiation proteins.
- Earlier oncogenic driver mutations can remain detectable despite loss of phenotype.
- Molecular ancestry and current histology are different lines of evidence.



Anaplastic carcinoma often produces an airway emergency

- The presentation is frequently a rapidly enlarging bulky cervical mass.
- Local invasion produces dyspnea, dysphagia, cough, or hoarseness.
- Many patients have extension beyond the thyroid or lung metastases at diagnosis.

Aggressive tumors dominate thyroid-cancer mortality

- Anaplastic thyroid carcinoma has an exceptionally poor prognosis.
- High-grade differentiated and poorly differentiated carcinomas fare better than anaplastic lesions, but worse than typical PTC.
- Biologic grade and invasion pattern are essential alongside anatomic stage.

Differentiated carcinoma

Generally favorable

High-grade differentiated / PDTC

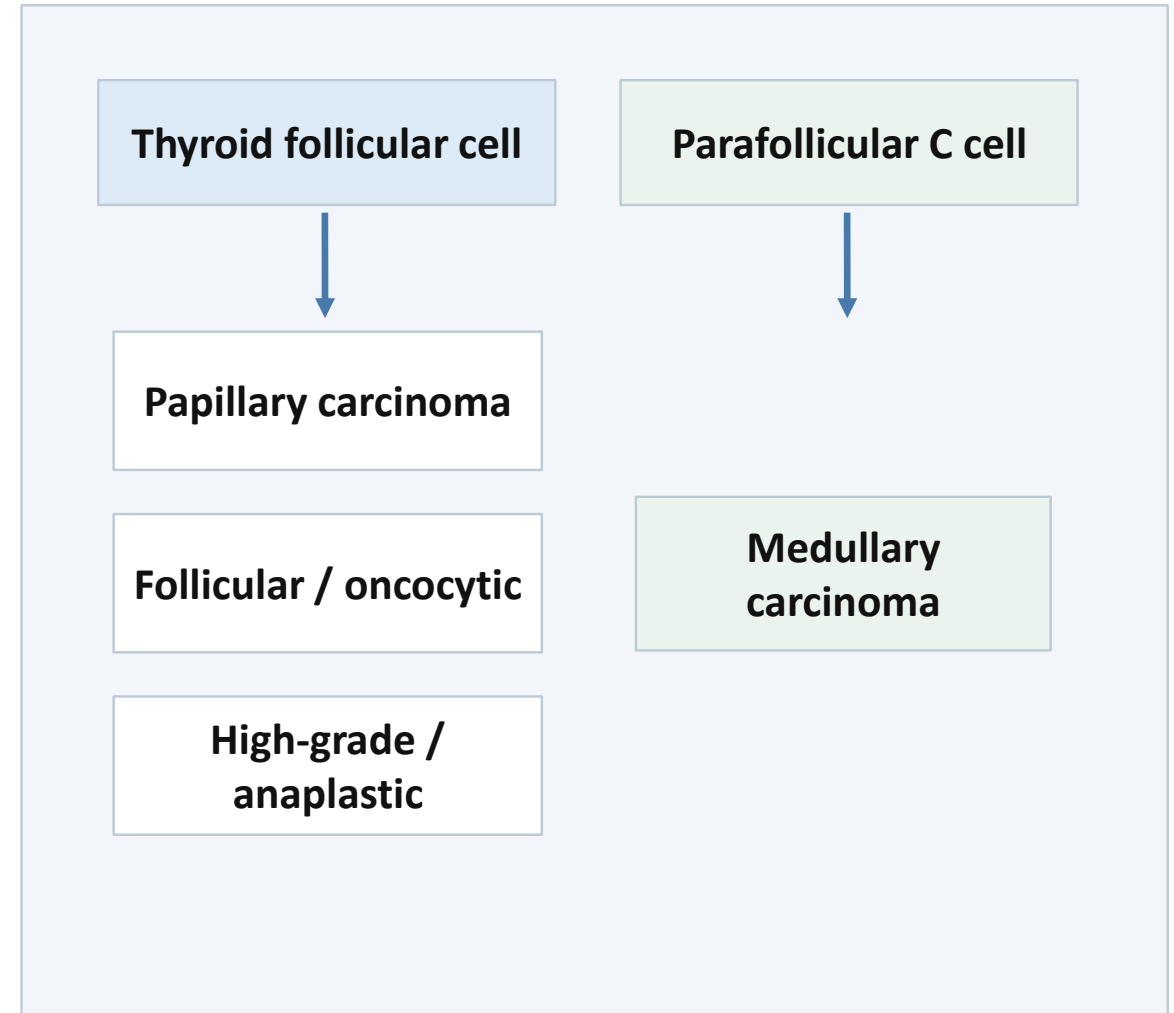
More aggressive

Anaplastic carcinoma

Very poor prognosis

Medullary carcinoma originates from parafollicular C cells

- C cells are calcitonin-producing neuroendocrine cells distinct from thyrocytes.
- Medullary carcinoma may show nests, trabeculae, or occasionally follicle-like arrangements.
- Its biomarkers and inherited predisposition differ from follicular-derived cancer.



Medullary carcinoma may be sporadic or MEN2-associated

Sporadic disease

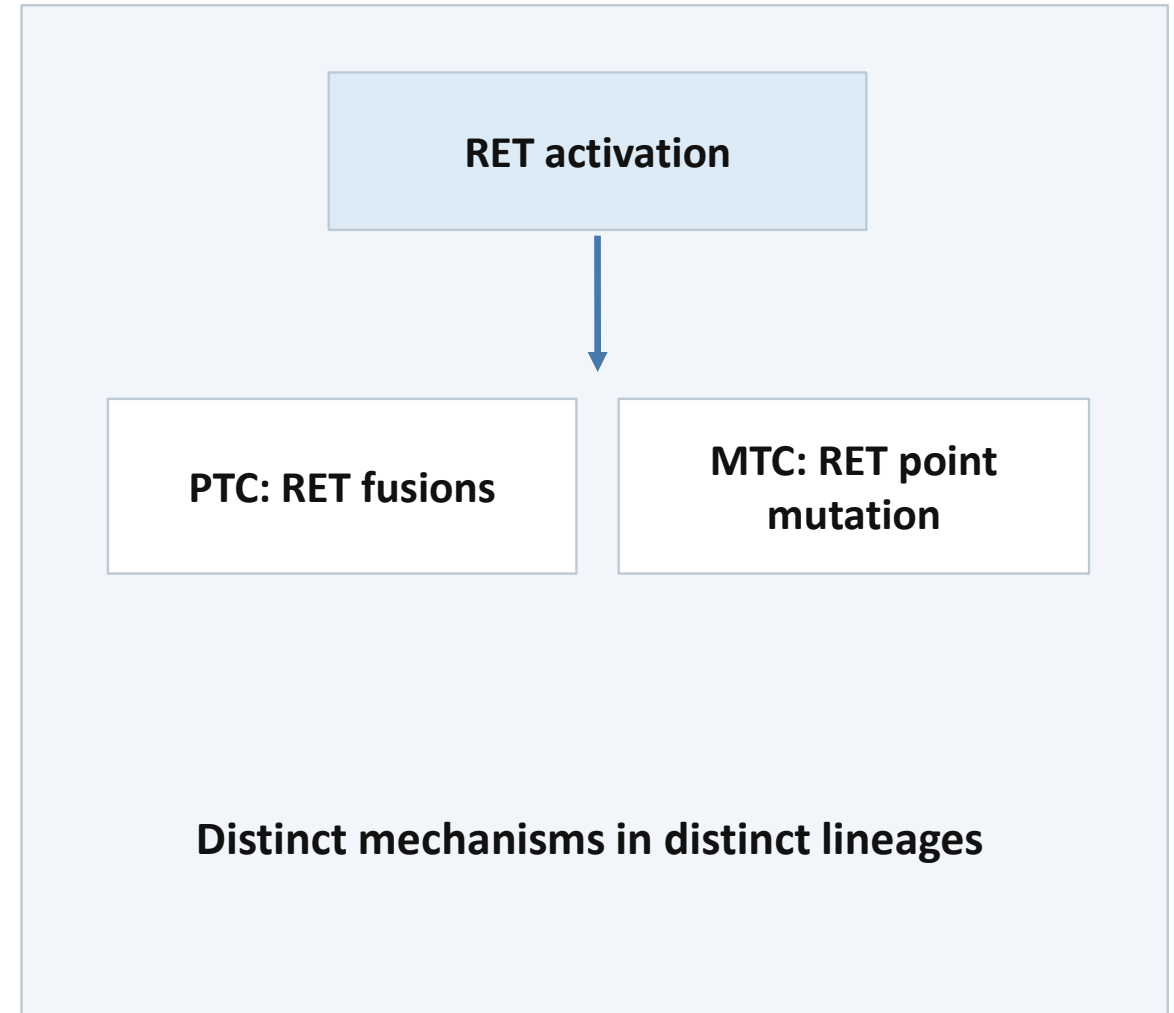
- Most medullary carcinomas arise sporadically in adulthood.
- Somatic activating RET mutations occur in many cases.
- A solitary tumor is the common presentation.

Inherited MEN2 disease

- Germline activating RET mutations underlie predisposition.
- Bilateral or multicentric tumors are common.
- C-cell hyperplasia may be evident nearby.

RET point mutations drive medullary thyroid tumorigenesis

- Constitutively active RET receptor signaling promotes C-cell neoplasia.
- Germline activation predisposes to inherited medullary carcinoma.
- RET fusion oncogenes typical of some PTCs are not the medullary mechanism.

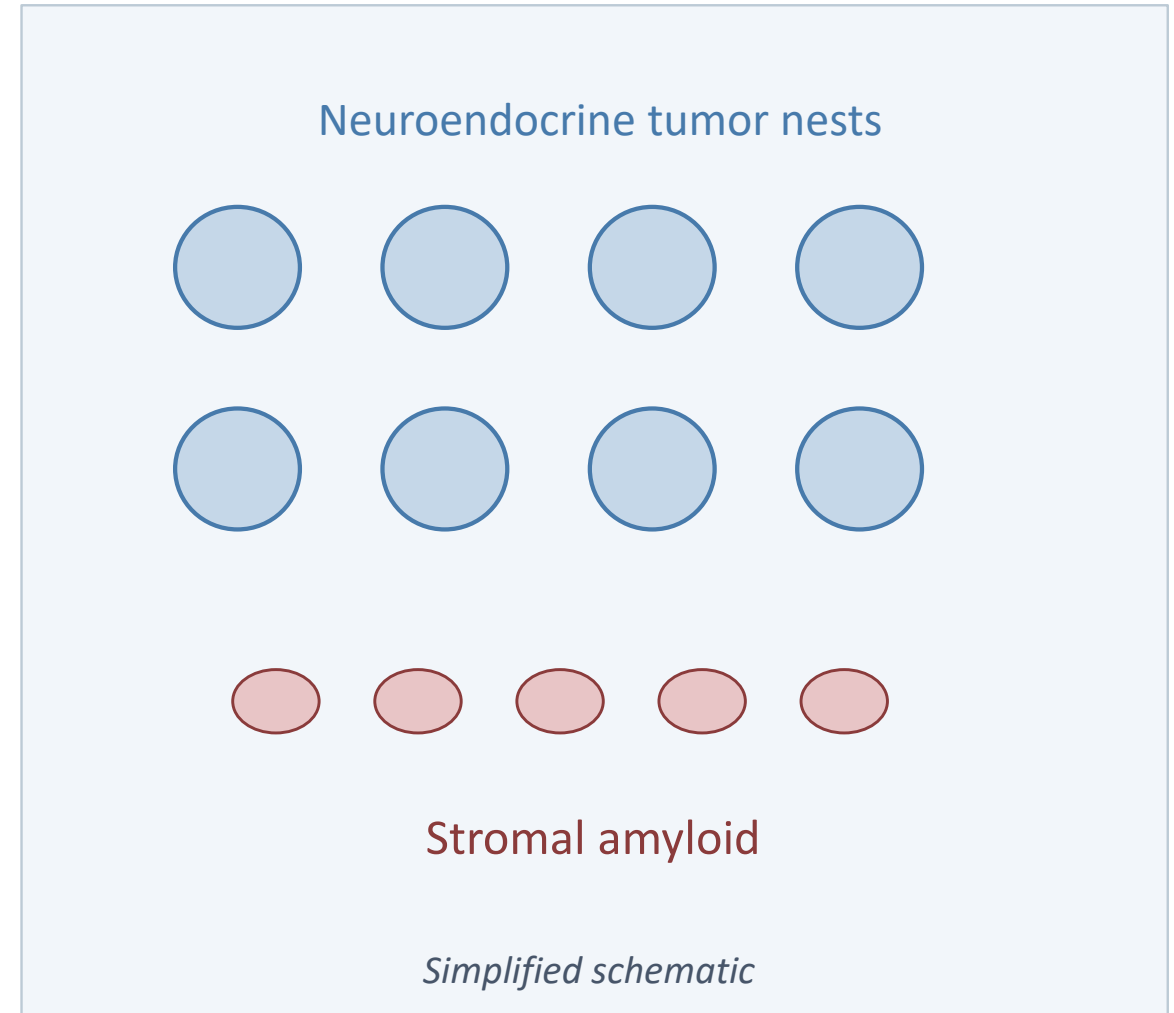


Medullary carcinoma is often infiltrative and nonencapsulated

- Gross tumors are often firm and pale gray-tan.
- Sporadic lesions are commonly solitary, whereas syndromic cases may be bilateral and multicentric.
- Larger masses may show hemorrhage, necrosis, and extrathyroidal extension.

Amyloid in medullary carcinoma derives from calcitonin

- Neoplastic cells may be polygonal or spindle-shaped and arranged in nests or trabeculae.
- Intercellular stromal amyloid deposits derive from calcitonin-related polypeptides.
- This is a biologically meaningful secretory product rather than follicular colloid.

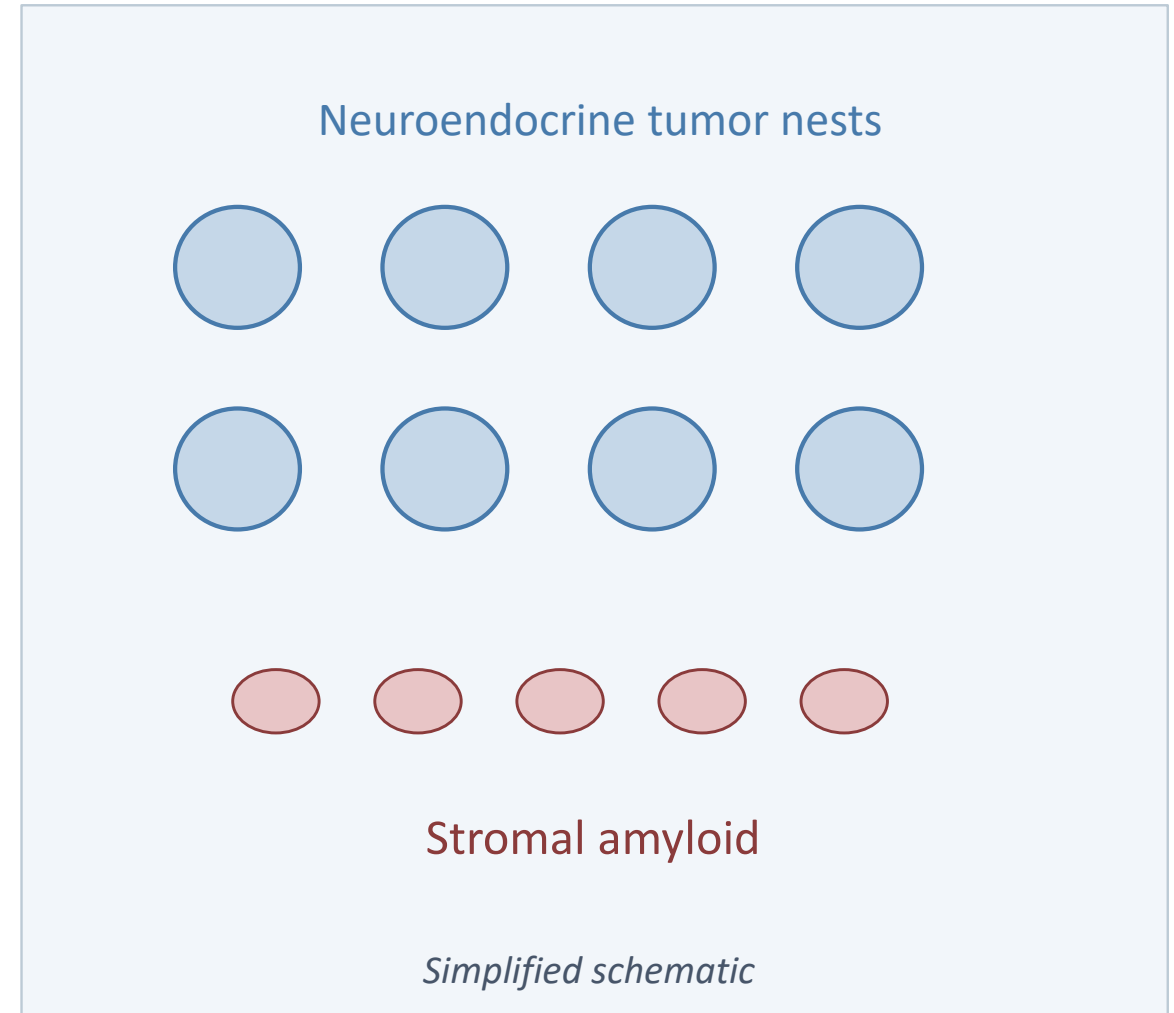


Calcitonin and CEA support medullary monitoring

- Calcitonin is produced by tumor cells and is valuable diagnostically and postoperatively.
- Carcinoembryonic antigen (CEA) is an additional useful tumor marker.
- Marked calcitonin elevation does not usually cause prominent hypocalcemia.

C-cell hyperplasia is an inherited-predisposition clue

- Multiple C-cell clusters in thyroid tissue may precede medullary carcinoma in MEN2.
- The contralateral lobe may show hyperplasia even when the dominant cancer is unilateral.
- This finding should raise suspicion for inherited disease, including when family history is absent.



Medullary tumors may secrete multiple peptide hormones

- Some lesions elaborate vasoactive intestinal peptide and cause diarrhea.
- Ectopic corticotropin secretion may cause a Cushing syndrome.
- Secretory symptoms can occasionally precede recognition of the thyroid mass.

A hereditary RET mutation changes family management

- MEN2-associated medullary carcinoma may develop at very young ages.
- Identification of a germline RET mutation informs familial risk assessment.
- The source describes prophylactic thyroidectomy in asymptomatic carriers, with timing influenced by the RET variant.

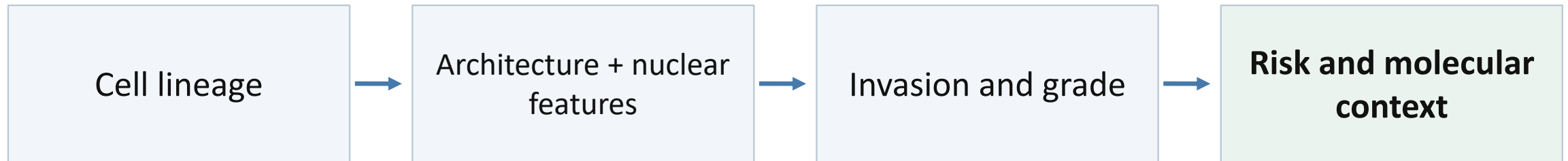
Biomarkers answer different pathologic questions

Marker / alteration	Tumor context	Main interpretive role
BRAF V600E	Conventional PTC	Molecular driver; tumor characterization
RAS / PAX8::PPARG	Follicular-pattern tumors	Molecular phenotype; not proof of invasion
TP53 / TERT promoter	Aggressive follicular-derived tumors	Progression-associated changes
Thyroglobulin	Differentiated follicular-derived tumors	Selected postoperative surveillance
Calcitonin / CEA	Medullary carcinoma	Tumor identification / monitoring

The subtype comparison has three decisive axes

Subtype	Defining pathology	Common spread / clinical clue
Papillary	Nuclear clearing; grooves; papillae; psammoma	Lymphatic → cervical nodes
Follicular	Capsular and/or vascular invasion	Hematogenous → distant organs
Anaplastic	Highly pleomorphic and undifferentiated	Rapid infiltrative neck mass
Medullary	C-cell neuroendocrine tumor; amyloid	Calcitonin / CEA; MEN2 association

Histology and genotype must be interpreted together



Schematic mechanism; Arrows indicate conceptual sequence

Case: Cervical node with papillary-type nuclei

- Teaching vignette (fictional): A patient presents with a cervical node and a small thyroid nodule.
- Cytology demonstrates optically clear nuclei, grooves, and psammoma bodies.
- Question: Which carcinoma and likely route of spread best explain the findings?

Discuss the explanation before advancing

Case resolution: Nuclear phenotype outweighs size

- Papillary-type nuclear features and psammoma bodies favor papillary carcinoma.
- Regional nodal presentation is consistent with lymphatic dissemination.
- Even small primary tumors can present with a cervical nodal metastasis.

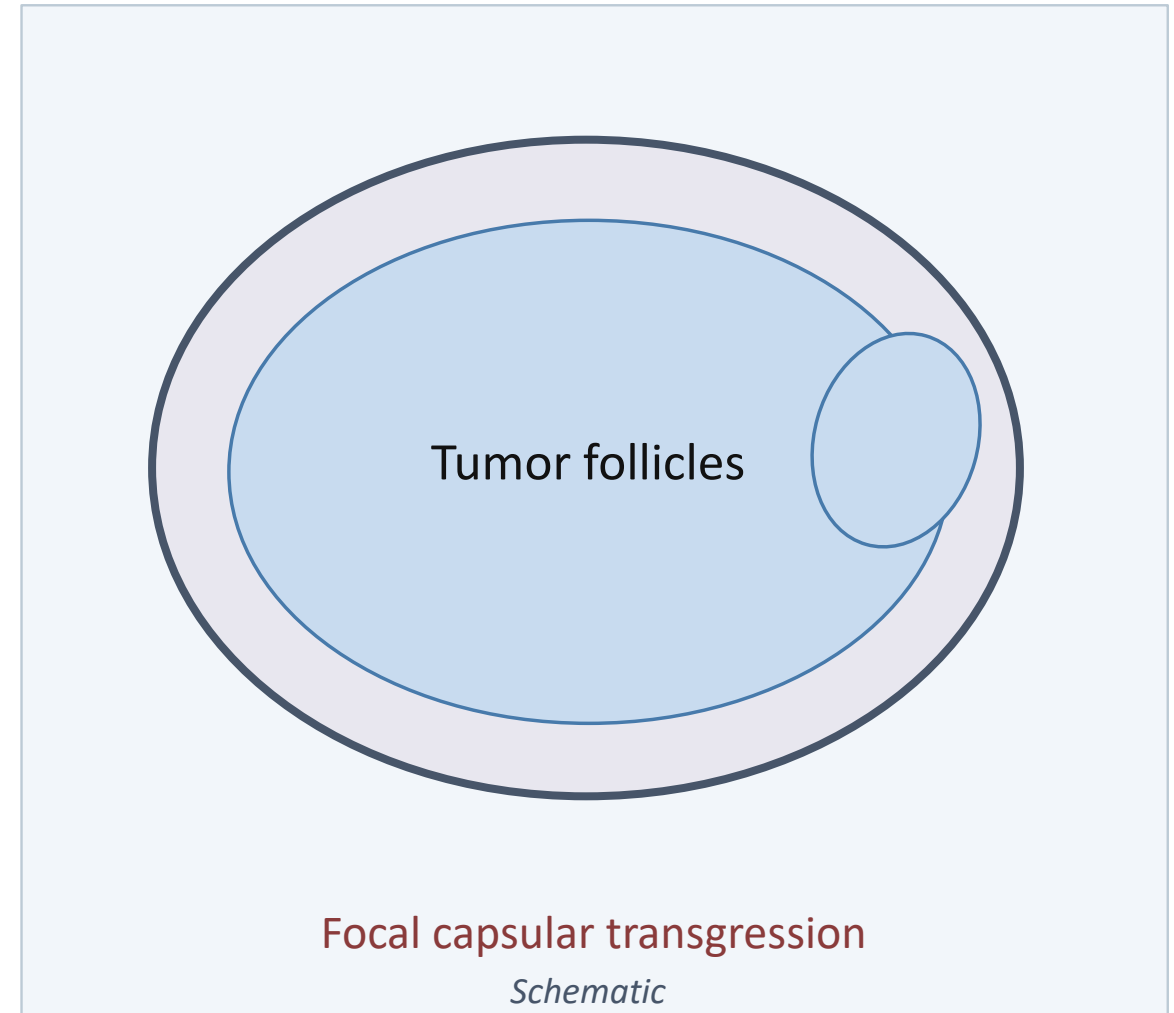
Case: Follicular tumor with bland aspirate

- Teaching vignette (fictional): FNA shows a cellular follicular neoplasm without convincing PTC-type nuclei.
- A resection specimen demonstrates tumor penetration through its capsule.
- Question: Why did FNA not determine whether this was carcinoma?

Discuss the explanation before advancing

Case resolution: The invasive front carries the diagnosis

- Follicular carcinoma may closely resemble adenoma cytologically.
- Histologic documentation of capsular and/or vascular invasion establishes malignancy.
- Complete or extensive capsule sampling is therefore diagnostically necessary.



Case: Bilateral tumors with stromal amyloid

- Teaching vignette (fictional): Multifocal thyroid masses contain nested tumor cells and eosinophilic stromal amyloid.
- A relative has a history of an endocrine tumor.
- Question: Which tumor lineage and hereditary mechanism should be considered?

Discuss the explanation before advancing

Case resolution: Consider MEN2 beyond the thyroid

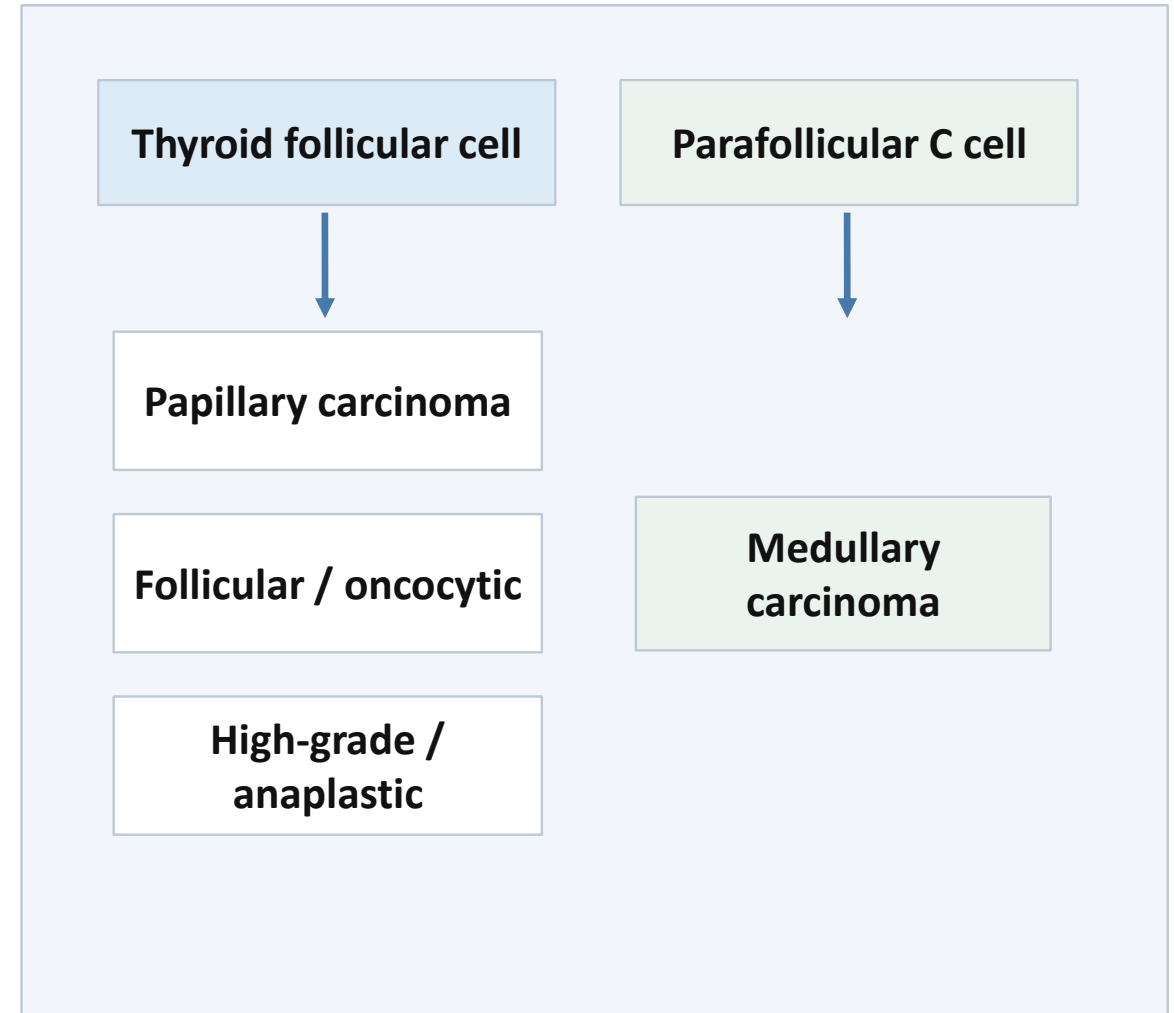
- Amyloid with a neuroendocrine thyroid neoplasm supports medullary carcinoma.
- Multifocal/bilateral disease and C-cell hyperplasia suggest an inherited predisposition.
- Germline RET status has implications for relatives and preventive care.

Five discriminators anchor thyroid carcinoma diagnosis

Diagnostic discriminator	Inference supported
Papillary-type nuclear findings ± psammoma bodies	Papillary carcinoma is favored
Capsular / venous invasion in follicular tumor	Follicular carcinoma rather than adenoma
Follicular growth + PTC-like nuclei; no invasion	NIFTP when strict criteria are satisfied
Necrosis / mitoses / undifferentiated morphology	Consider high-grade or anaplastic disease
C-cell neuroendocrine tumor + amyloid	Medullary carcinoma is favored

Final synthesis: Morphology explains clinical behavior

- Cell of origin separates medullary carcinoma from follicular-derived malignancies.
- The decisive morphologic discriminator is often nuclear phenotype, invasion, or dedifferentiation.
- Molecular alterations explain biologic lineage, signaling, and sometimes progression—but do not replace histology.



Primary reference and verification limits

Robbins, Cotran & Kumar. Pathologic Basis of Disease. 11th edition (2026). Chapter 24: The Endocrine System, pp. 988–993.

Working source: project-supplied chapter text and adjacent thyroid carcinoma subsection excerpts.

The corresponding original chapter PDF and its diagnostic photomicrographs were not provided; all drawings here are editable conceptual schematics, not specimens.