Colorectal Cancer (CRC)

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Colorectal Neoplasia

Colorectal adenocarcinoma – leading cancer in developed countries
In US, annual incidence of colorectal adenocarcinoma 150,000.
In US, annual deaths due to colorectal adenocarcinoma 50,000.

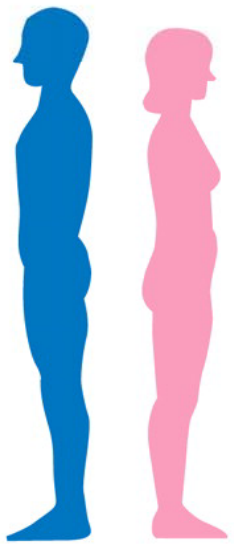
Colonic Adenocarcinoma (Overview of lecture)

- Precursor lesions (Adenoma- Carcinoma sequence)
- Pathologic staging of colorectal tumors

- Chronic inflammation (IBD, including UC and Crohns)
- Genetics (genetic predisposition)
  - FAP (germline mutation of APC gene)
  - HNPCC (germline mutation of mismatch repair gene)
- Molecular pathways of colorectal carcinogenesis
  - Suppressor pathway (APC/beta catenin)
  - Mutator pathway (DNA mismatch repair genes)

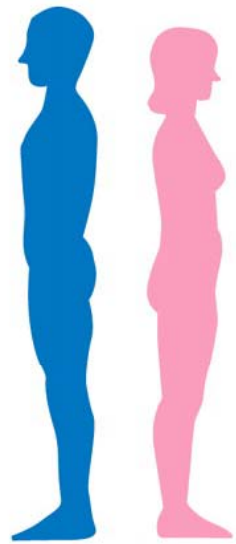
Estimated New Cases*

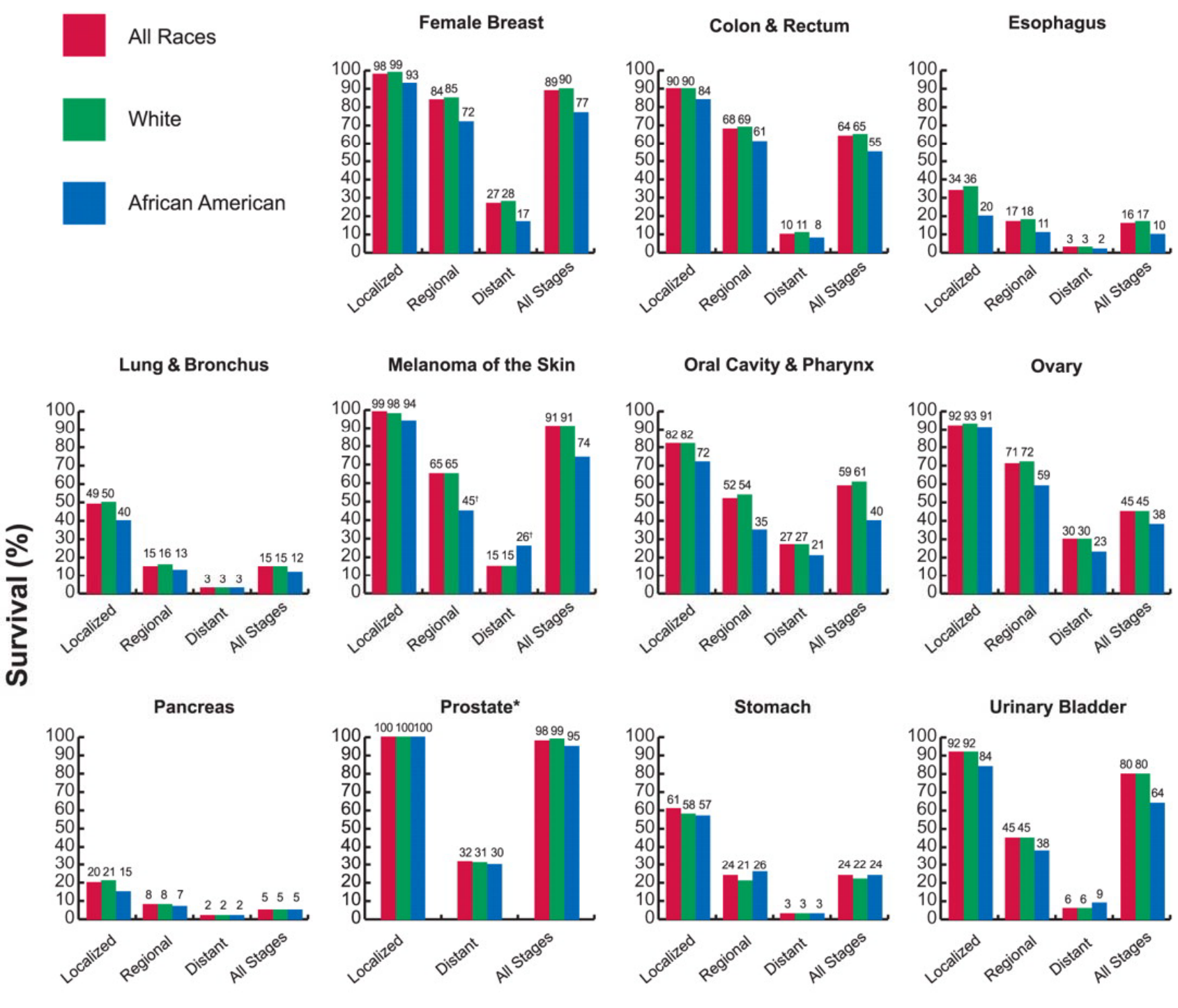
Males			Females		
Prostate	186,320	25%	Breast	182,460	26%
Lung & bronchus	114,690	15%	Lung & bronchus	100,330	14%
Colon & rectum	77,250	10%	Colon & rectum	71,560	10%
Urinary bladder	51,230	7%	Uterine corpus	40,100	6%
Non-Hodgkin lymphoma	35,450	5%	Non-Hodgkin lymphoma	30,670	4%
Melanoma of the skin	34,950	5%	Thyroid	28,410	4%
Kidney & renal pelvis	33,130	4%	Melanoma of the skin	27,530	4%
Oral cavity & pharynx	25,310	3%	Ovary	21,650	3%
Leukemia	25,180	3%	Kidney & renal pelvis	21,260	3%
Pancreas	18,770	3%	Leukemia	19,090	3%
All Sites	**745,180**	**100%**	**All Sites**	**692,000**	**100%**

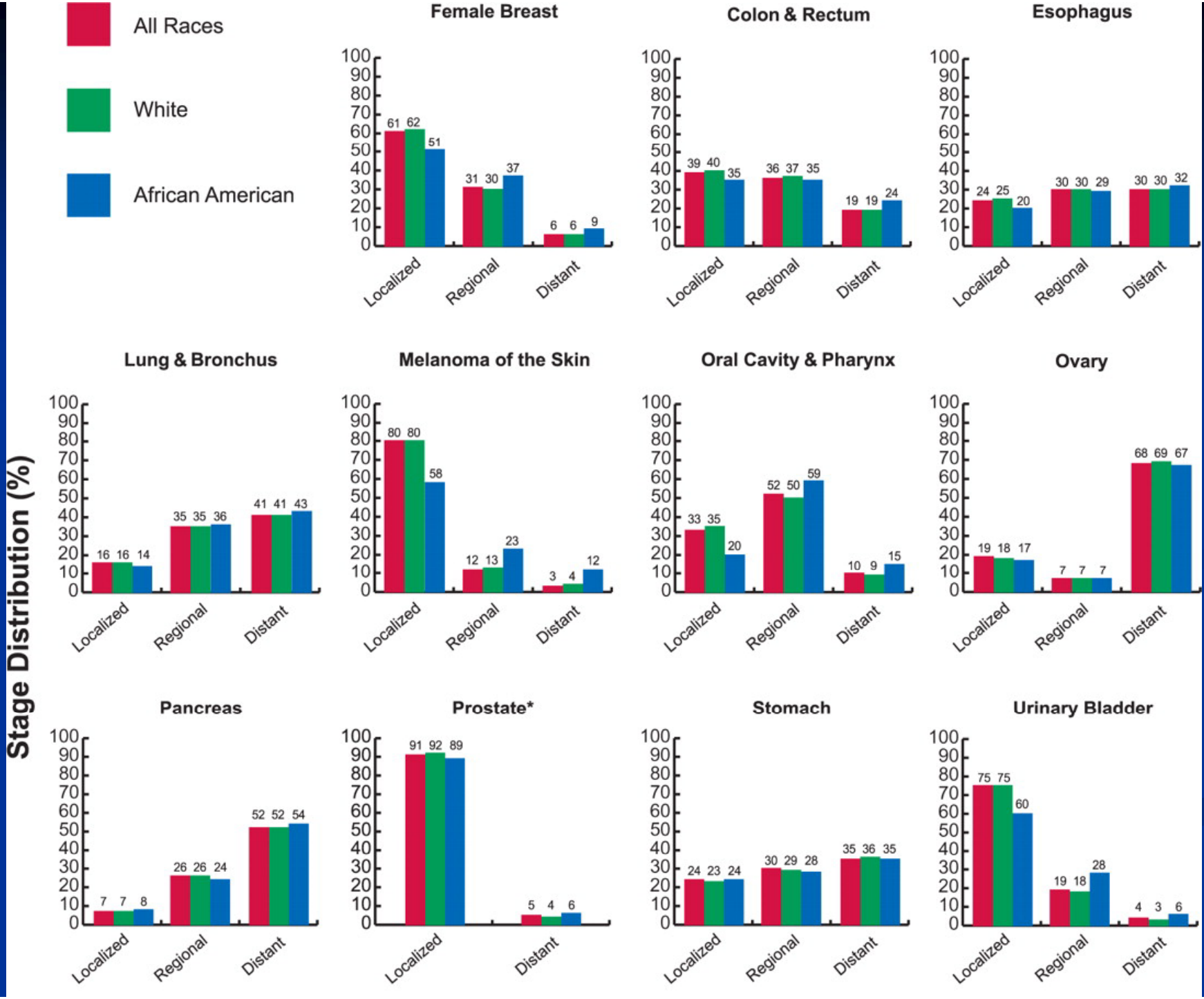


Estimated Deaths

Males			Females		
Lung & bronchus	90,810	31%	Lung & bronchus	71,030	26%
Prostate	28,660	10%	Breast	40,480	15%
Colon & rectum	24,260	8%	Colon & rectum	25,700	9%
Pancreas	17,500	6%	Pancreas	16,790	6%
Liver & intrahepatic bile duct	12,570	4%	Ovary	15,520	6%
Leukemia	12,460	4%	Non-Hodgkin lymphoma	9,370	3%
Esophagus	11,250	4%	Leukemia	9,250	3%
Urinary bladder	9,950	3%	Uterine corpus	7,470	3%
Non-Hodgkin lymphoma	9,790	3%	Liver & intrahepatic bile duct	5,840	2%
Kidney & renal pelvis	8,100	3%	Brain & other nervous system	5,650	2%
All Sites	**294,120**	**100%**	**All Sites**	**271,530**	**100%**



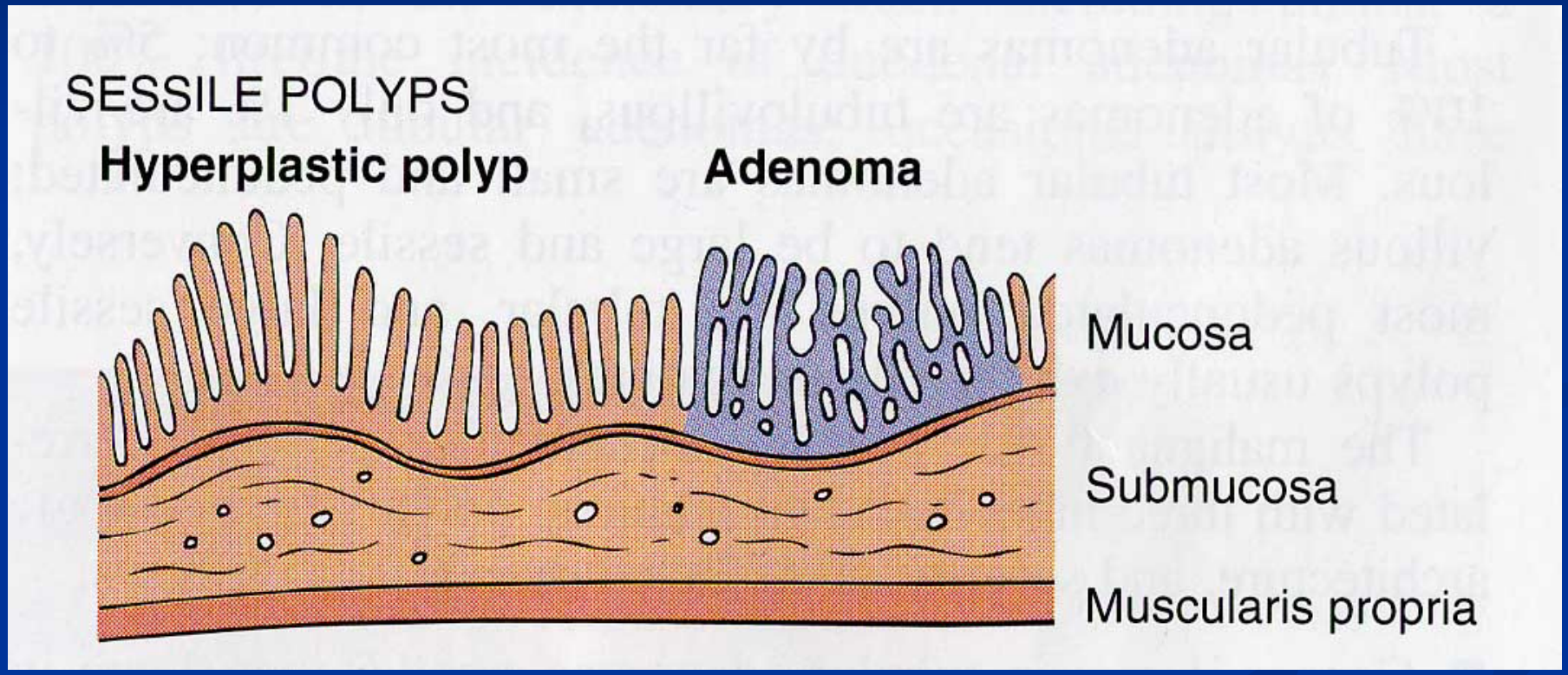

All Races
White
African American
Survival (%)
Female Breast
98 99 93
84 85 72
27 28 17
89 90 77
Colon & Rectum
90 90 84
68 69 61
10 11 8
64 65 55
Esophagus
34 36 20
17 18 11
3 3 2
16 17 10
Lung & Bronchus
49 50 40
15 16 13
3 3 3
15 15 12
Melanoma of the Skin
99 98 94
65 65 45†
15 15 26†
91 91 74
Oral Cavity & Pharynx
82 82 72
52 54 35
27 27 21
59 61 40
Ovary
92 93 91
71 72 59
30 30 23
45 45 38
Pancreas
20 21 15
8 8 7
2 2 2
5 5 5
Prostate*
100 100100
32 31 30
98 99 95
Stomach
61 58 57
24 21 26
3 3 3
24 22 24
Urinary Bladder
92 92 84
45 45 38
6 6 9
80 80 64
Localized
Regional
Distant
All Stages

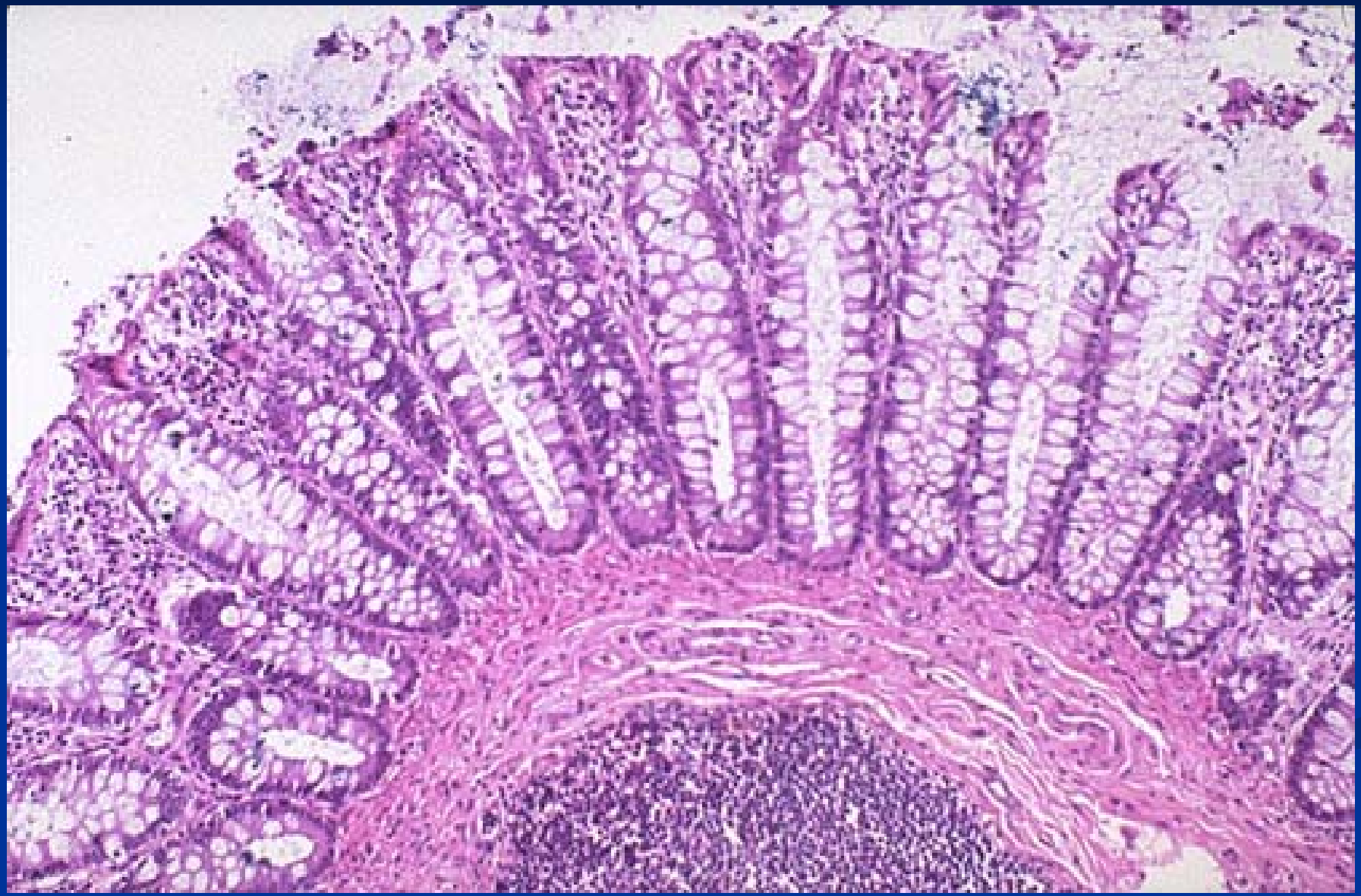

All Races
White
African American
Stage Distribution (%)
Female Breast
61 62 51
31 30 37
6 6 9
Colon & Rectum
39 40 35
36 37 35
19 19 24
Esophagus
24 25 20
30 30 29
30 30 32
Lung & Bronchus
16 16 14
35 35 36
41 41 43
Melanoma of the Skin
80 80 58
12 13 23
3 4 12
Oral Cavity & Pharynx
33 35 20
52 50 59
10 9 15
Ovary
19 18 17
7 7 7
68 69 67
Pancreas
7 7 8
26 26 24
52 52 54
Prostate*
91 92 89
5 4 6
Stomach
24 23 24
30 29 28
35 36 35
Urinary Bladder
75 75 60
19 18 28
4 3 6
Localized
Regional
Distant

Earliest precursor lesions

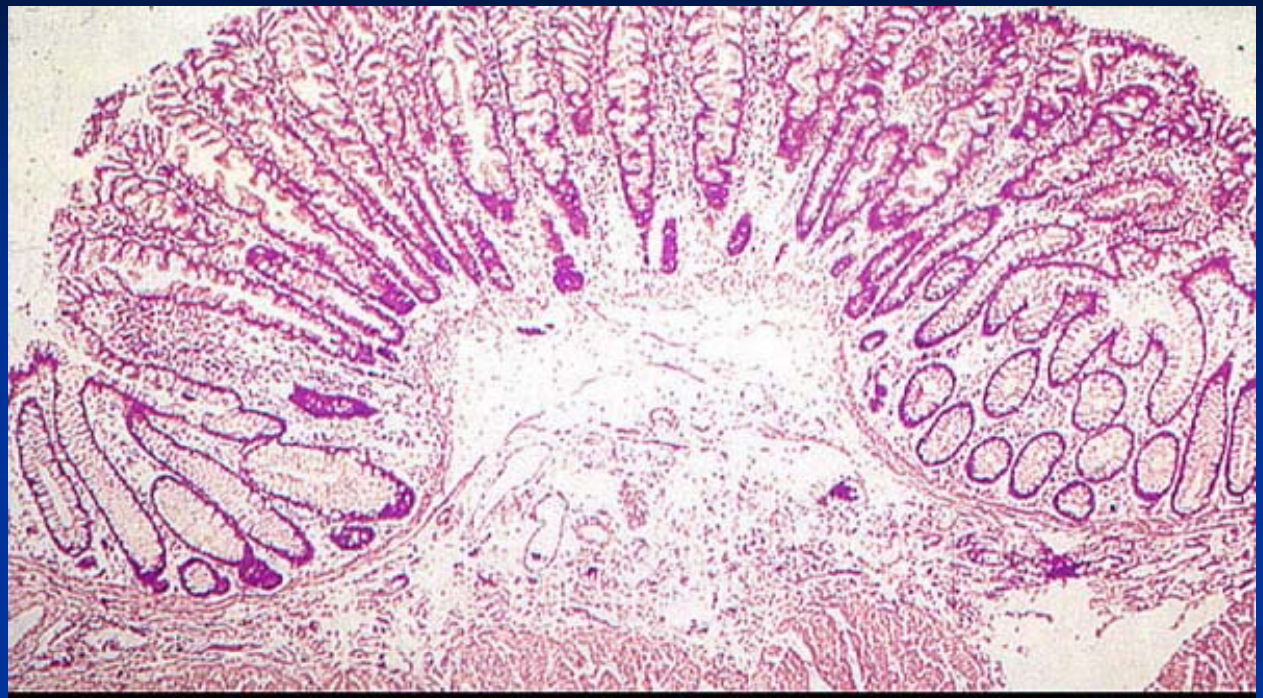
- Polyps
  - Adenomas
  - Serrated sessile polyps
  - Hyperplastic polyps

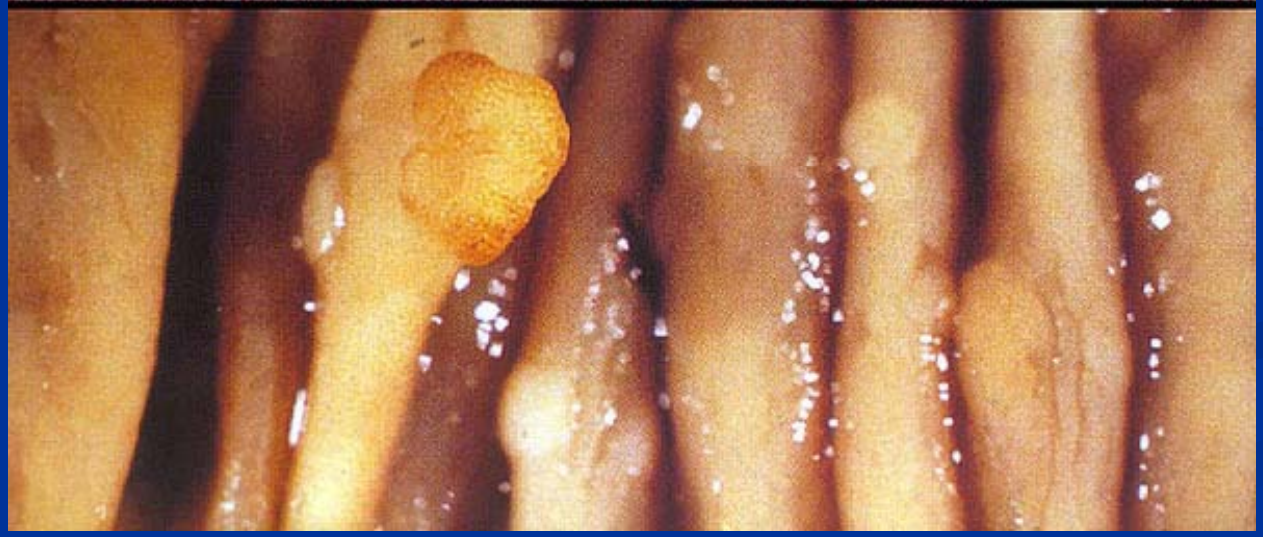
Colonic Polyps : Hyperplastic vs. Adenomatous





Colonic Polyps : Hyperplastic

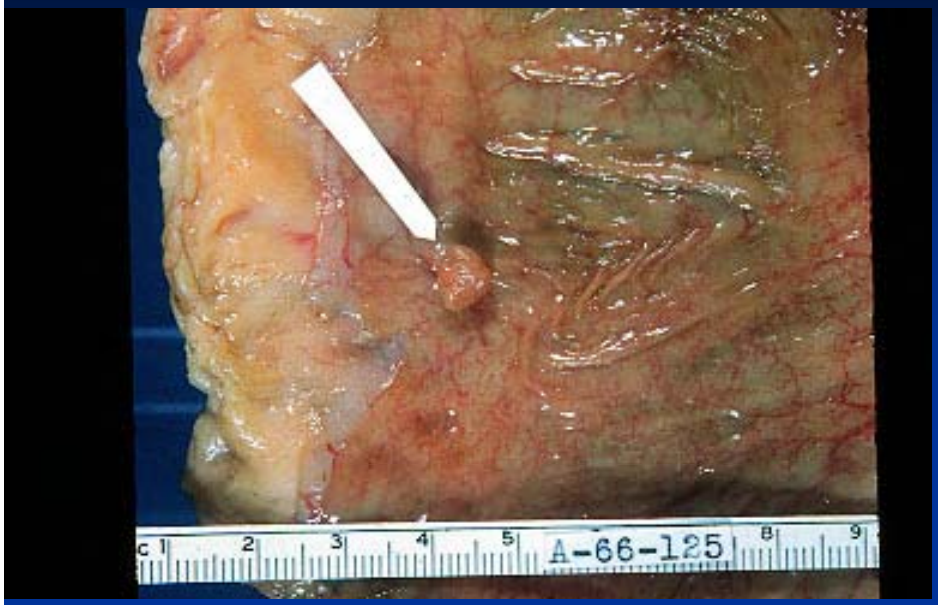


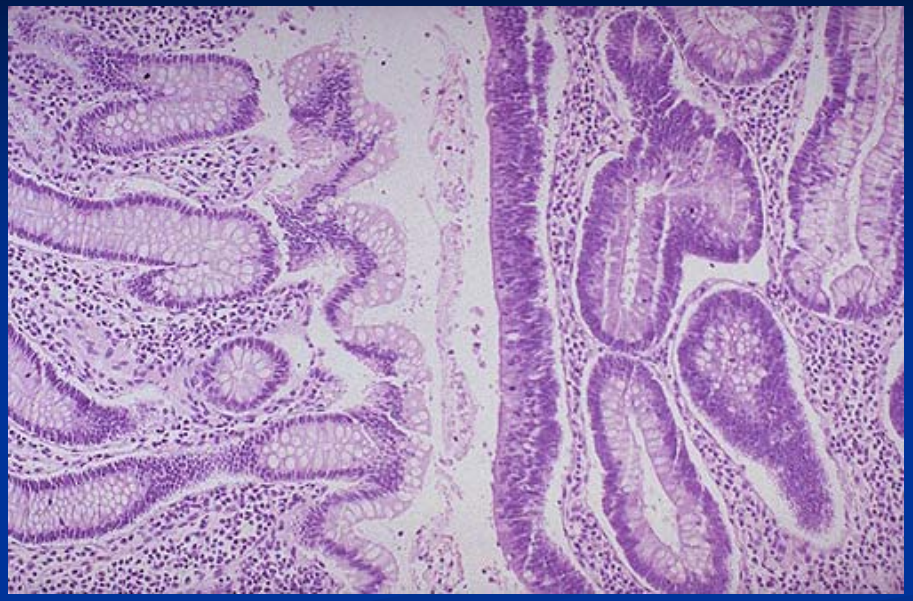


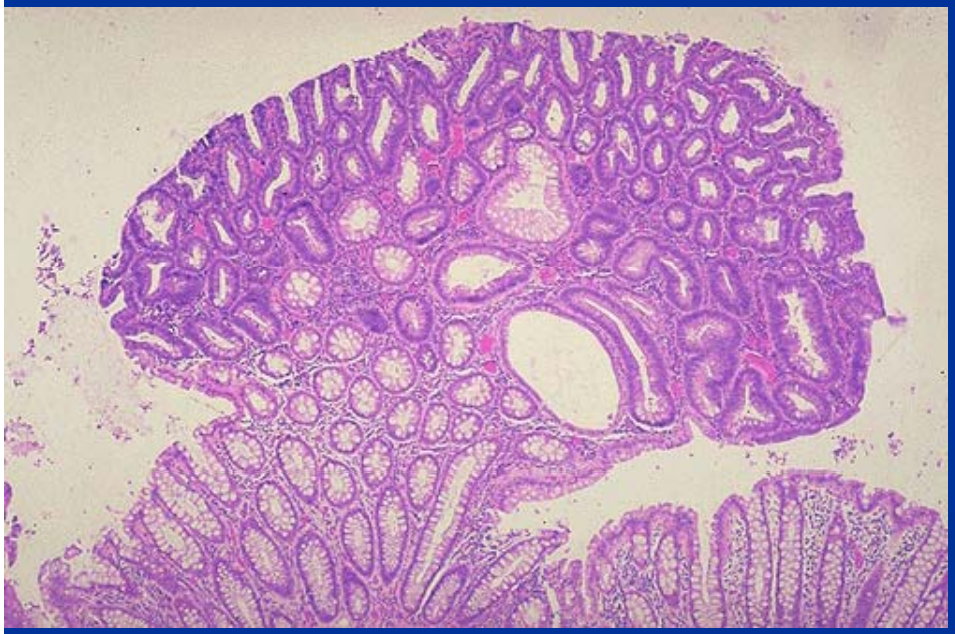
Saw tooth shape of surface epithelium

No dysplasia.

Colonic Polyps : Adenoma

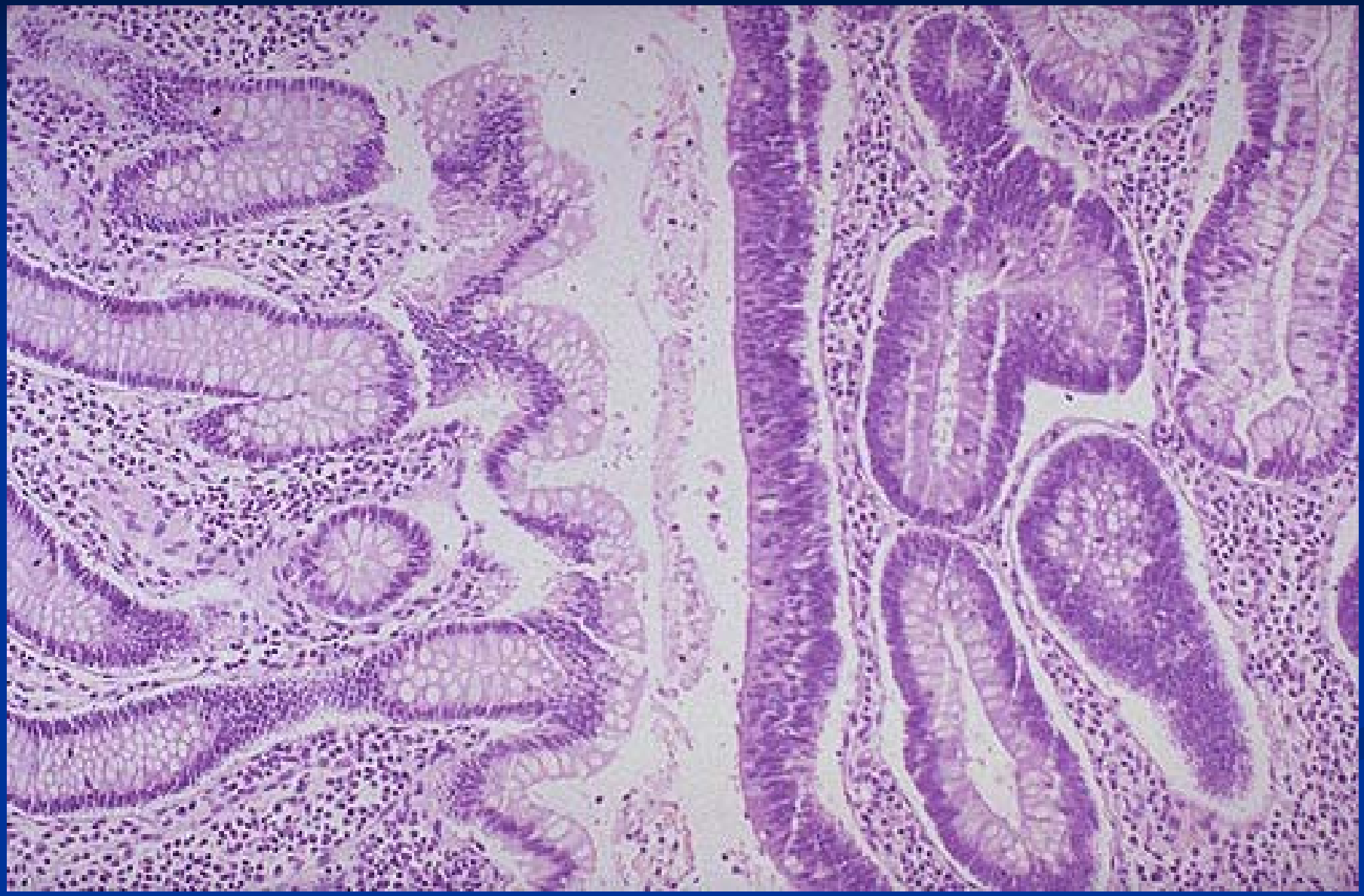






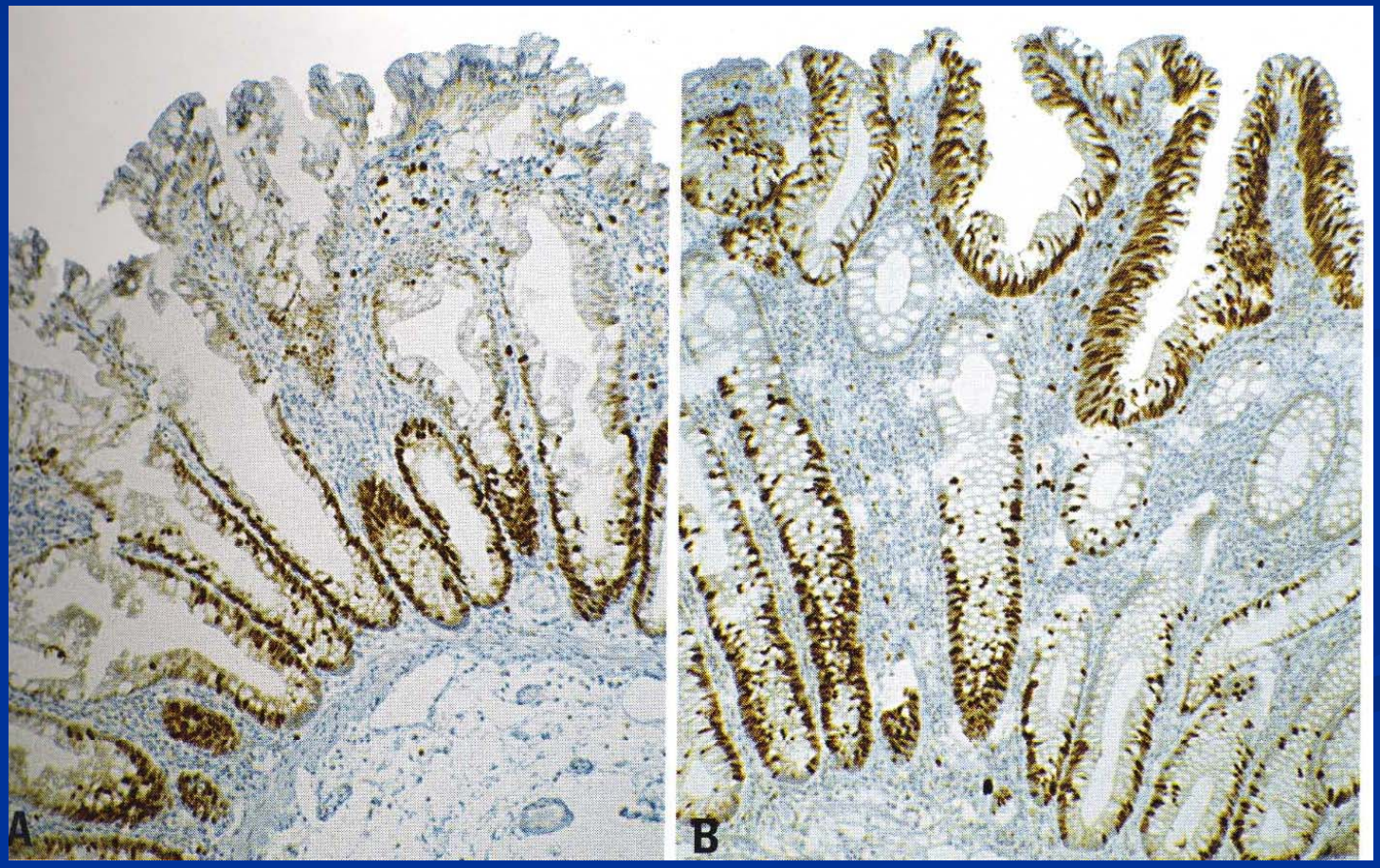
Adenomas by definition have dysplasia.

Lack of surface maturation



Colonic Polyps : Hyperplastic vs. Adenomatous

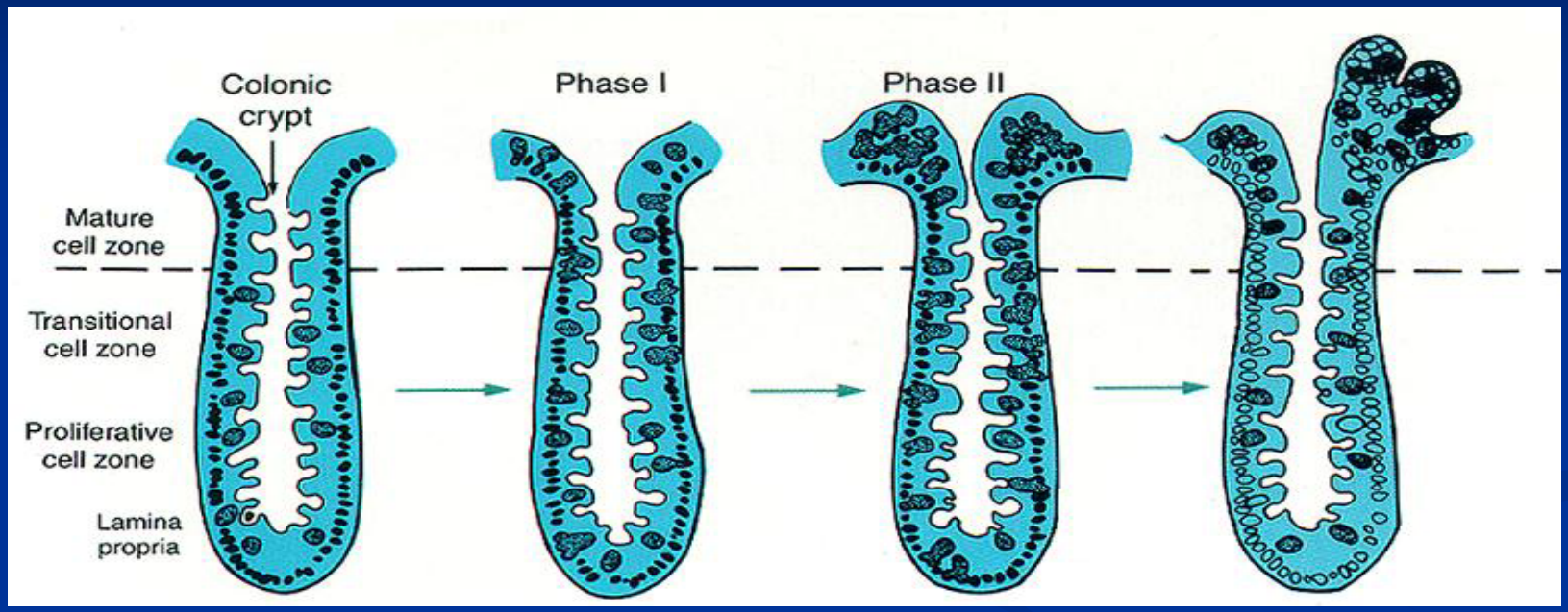
MIB-1/ Ki-67 (immunostain) nuclear staining-
measure of proliferative index.
Adenoma- lacks surface maturation; proliferation extends to surface.
HPP- proliferation is restricted to crypts



Hyperplastic Polyp (HPP)

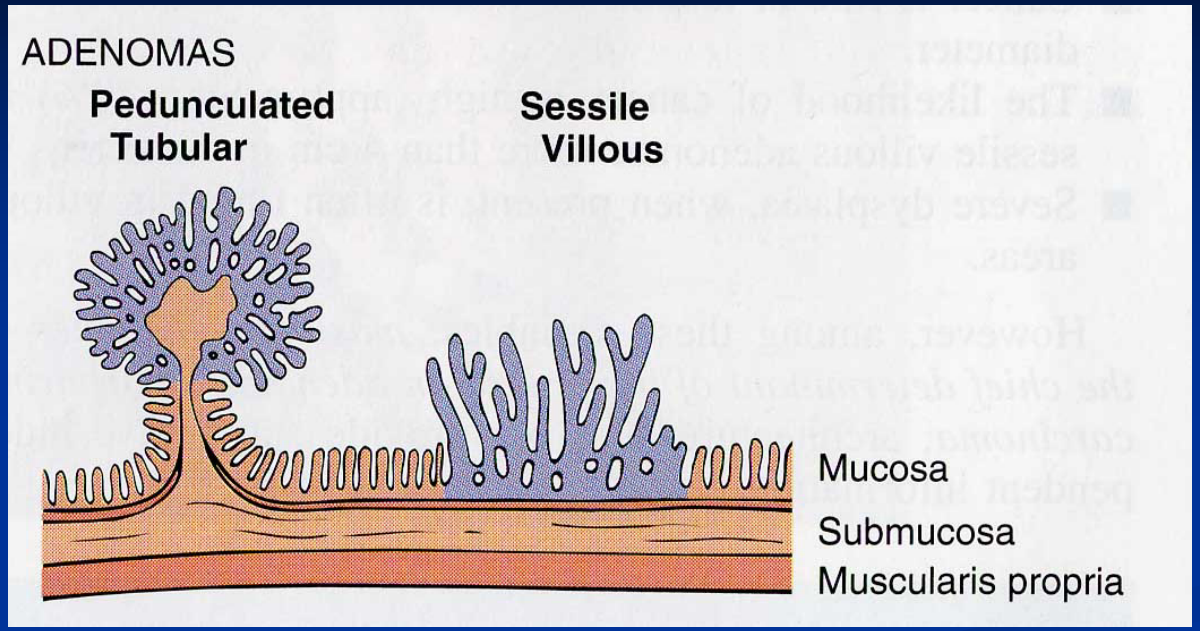
Adenoma

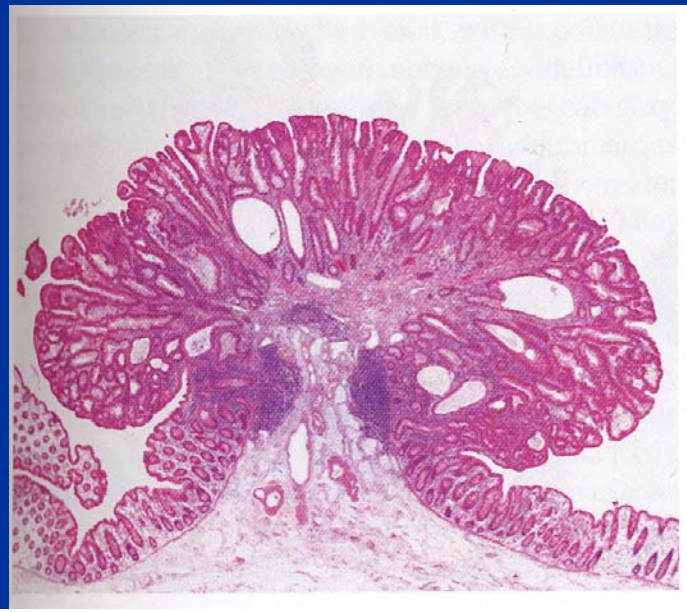
Abnormal proliferation is a hallmark of neoplasia

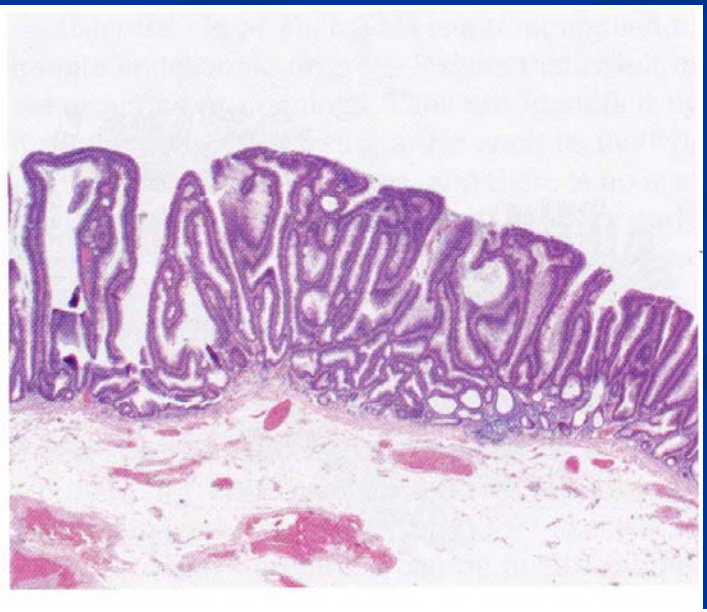


Lack of surface maturation
Proliferation extends to the surface

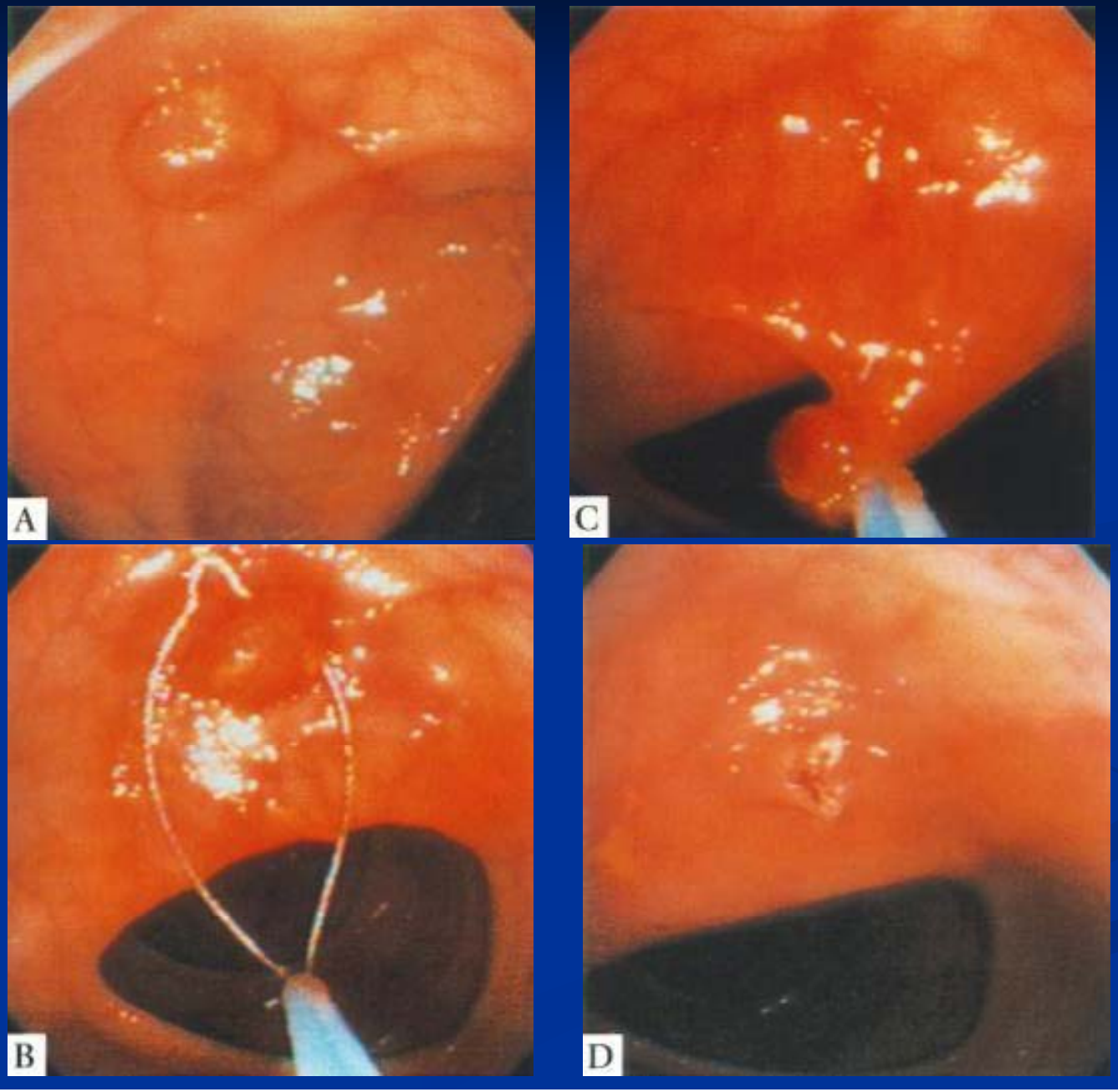
Adenomas – pedunculated vs sessile



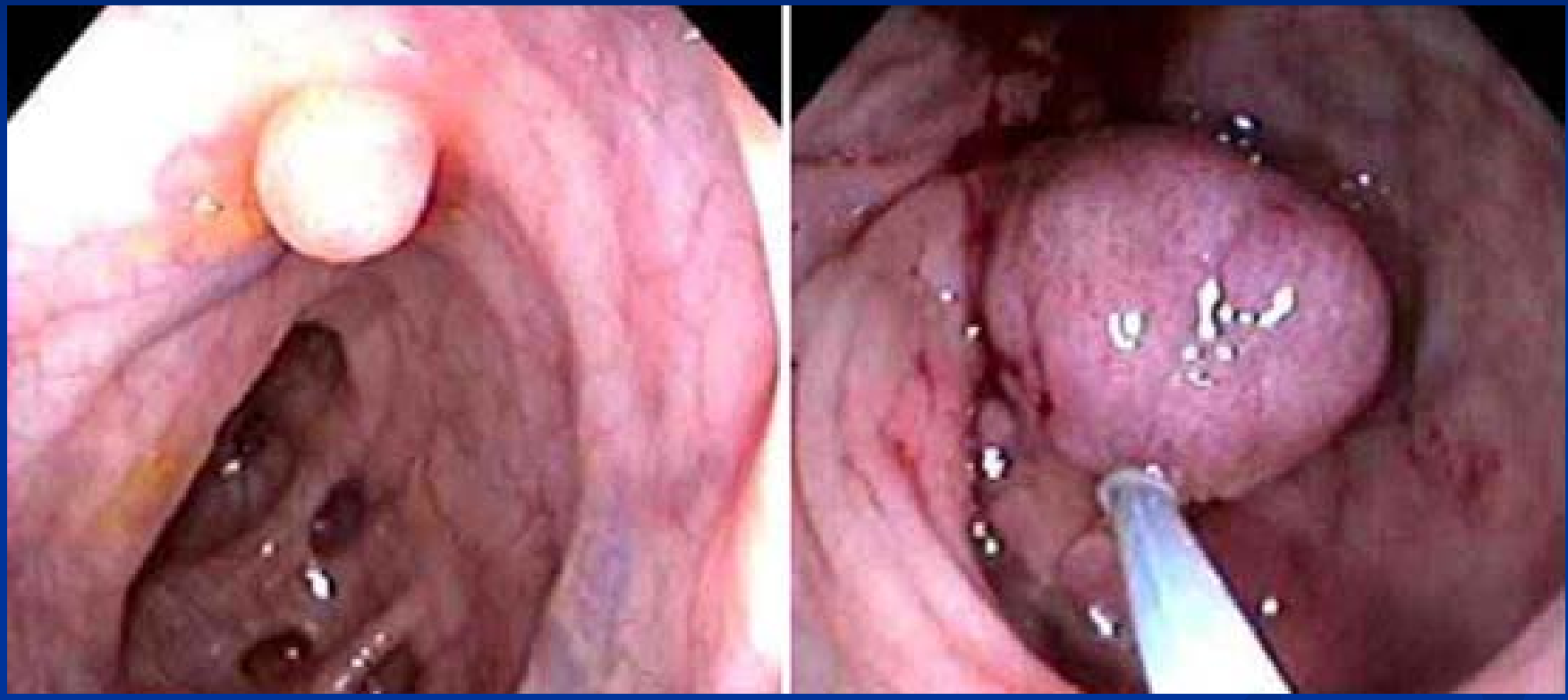


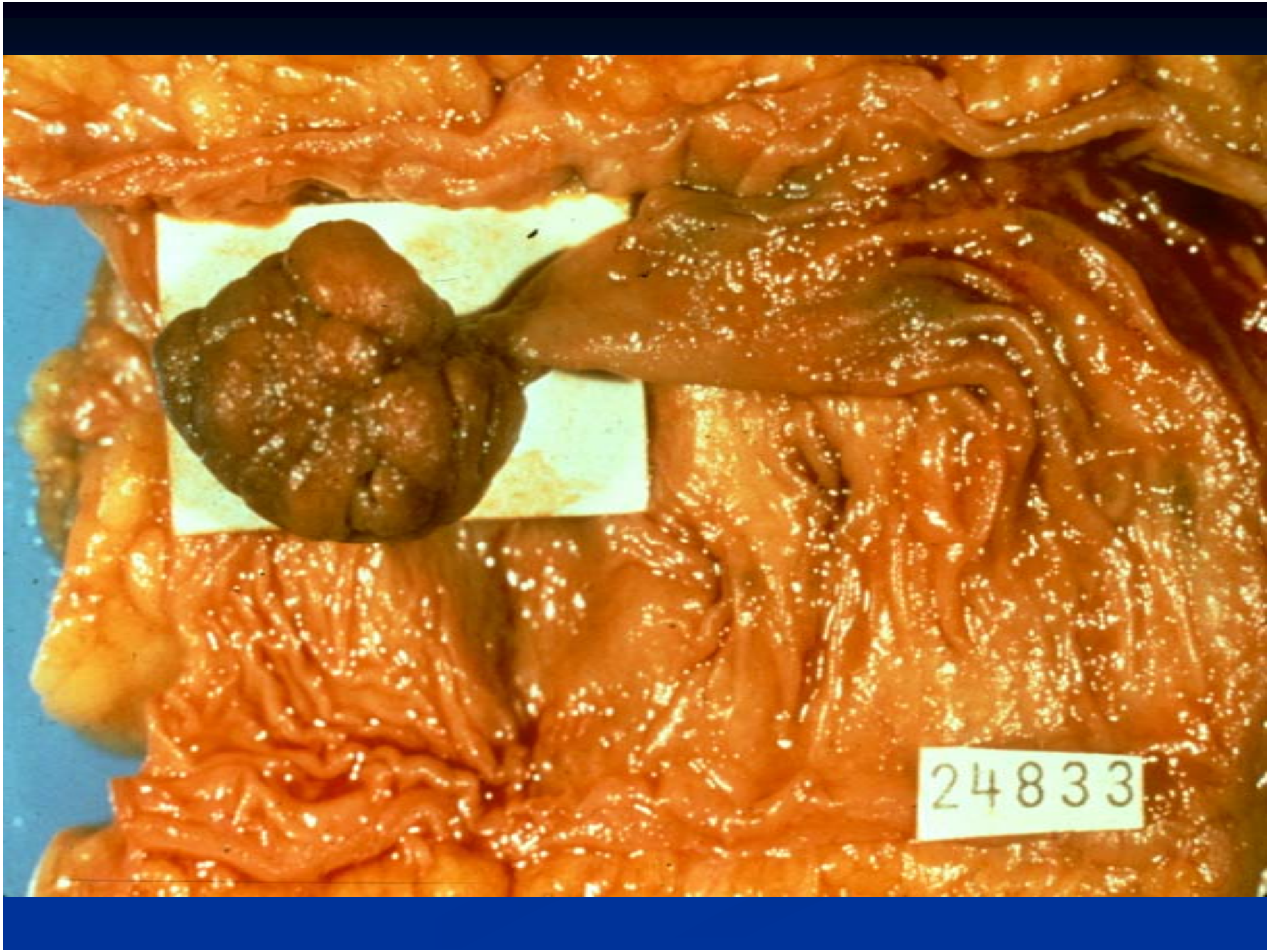


Endoscopic polypectomy



Adenoma on endoscopy

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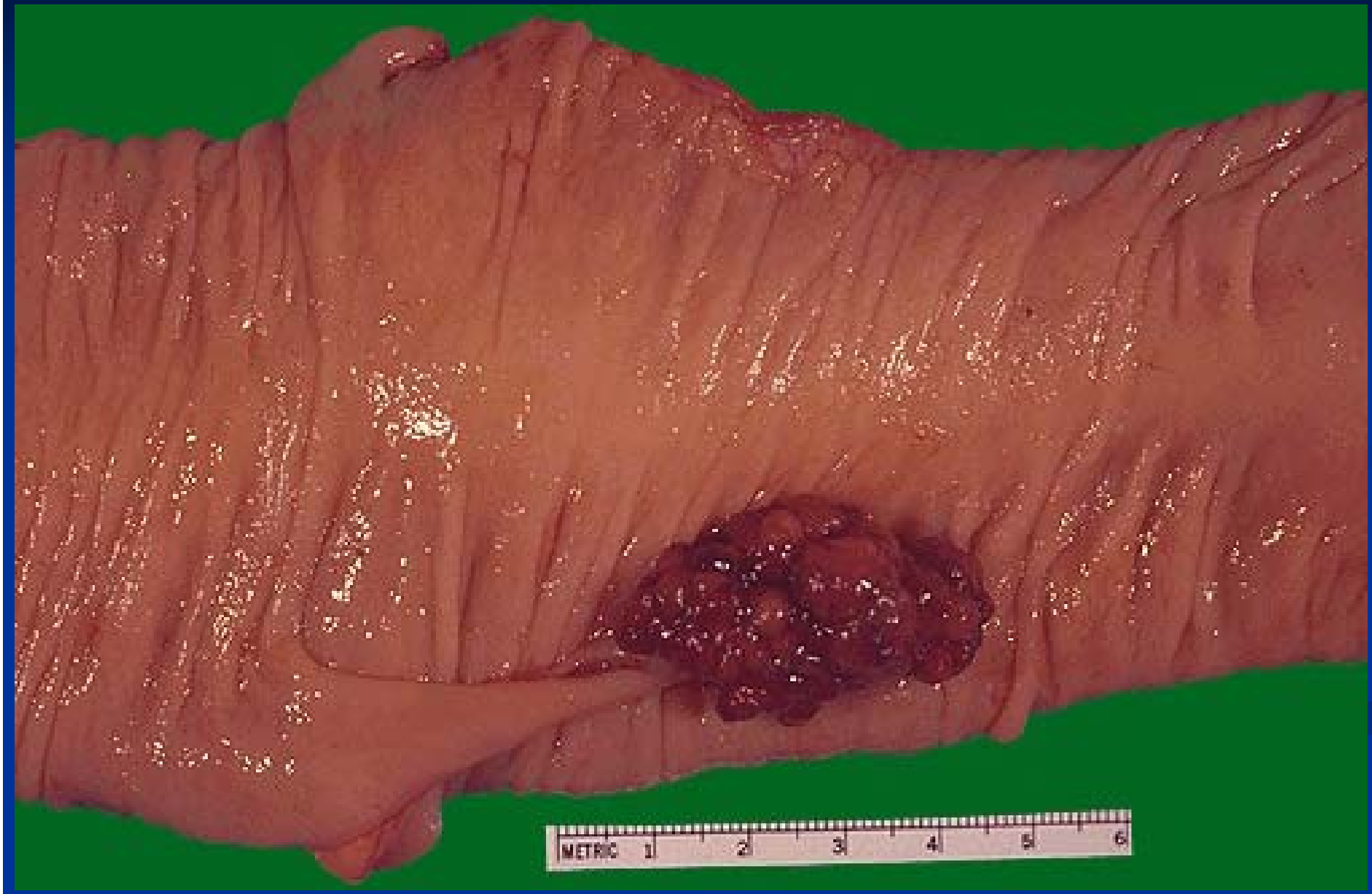
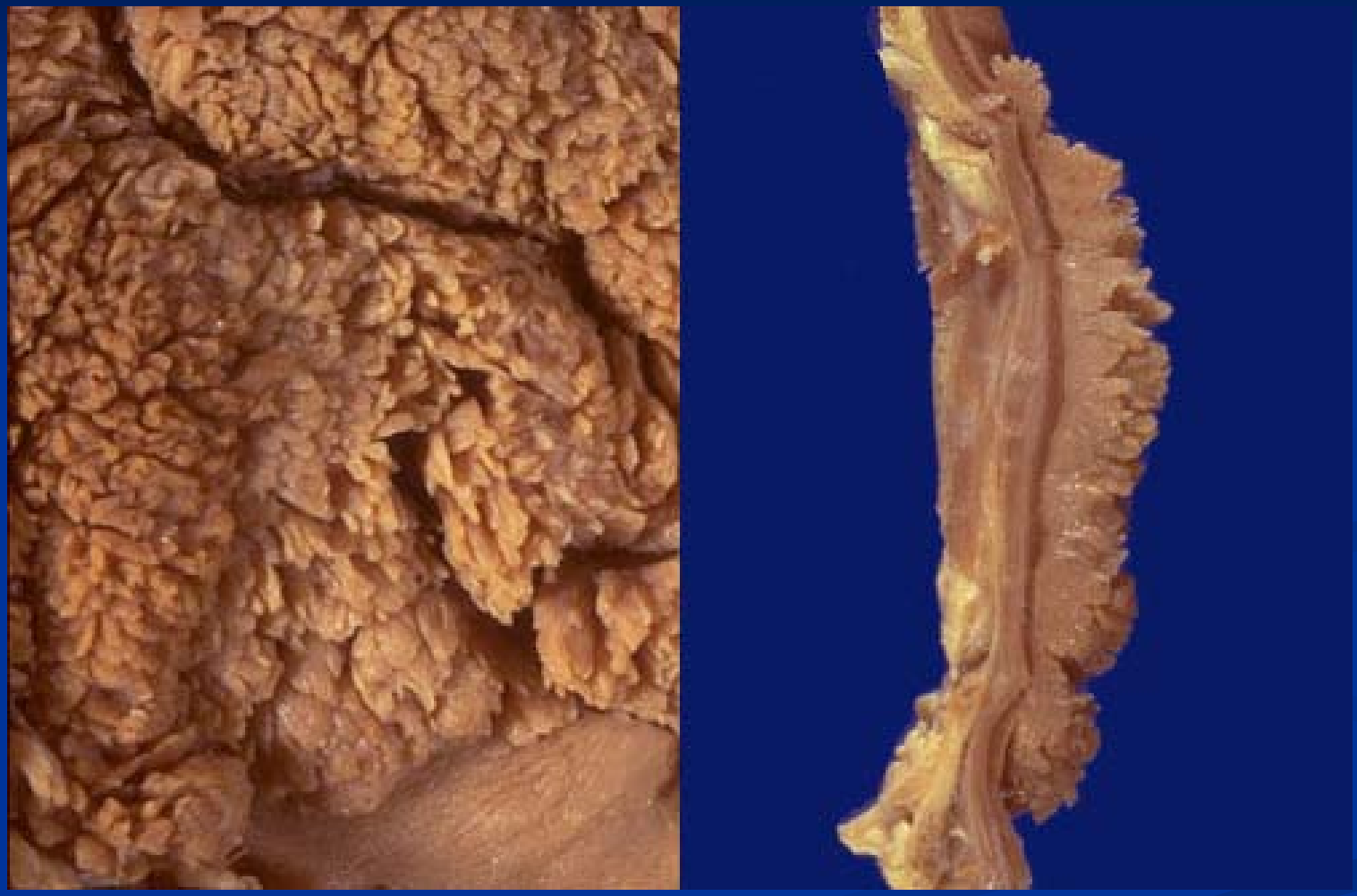
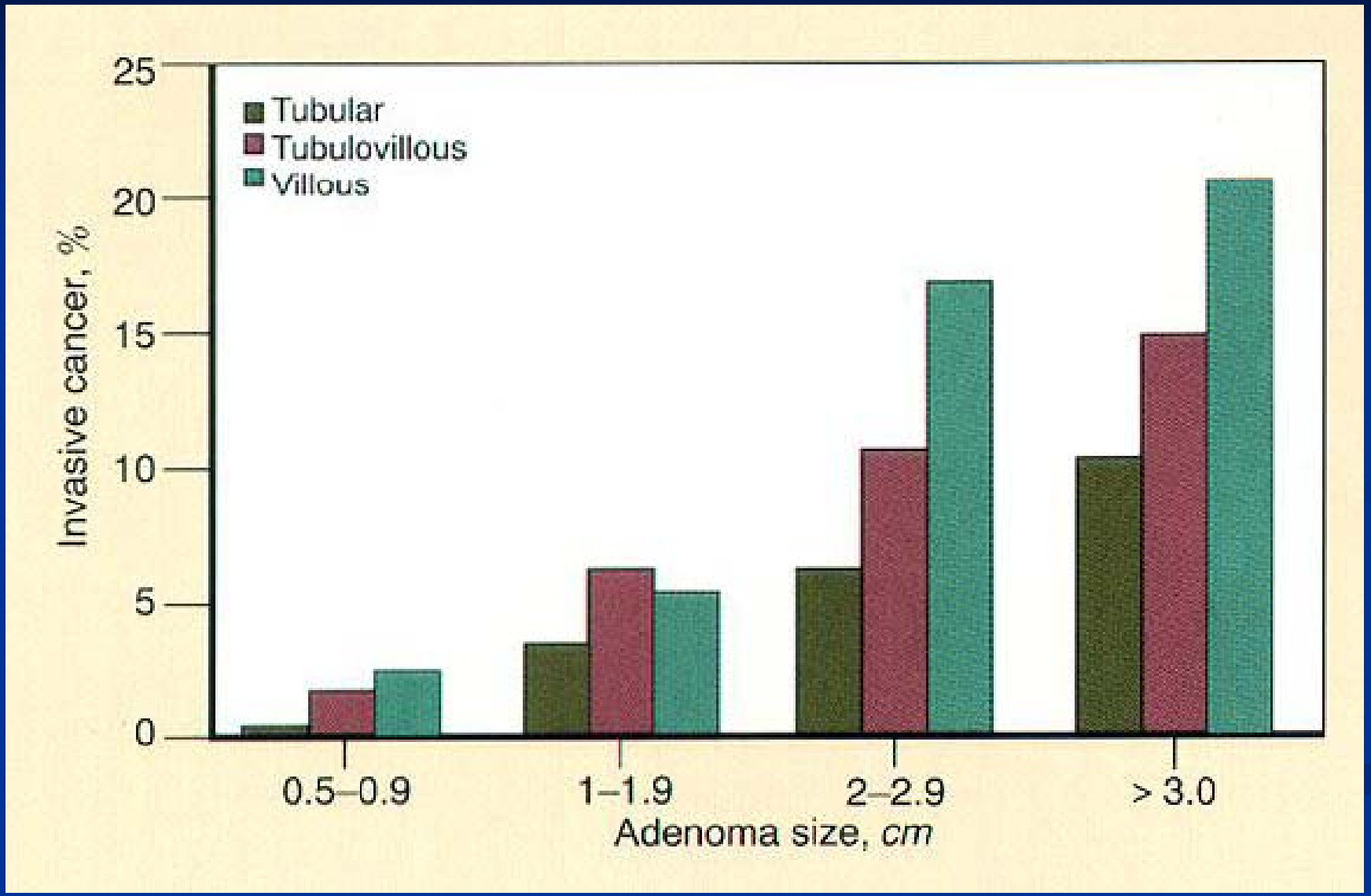
Sessile adenoma



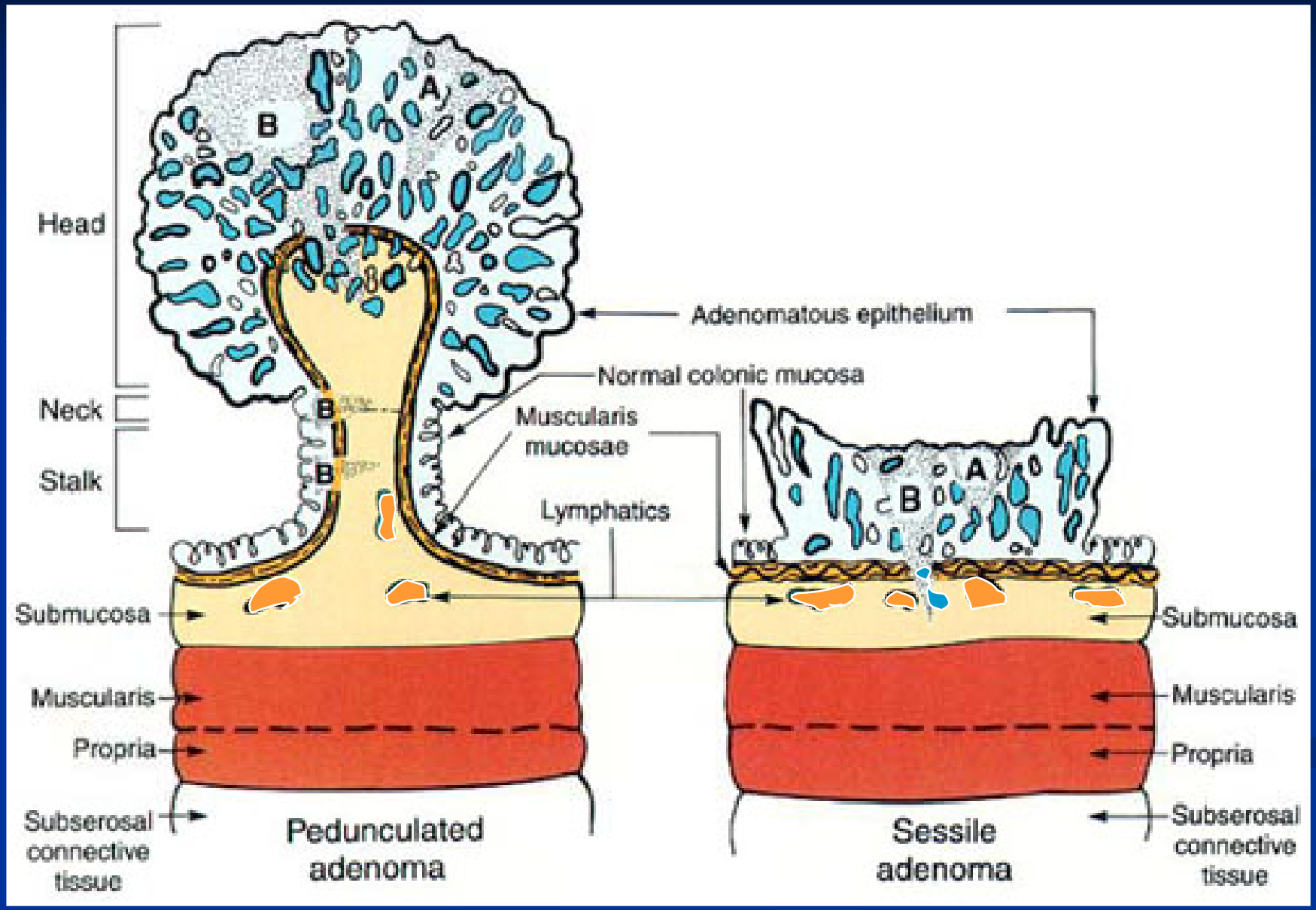
Sessile villous adenoma

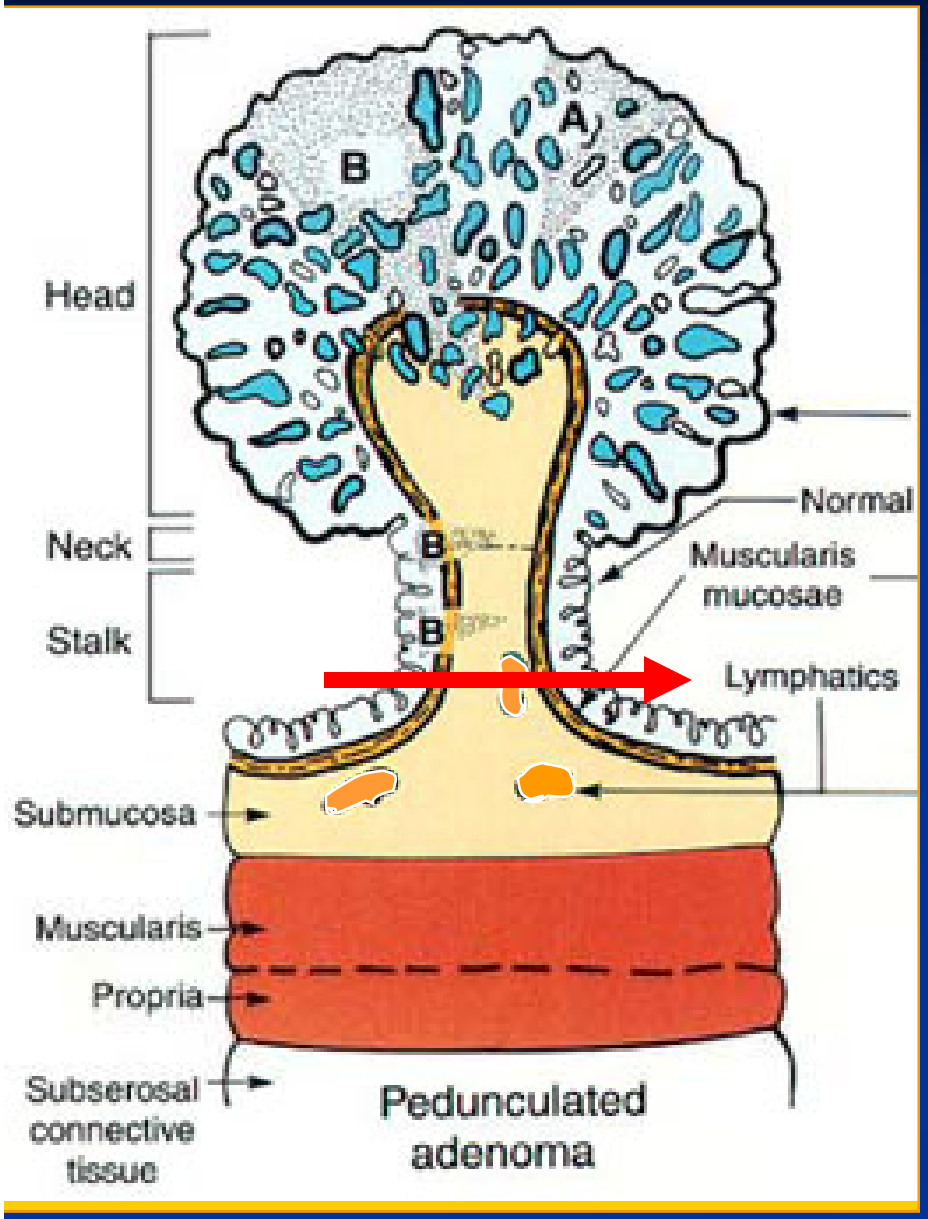


Percent of adenomas containing invasive cancer –
SIZE MATTERS – THE BIGGER THE GREATER THE RISK for CA.



Carcinoma within a polyp





Polypectomy is only Treatment

IF:

1) Stalk margin is negative
2) No lymphatic/vascular invasion
3) Tumor is <u>not poorly</u> differentiated.

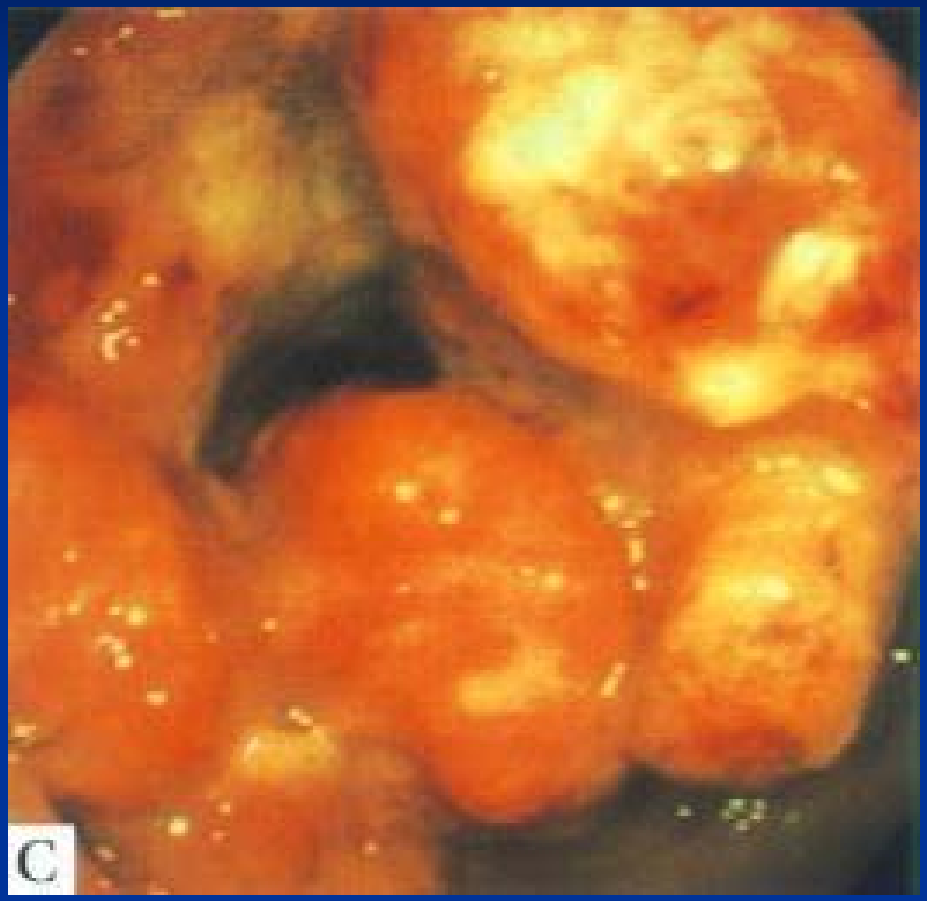
Adenoma – Carcinoma Sequence

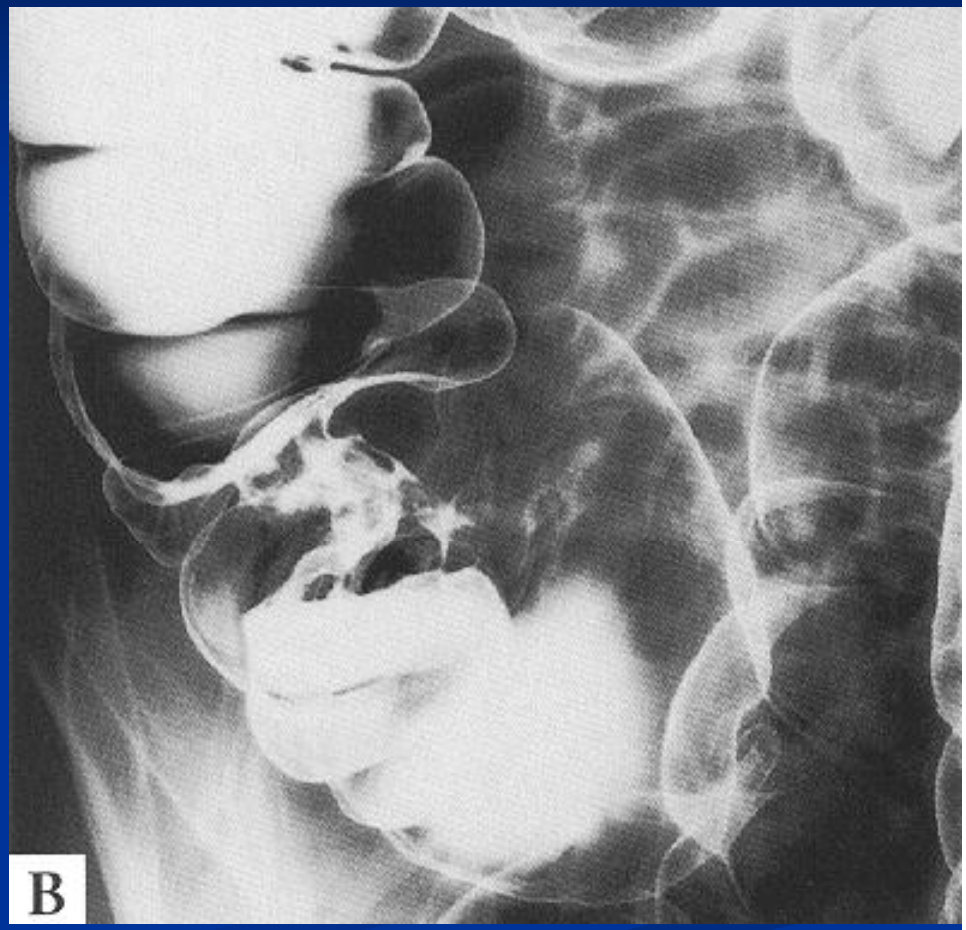
Populations that have a high prevalence of adenomas have a high prevalence of colorectal carcinoma.

- The distribution of adenomas within the colorectum is similar to that of colorectal carcinoma.
- Peak incidence of adenomas antedates the peak for colorectal carcinoma.
- Adenomatous epithelium is often co-existent with adenocarcinoma.

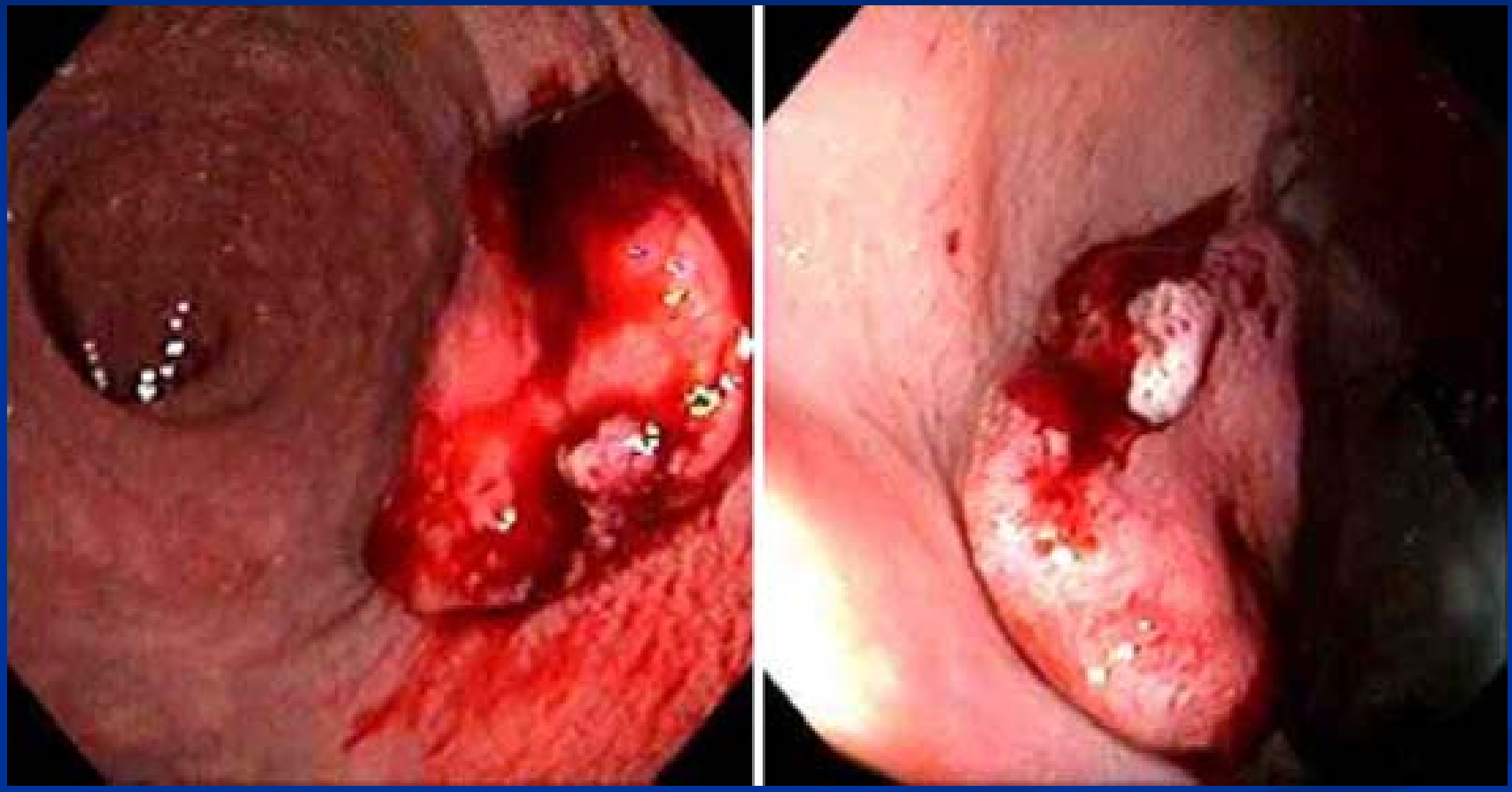
- Screening programs that carefully follow patients for the development of adenomas and remove all that are identified, reduce the incidence of colorectal cancer.

Adenocarcinomas and carcinomas affecting colon

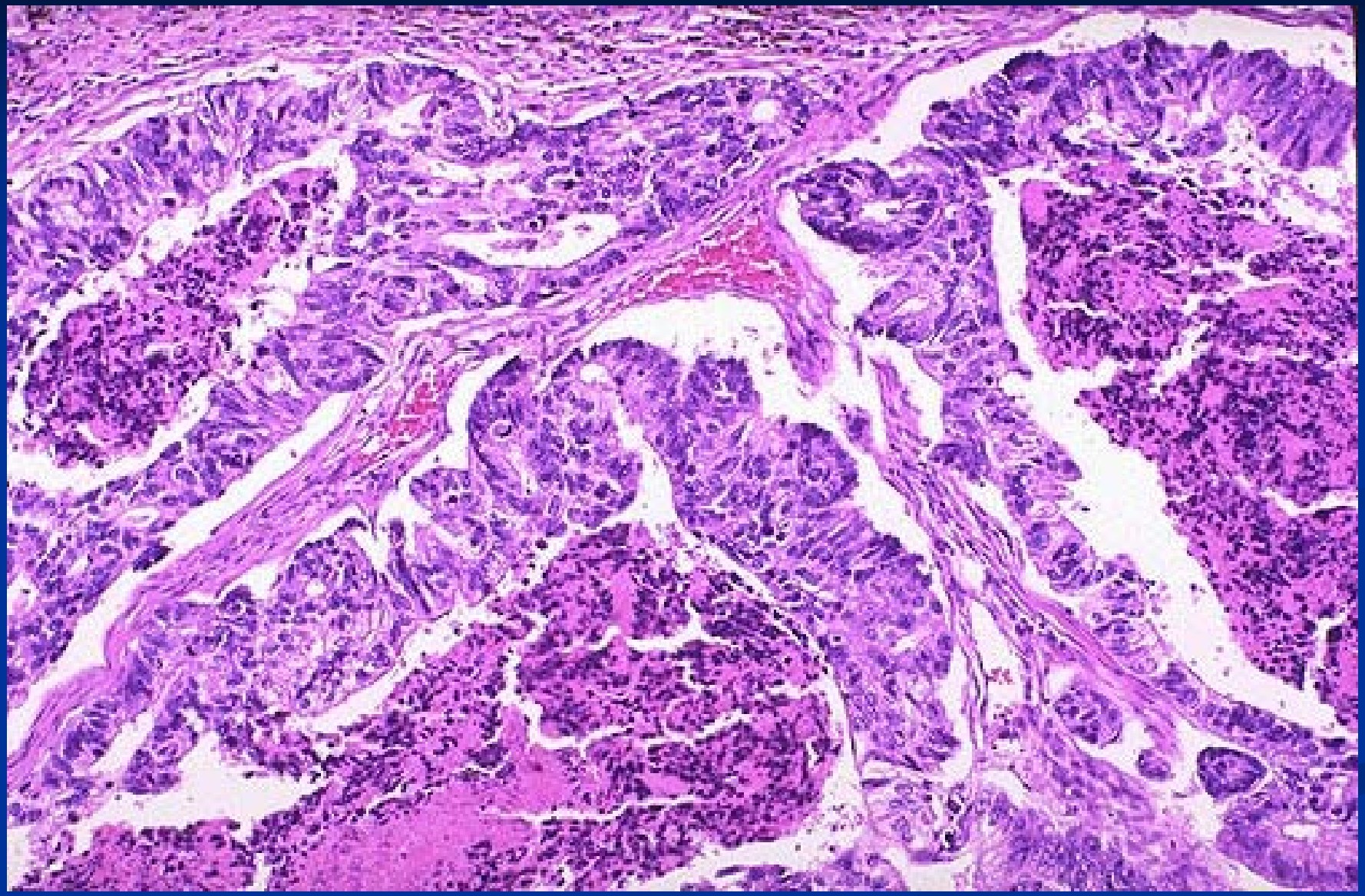




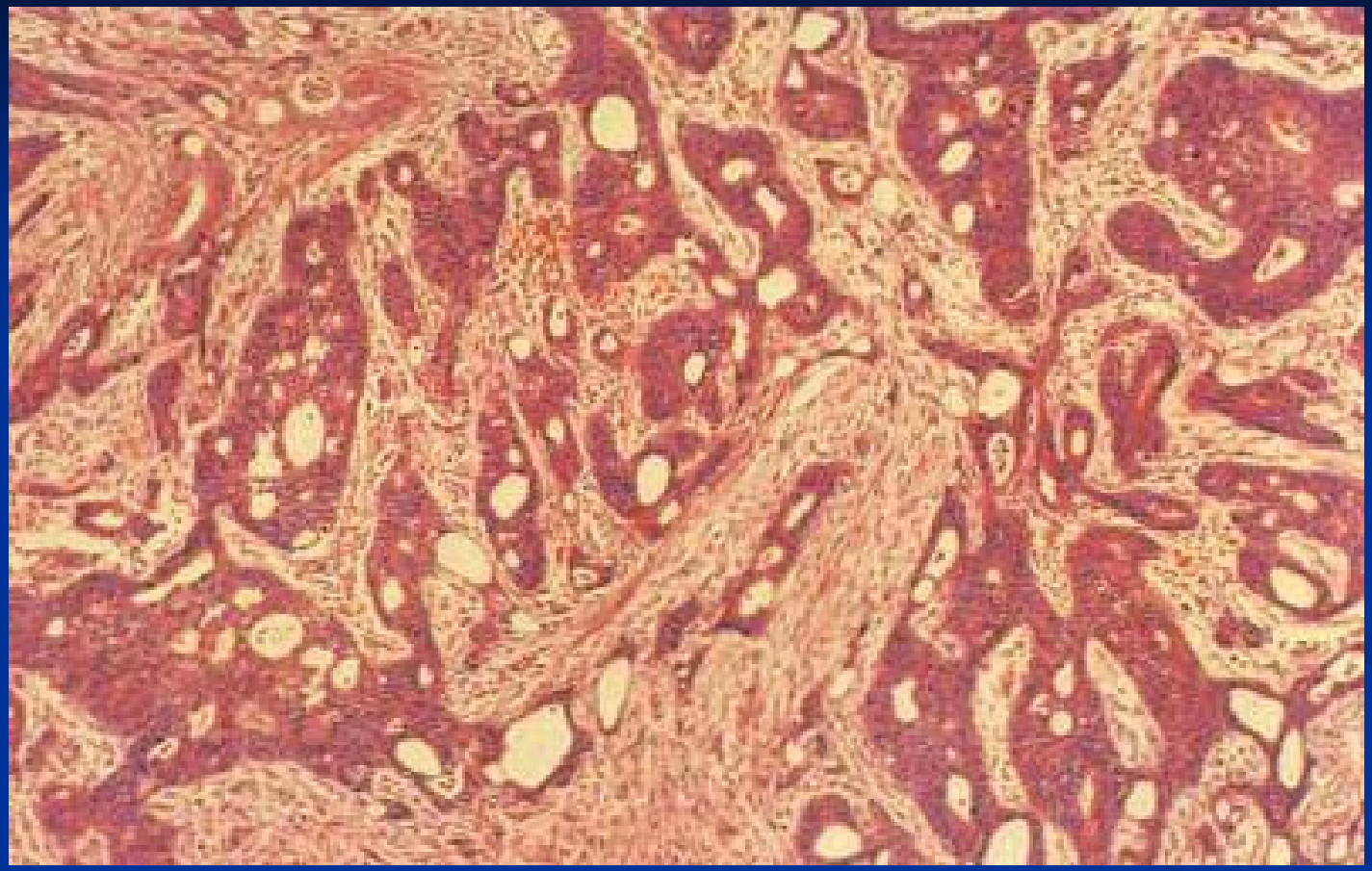
Colon cancer -endoscopy



Adenocarcinoma

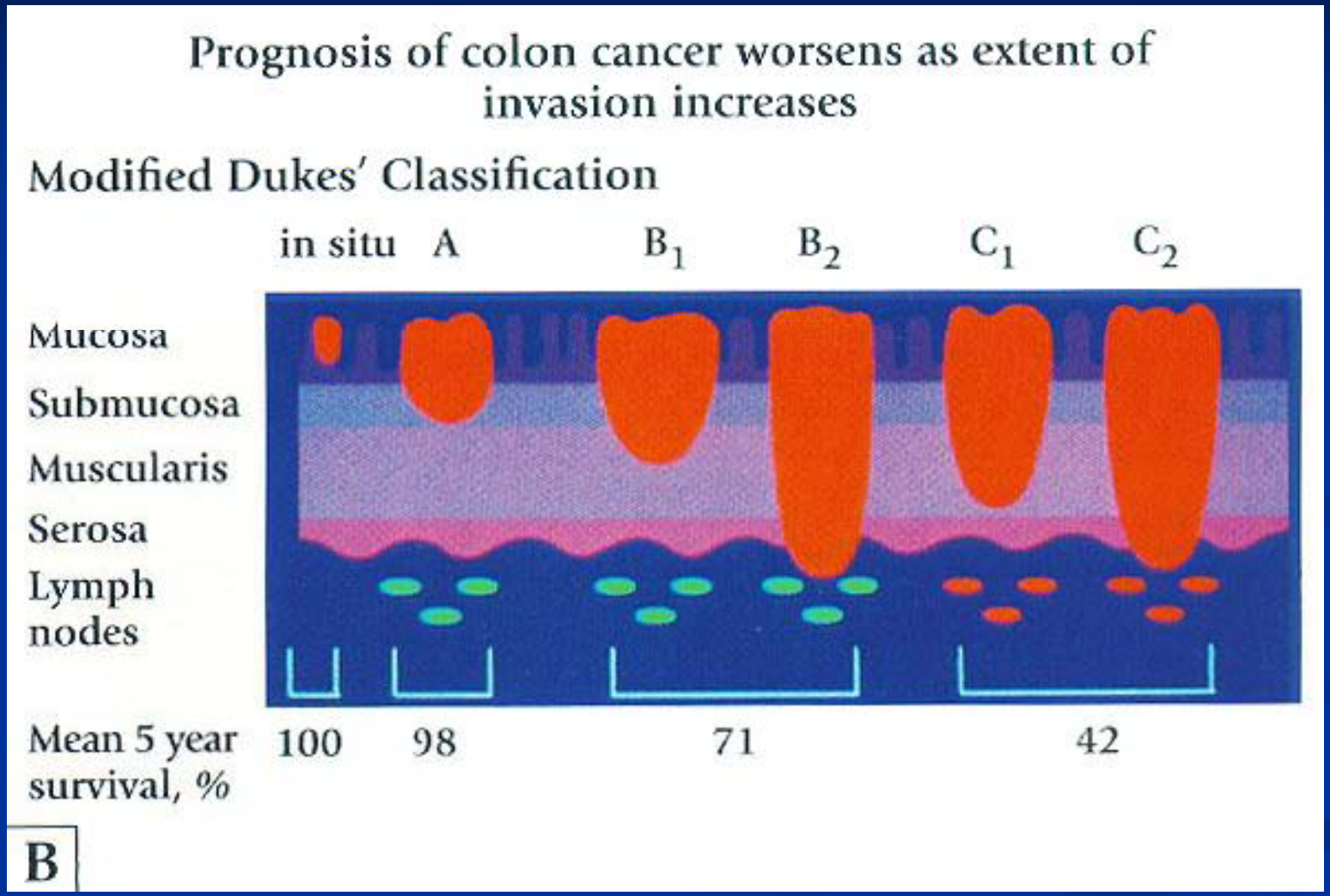


Invasive adenocarcinoma



Irregular infiltrative glands within submucosa
Desmoplastic “ loose fibrotic” tissue response

Survival probabilities according to stage of disease



TNM classification of colorectal adenocarcinoma

T- Primary tumor

Tx **Primary tumor cannot be assessed**

T0 **No evidence of primary tumor**

Tis **Carcinoma in situ (intraepithelial or intramucosal invasion of lamina propria)*****

T1 **Tumor invades submucosa**

T2 **Tumor invades muscularis propria**

T3 **Tumor invades through muscularis propria into subserosa or into pericolic/perirectal fat.**

T4 **Tumor directly invades other organs or structures and/or perforates visceral peritoneum.**

***** **In the colon, unless a tumor invades into the submucosa, it is not considered an invasive adenocarcinoma.**

TNM classification of colorectal adenocarcinoma

N-Regional Lymph Nodes

N0 No regional lymph node metastasis

N1 Metastasis in 1 to 3 regional lymph nodes

N2 Metastasis in 4 or more regional lymph nodes

M- Distant Metastases

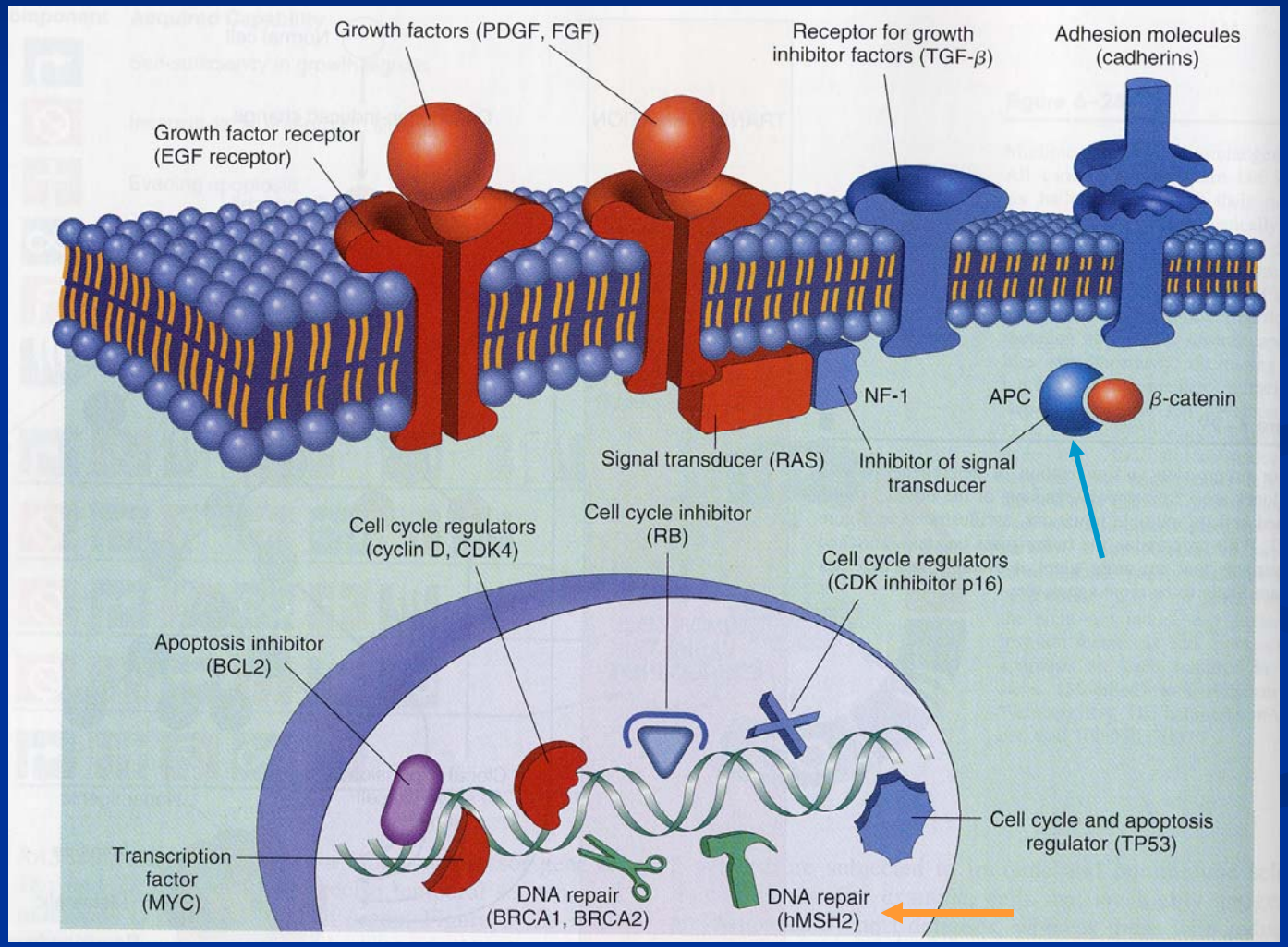
M0 No distant metastasis

M1 Distant metastasis

MOLECULAR BIOLOGY OF COLON CANCER

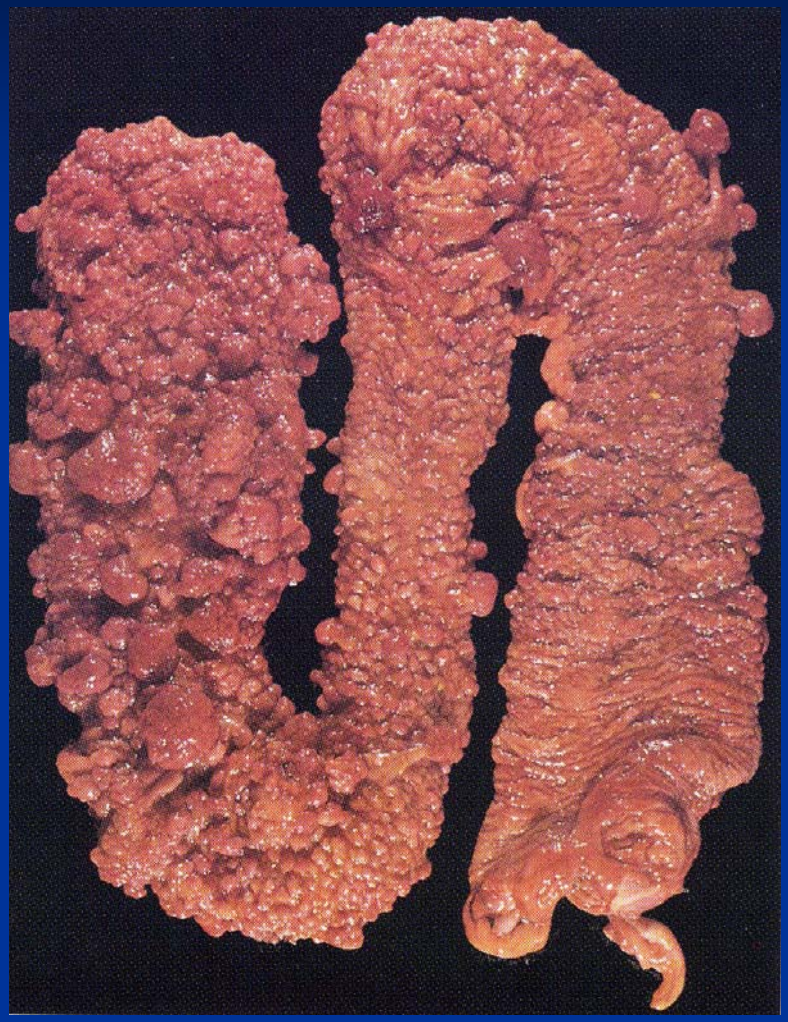
Major classes of proteins encoded by cancer-associated genes:

Tumor suppressor genes, DNA repair genes, Protooncogenes, Proteins regulating apoptosis.

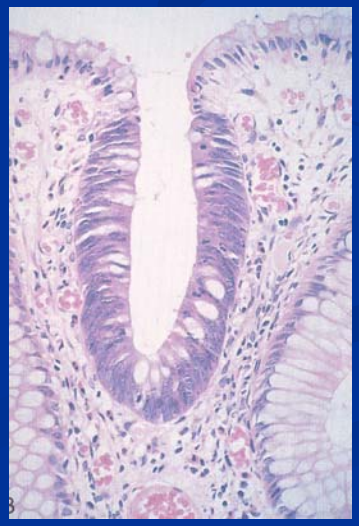


Familial Adenomatous Polyposis

Familial adenomatous polyposis (FAP)

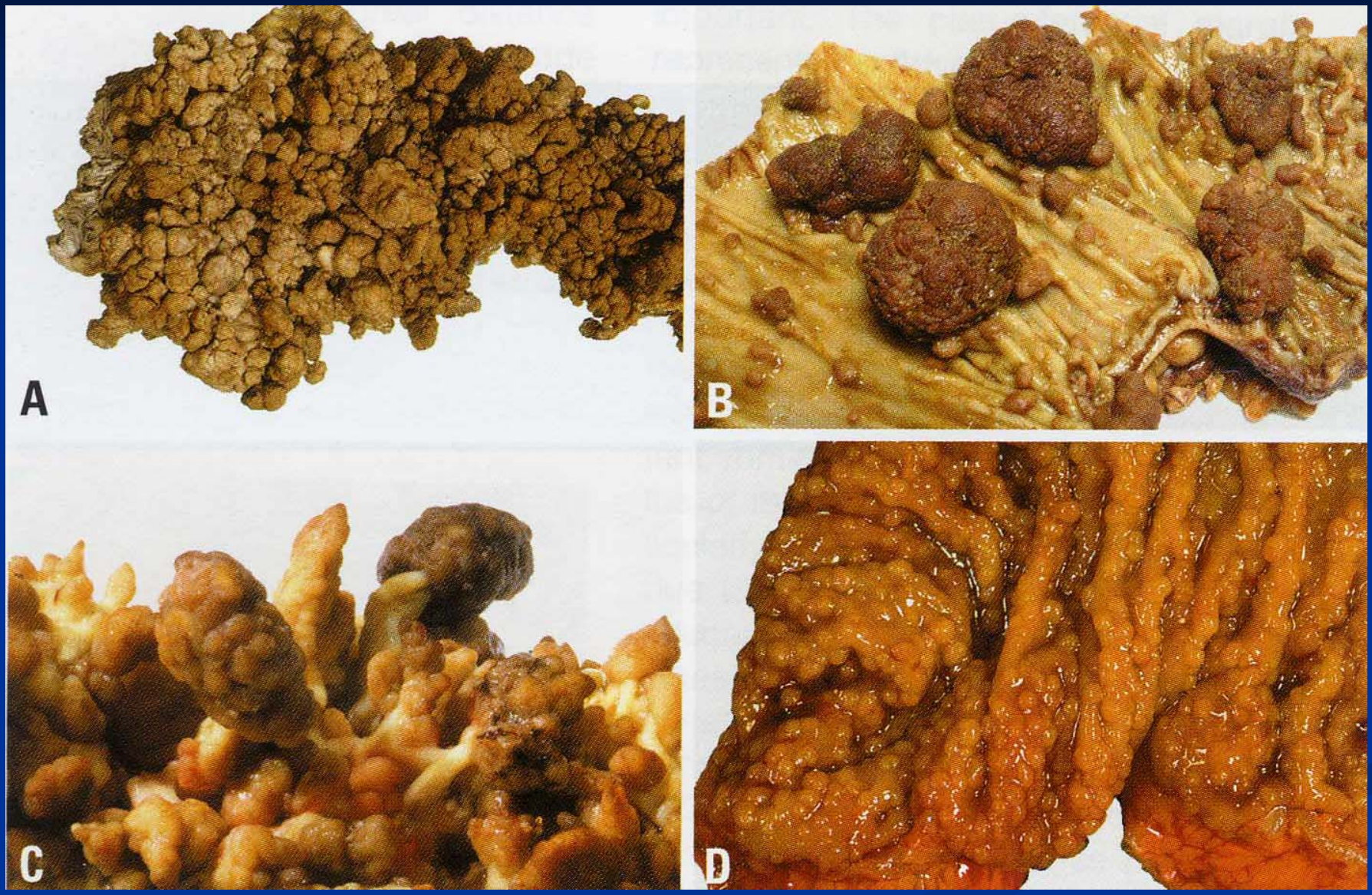


APC- tumor suppressor gene
Germline mutation of APC gene
Patients develop thousands of polyps by their 2nd decade.
The second APC gene must be lost for adenoma formation.
Virtually 100% risk for developing Colorectal adenocarcinoma; also high risk of ampullary carcinoma.

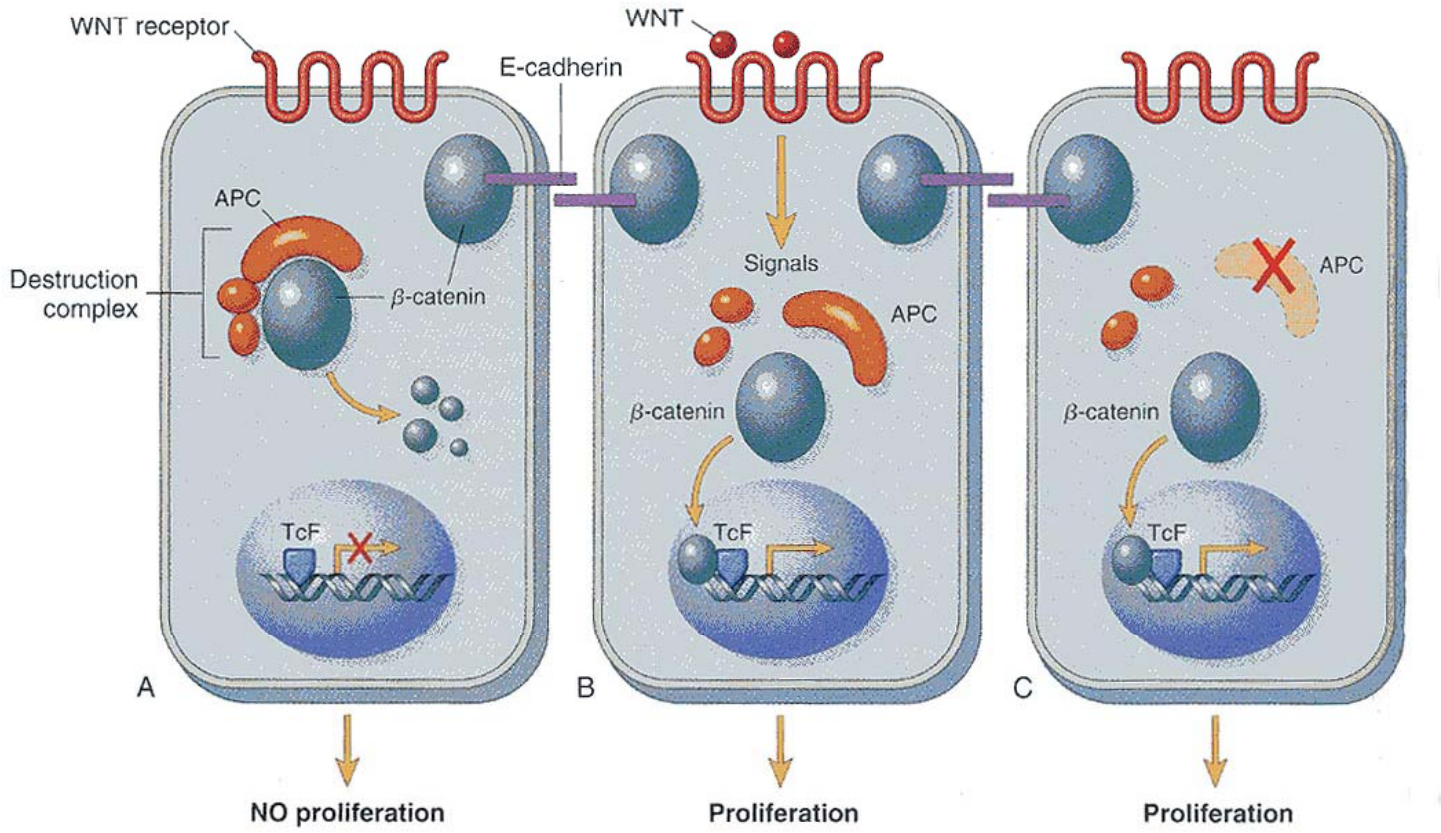


Earliest precursor lesion –
“aberrant crypt”

Familial Adenomatous Polyposis (FAP)



WNT signaling pathway involves APC/beta-catenin and Tcf-4.

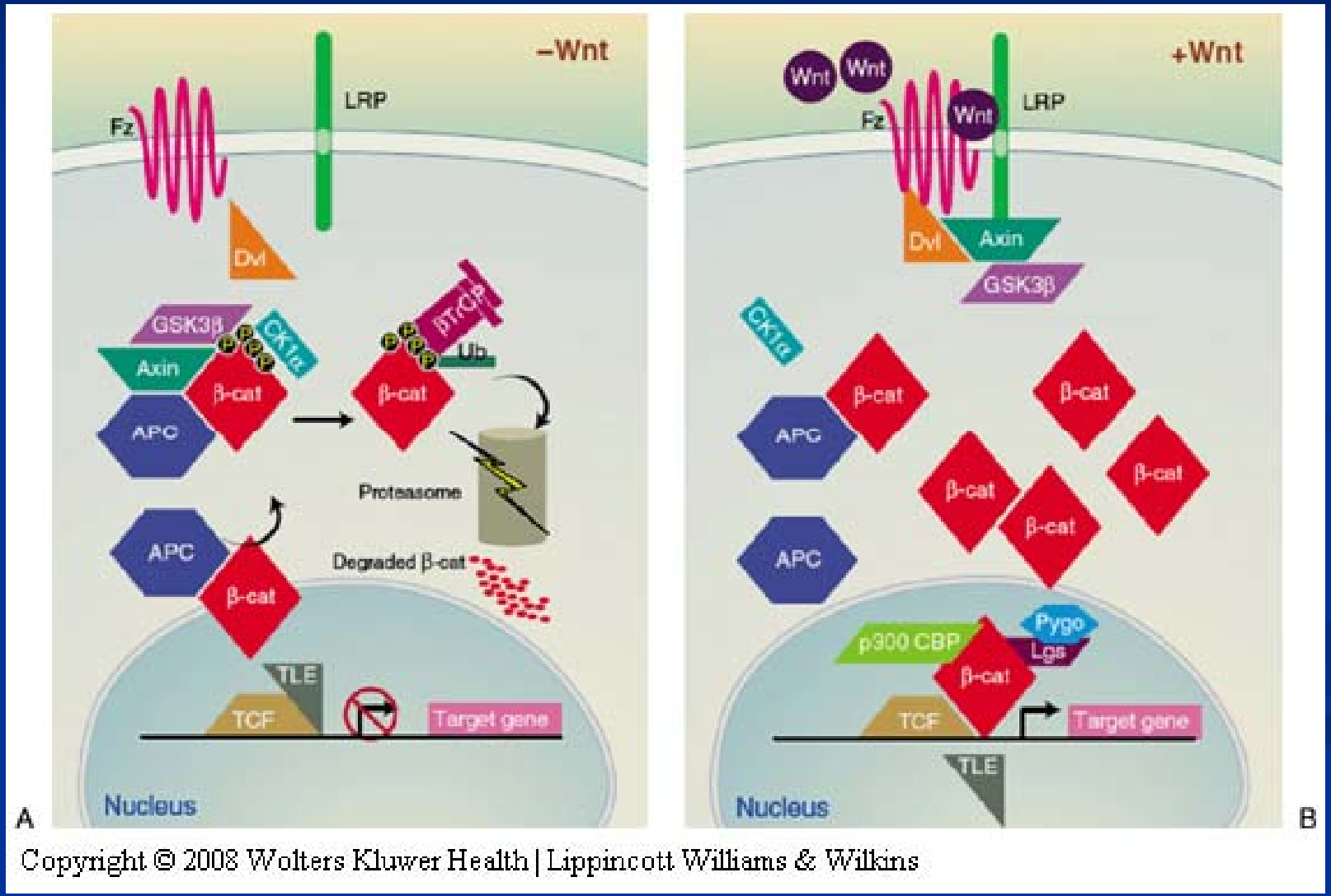


In malignant cells with loss of APC, beta catenin degradation is prevented, so WNT signaling response is continually activated.

WNT-soluble factor that induces cellular proliferation by binding to its cytoplasmic receptor Preventing degradation of beta-catenin allowing it to translocate to the nucleus where it acts as a transcriptional activator in conjunction with Tcf-4.

APC protein- antiproliferative effect; integral part of complex that destoys beta-catenin.

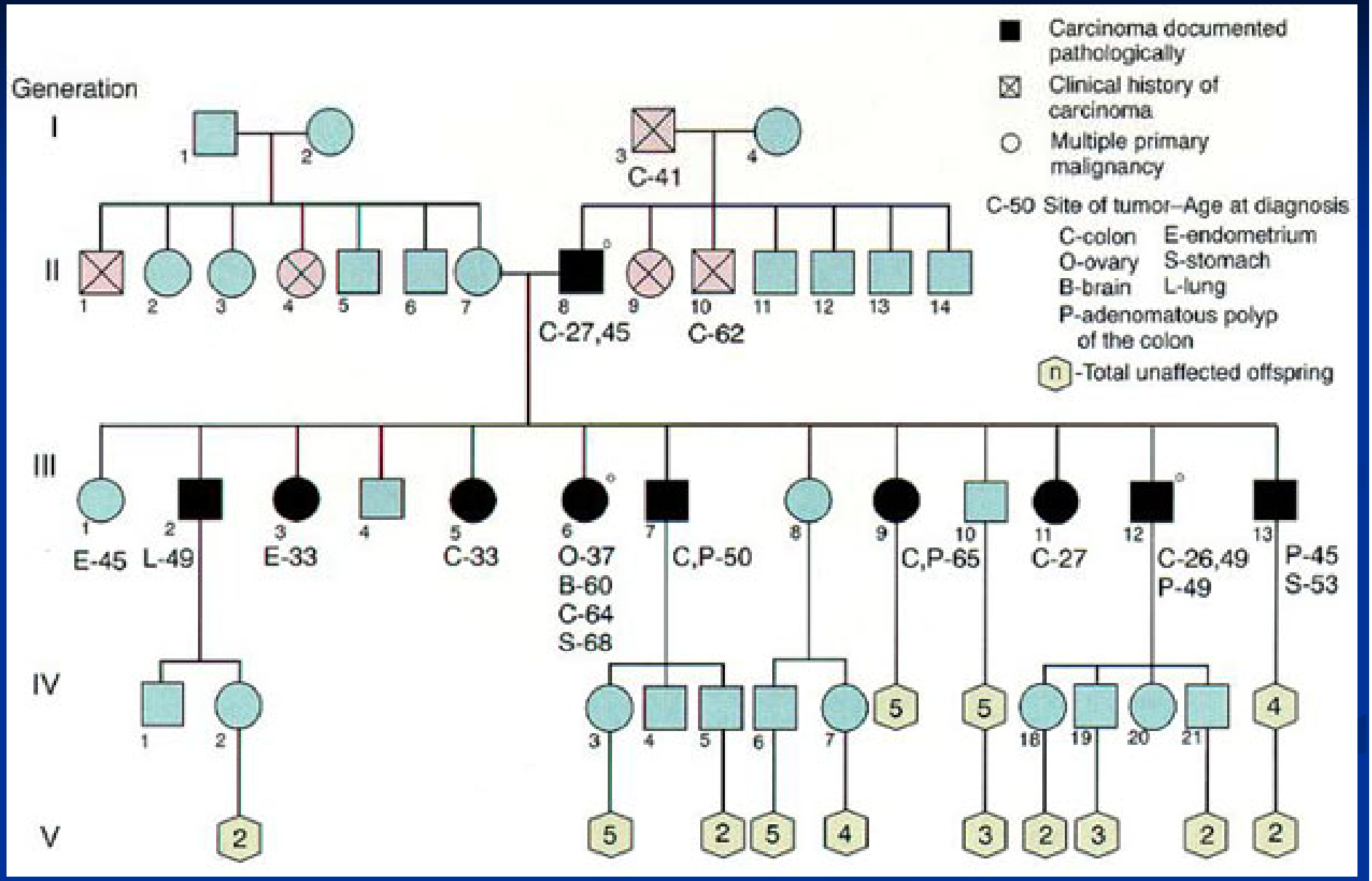
..more detailed schematic of wnt pathway



HNPCC

Hereditary Non-Polyposis Colon Cancer

Inheritance in family with cancer family syndrome



HNPCC

Clinical Criteria for HNPCC

Amsterdam criteria:

At least three **(3)** relatives with colon cancer and all of the following and one affected person is a first degree relative of the other two affected persons

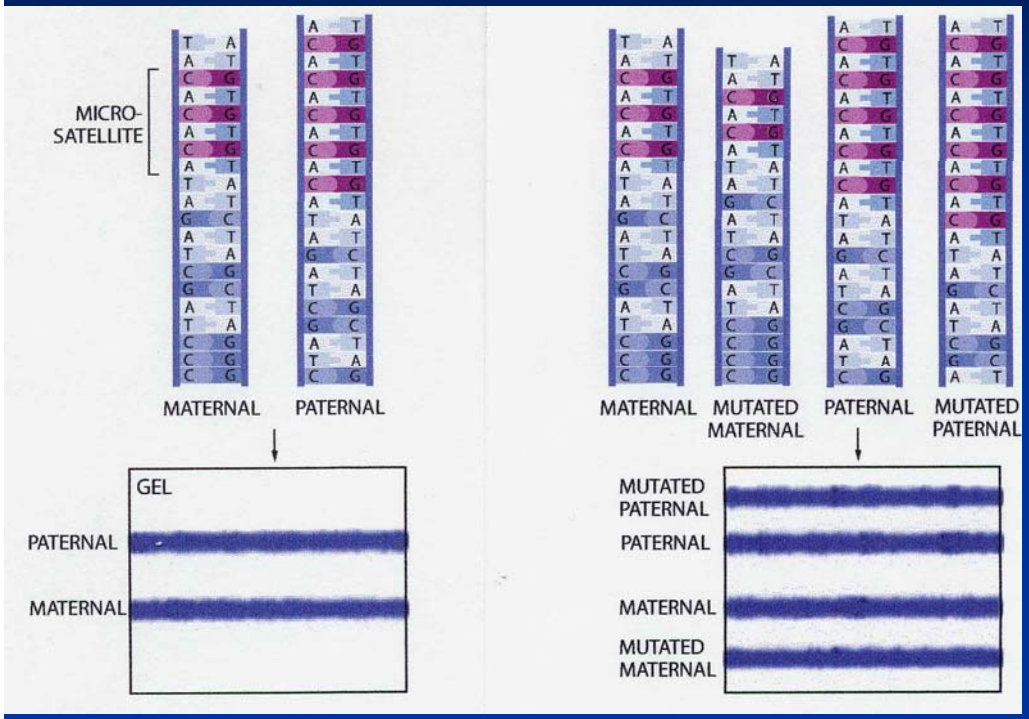
-Two **(2)** successive generations affected.

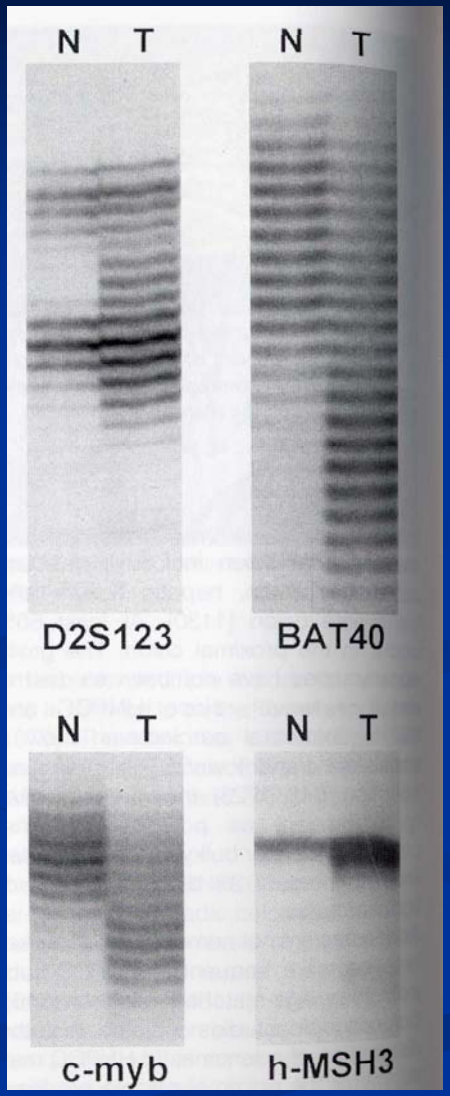
-At least one **(1)** case of colon cancer diagnosed **< 50 y**

-FAP excluded

Modified Amsterdam criteria*: same as Amsterdam criteria except cancer can involve (colon, endometrium, small bowel, ureter or renal pelvis) instead of only colon cancer.*

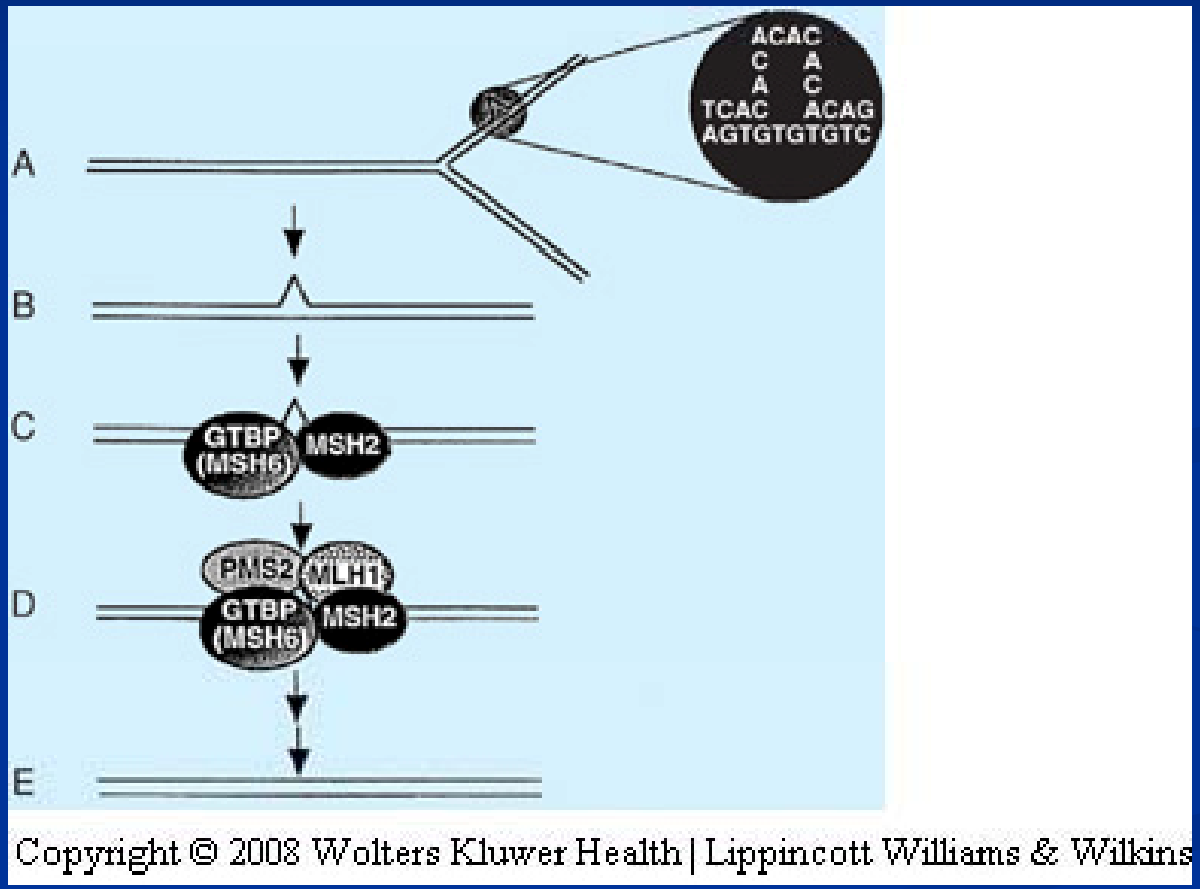
Microsatellite Instability- the result of mismatch repair gene mutations



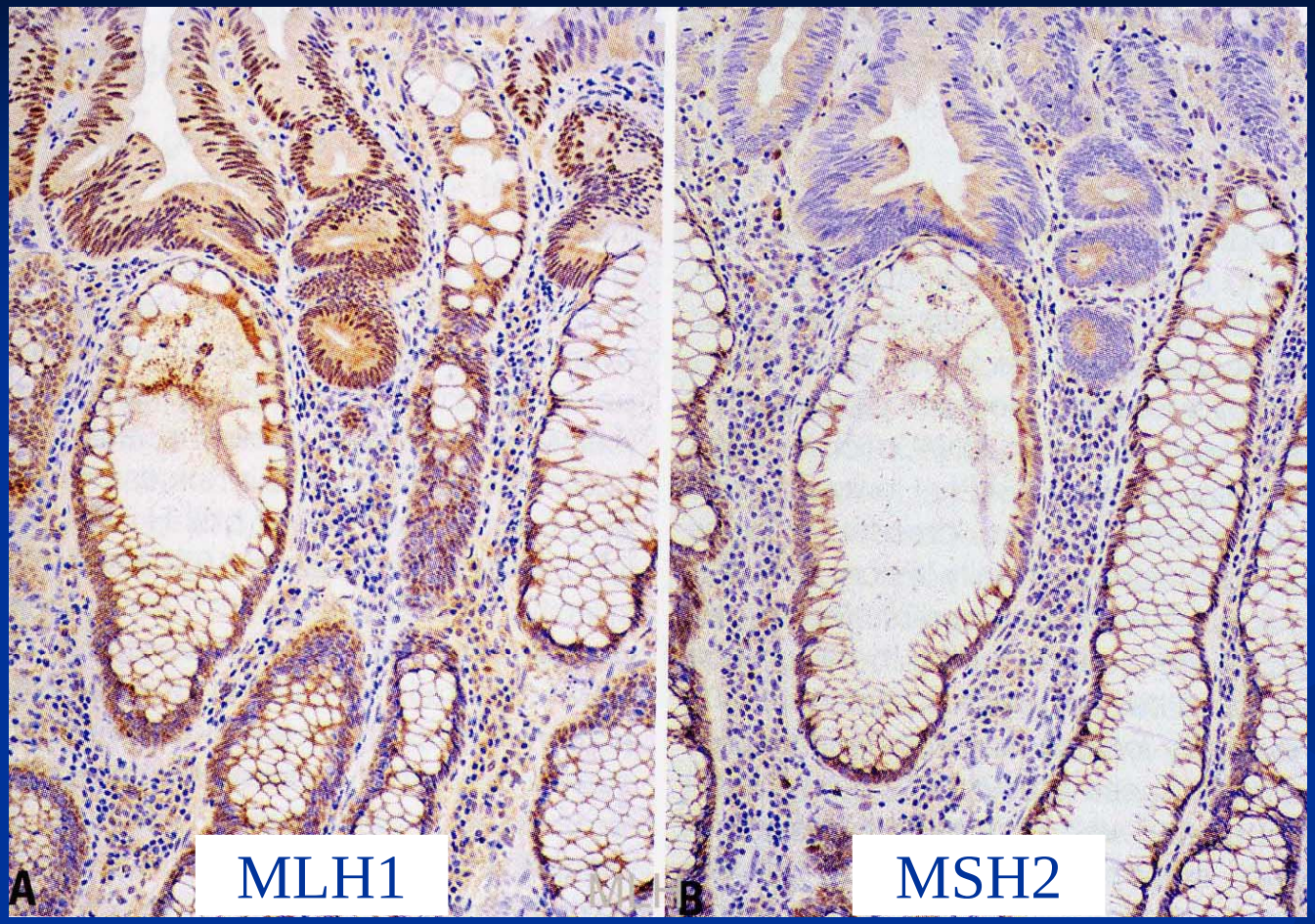


Microsatellites are simple repetitive DNA sequences (mono or dinucleotide repeats); Most microsatellites are in non-coding regions but a few are in coding regions of critical genes TGF-beta RII, IGFIIR, Tcf-4, BAX.

Mismatch Repair Enzymes



Immunohistochemical Staining for mismatch repair enzymes



Tubular adenoma in an HNPCC patient.
Neoplastic epithelium shows of loss of MSH2 expression, which correlates with mutation of the MSH2 mismatch repair gene.

Summary of clinical, pathological and genetic features of HNPCC

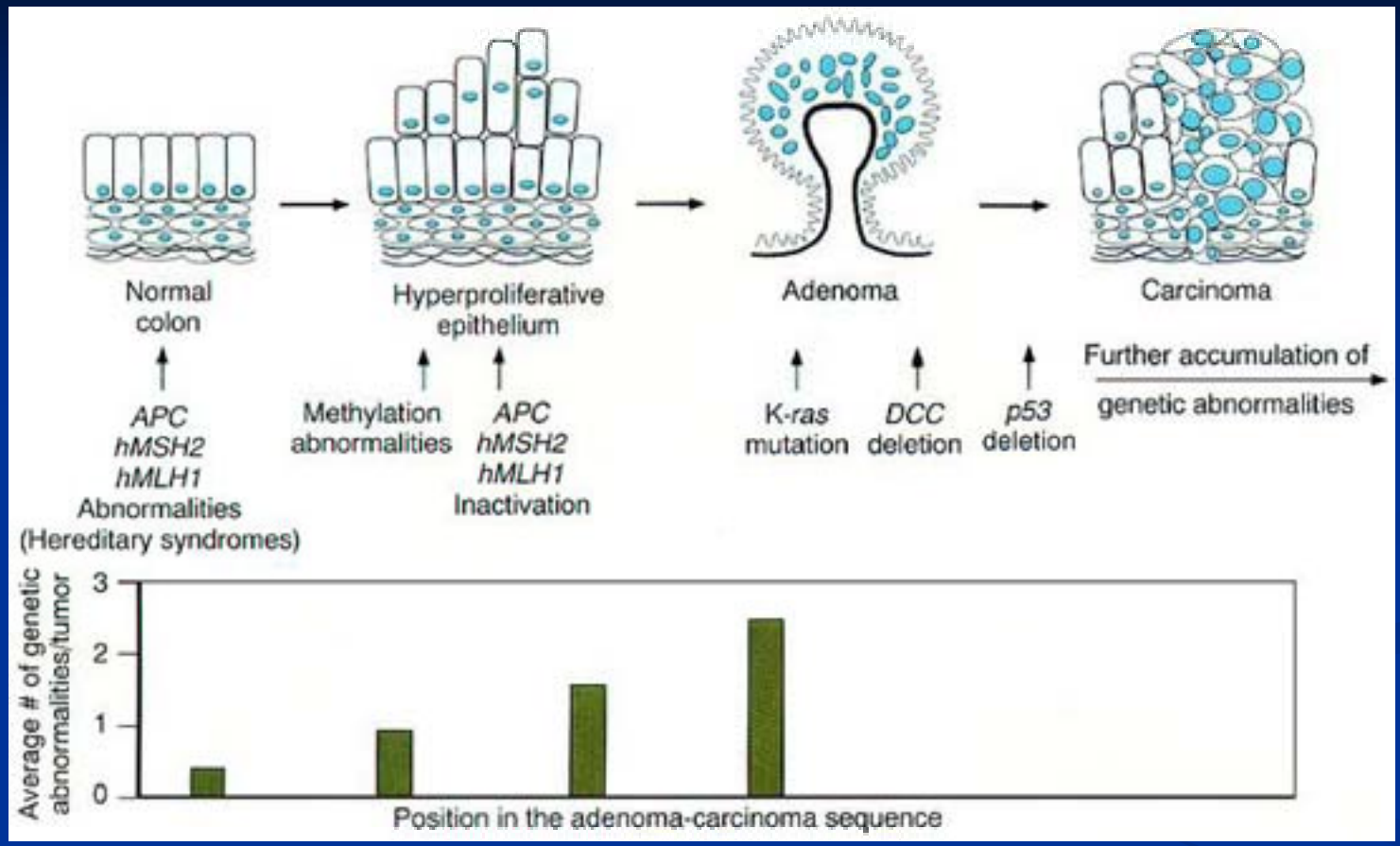
- Familial clustering of colorectal and/or endometrial cancer
- Excess risk of cancer of the ovary, ureter/renal pelvis, small bowel, stomach, brain, hepatobiliary tract, and skin (sebaceous tumors)
- Development of multiple cancers at an early age
- Features of colorectal adenoma include:
  i. variable numbers (one to a few)
  ii. high degree of dysplasia
  iii. rapid progression from adenoma to carcinoma (additional mutations rapidly accumulate – ACCELERATED TUMORIGENESIS)
  iv. high frequency of MSI
- Features of colorectal cancer include:
  i. predilection to proximal colon
  ii. improved survival
  iii. multiple colorectal tumors
  iv. increased proportion of mucinous tumors, poorly differentiated tumors, and tumors with marked host lymphocytic infiltrate at tumor margin.

HNPCC clinical characteristics

HNPCC CLINICAL CHARACTERISTICS

	HNPCC	Sporadic
Mean age at diagnosis, *y*	44.6	67
Multiple colon cancers, %	34.5	4 - 11
Synchronous	18.1	3 - 6
Metachronous	24.3	1 - 5
Proximal location, %	72.3	35
Excess malignancies at other sites	Yes	No
Mucinous and poorly differentiated cancers	Common	Infrequent
RER + %	79	17

Molecular genetic events in evolution of colon cancer



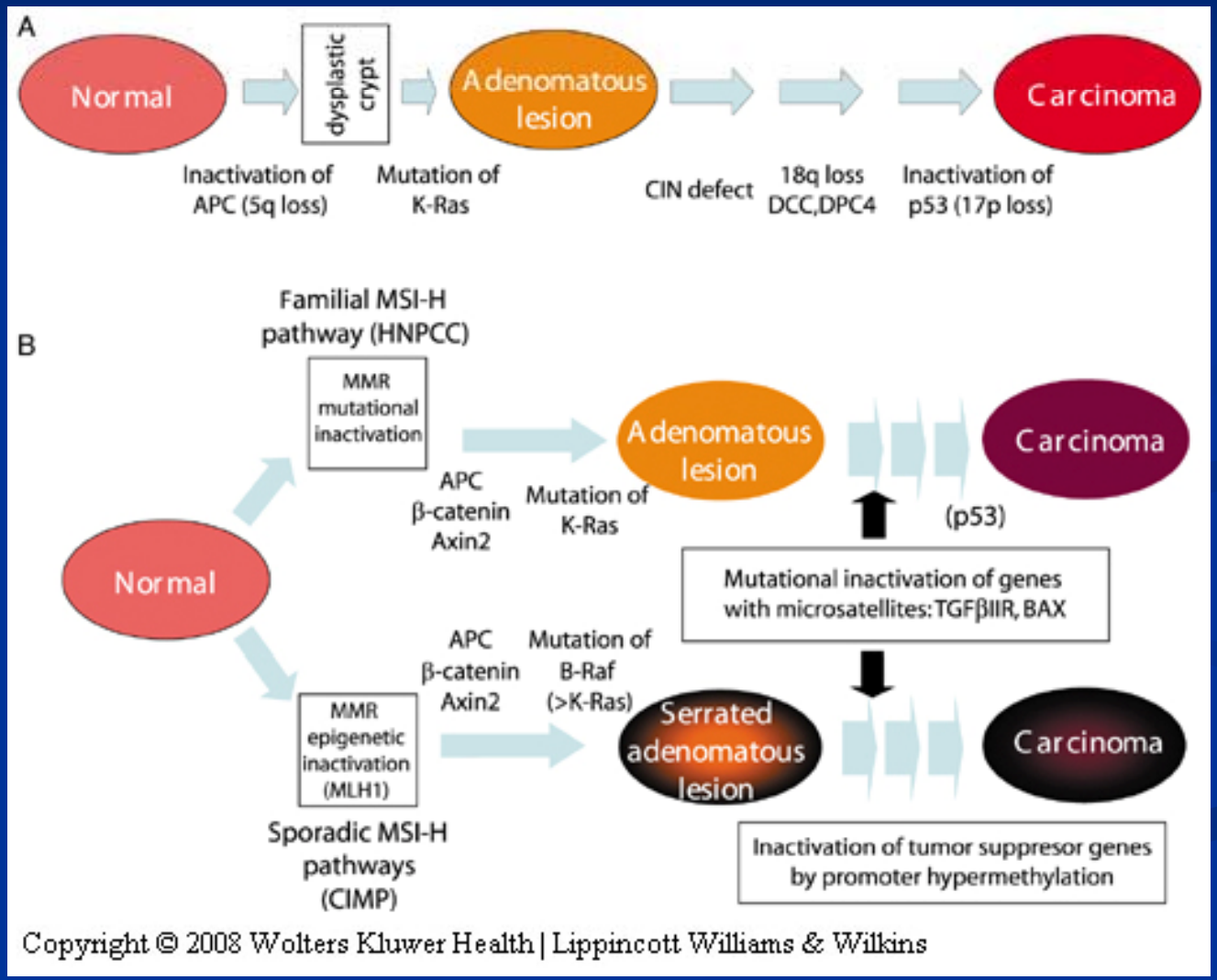
The progression to colorectal cancer is associated with an accumulation of genetic alterations, including alterations in oncogenes (K-ras), tumor suppressor genes (APC, DCC, p53), and DNA repair genes (hMSH2, hMLH1). The exact sequence of events is approximate and may vary in sporadic cancers compared with those arising in hereditary syndromes or inflammatory bowel disease.

Genes altered in colon cancer

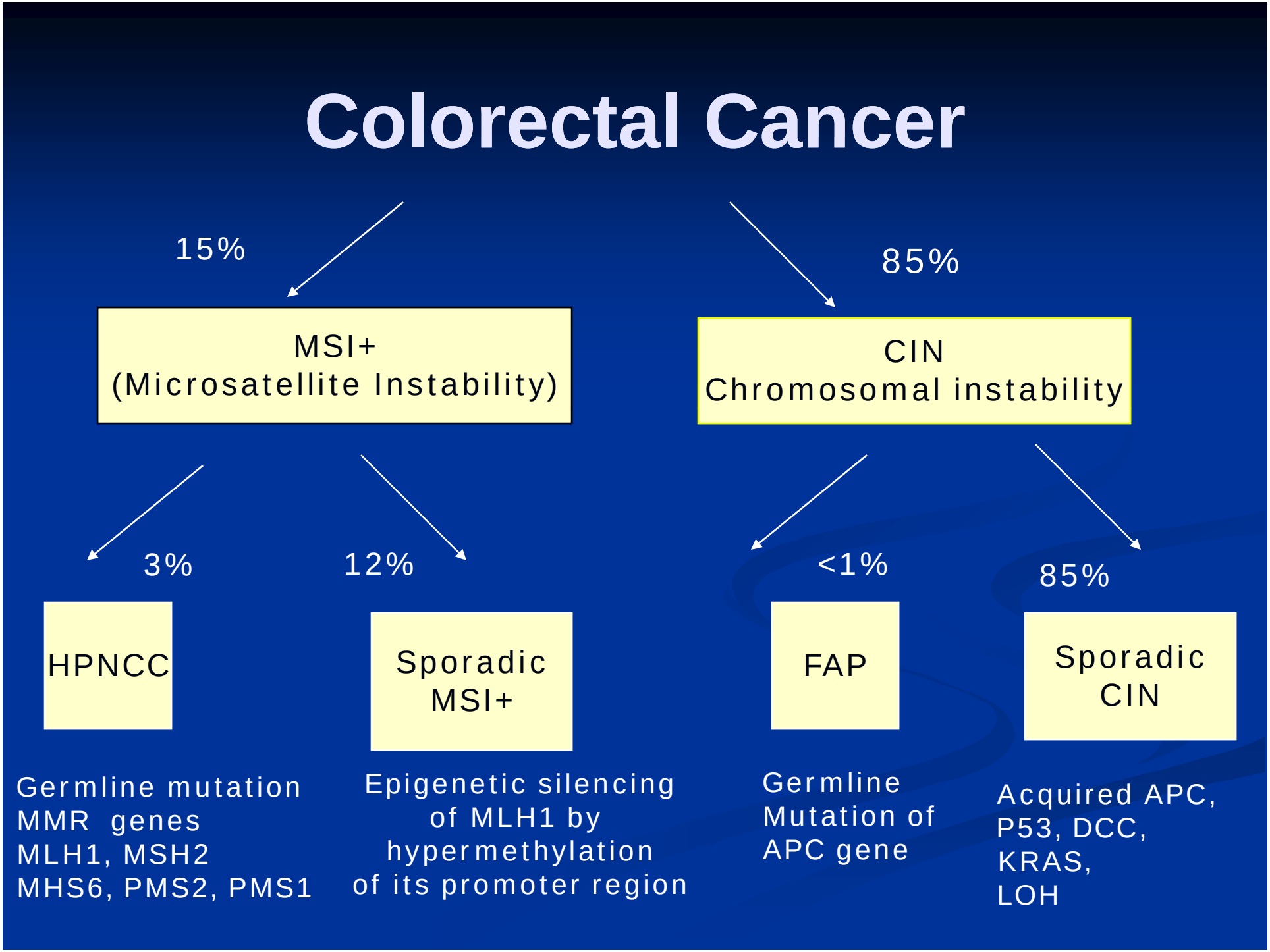
GENES ALTERED IN COLON CANCER

Gene	Chromosome	Sporadic tumors with alterations, %	Class	Function
K - *ras*	12	50	Protooncogene	Signal transduction
APC	5	60	Tumor supressor	?Cell adhesion Anti-proliferative function
DCC	18	70	Tumor supressor	?Cell adhesion
p53	17	75	Tumor supressor	Cell cycle control (G1/S arrest)
hMSH2	2		DNA Mismatch repair	Maintains fidelity of DNA replication
hMLH1	3		DNA Mismatch repair	Maintains fidelity of DNA replication

Genetic Model of Colorectal Cancer

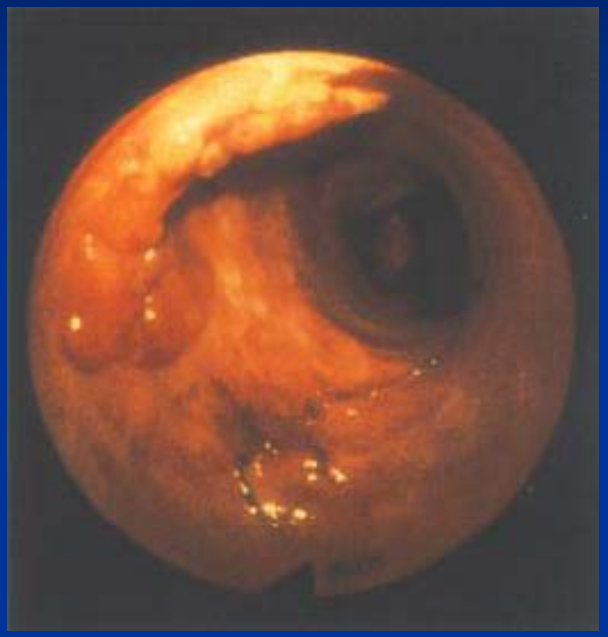


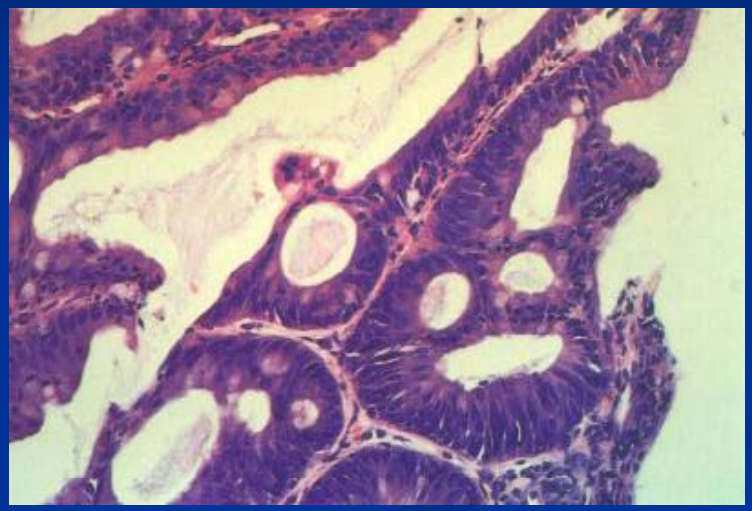
Colorectal Cancer



Dysplasia and Carcinoma in Inflammatory Bowel disease

Dysplasia-associated lesion/mass (DALM) in Ulcerative Colitis



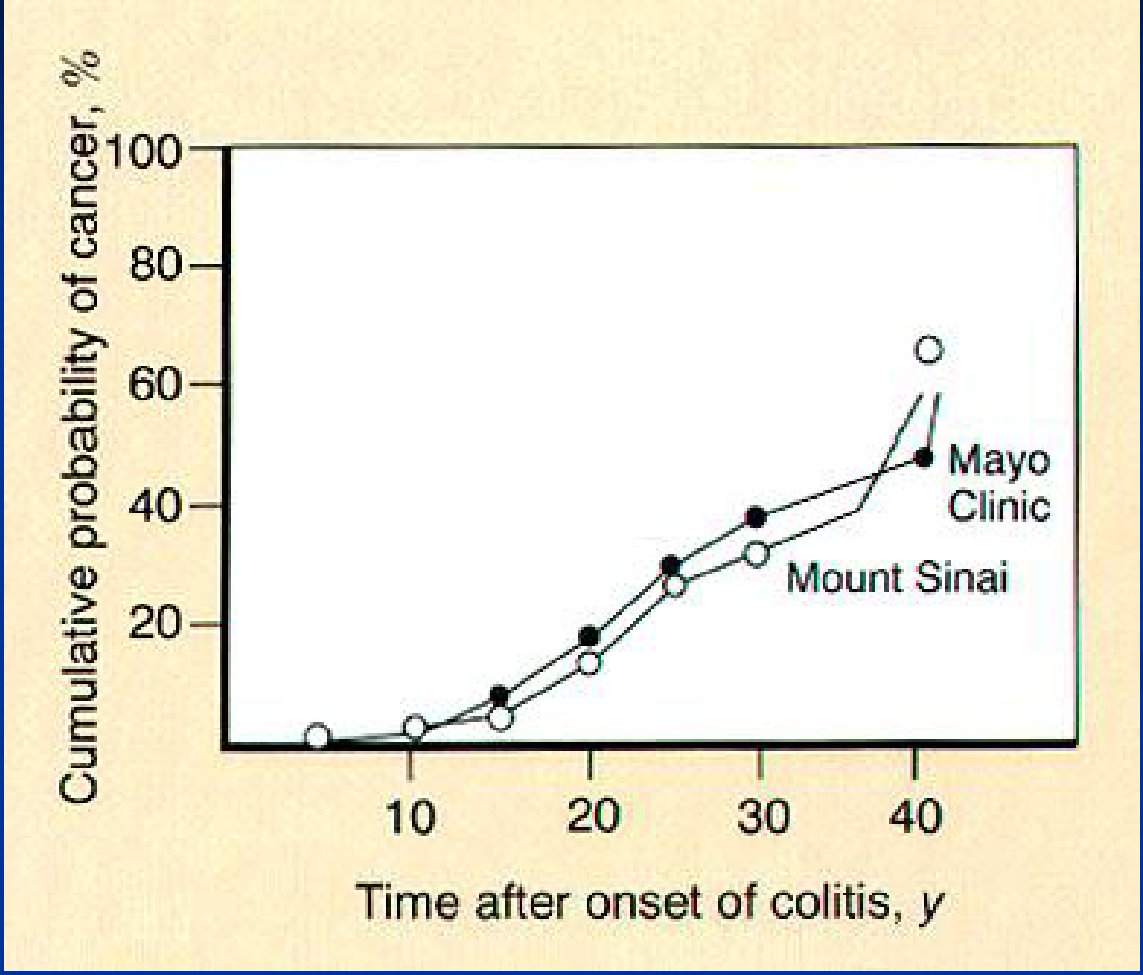


High grade Dysplasia

Risk of dysplasia in UC correlate with EXTENT and DURATION of disease.
UC patients with pancolitis are at highest risk.
Ulcerative proctitis (disease limited to rectum) -negligible risk.

DALM – (dysplasia associated lesions)
greater than 50% chance of coexistent invasive adenocarcinoma.

Probability of developing colorectal carcinoma in ulcerative colitis

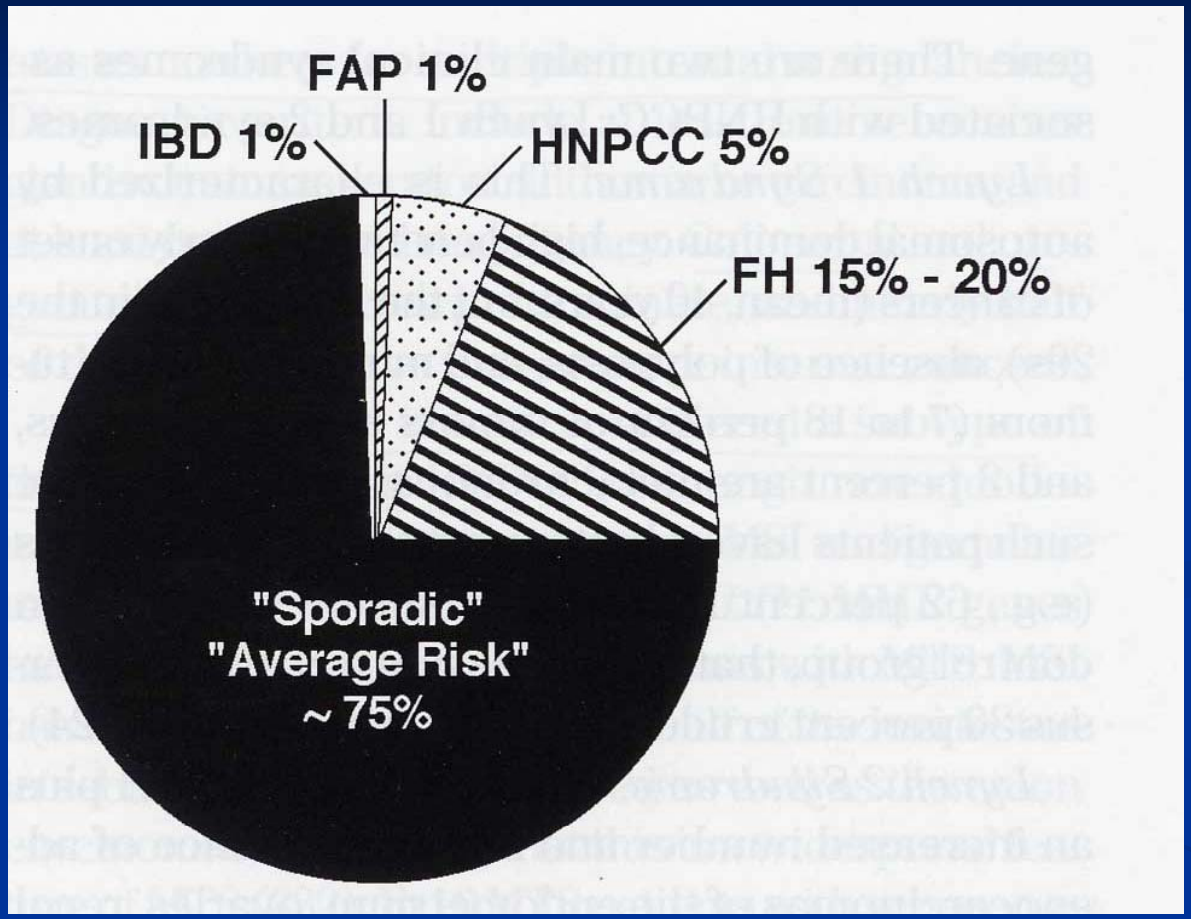


Cumulative risk of developing adenocarcinoma correlates with duration of UC:

5% in 5 years
15% in 25 years
30-50% in 40 years

1% per year cumulative incidence of carcinoma after 10 years duration of disease.

Bresalier RS, Kim YS, In Gastrointestinal Disease: Pathophysiology/Diagnosis/Management, edn 5. Edited by Sleisenger MH, Fordtran JS. Philadelphia: WB Saunders; 1993 1449-1493



Estimates of the predisposing causes of Colorectal Carcinoma

Why screen for CRC (Colorectal Cancer) ?

- Detect earlier stage cancers.
- Early stage CRC has excellent prognosis.

Current screening (average risk)

FOBT Flex sig	FOBT annual Flex sig - 5yr	Positive tests Colonoscopy
Colonoscopy	every 10 yr	
Barium Enema	every 5 yr	

Current screening (increased risk)

1 adenoma <1cm	3-6 yr after initial polypectomy	Colonoscopy
Adenoma>1cm, Multiple adenomas	3 yrs after initial polypectomy	
Curative resection of colon cancer	Within 1 yr	If normal , repeat in 3yr.

Current screening (high risk)

FAP (family hx)	puberty	Genetic testing
HNPCC (family hx)	age 21	Genetic testing, 1-2 yr until age 40, then annually
IBD	Risk greater with Pancolitis, >10yr duration	Every 1-2 yr.

Colonic Neoplasia

Colonic Adenocarcinoma (Summary)

- Precursor lesions (Adenoma- Carcinoma sequence)
- Pathologic staging of colorectal tumors

- Chronic inflammation (IBD, including UC and Crohns)
- Genetics (genetic predisposition)
  - FAP (germline mutation of APC gene)
  - HNPCC (germline mutation of mismatch repair gene)

- Molecular pathways of colorectal carcinogenesis
  - Suppressor pathway (APC/beta catenin)
  - Mutator pathway (DNA mismatch repair genes)

- Questions or Comments…
- Please email me..
  - her2007@columbia.edu
  - (all feedback welcome… negative or positive.. your imput will help make lectures less confusing for the next year of medical students…)