

Color changes in various lesions

Color of the tissues and organs represent the functional state of the component cells. The color of the normal and abnormal tissues and organs is determined by the abundance or paucity of intracellular or extracellular pigments: These include hemoglobin, myoglobin, cytochrome, myeloperoxidase, bilirubin, biliverdin, hemosiderin, lipofuscin/ceroid, carotenoid and carbon particles. Representative examples are demonstrated herein.

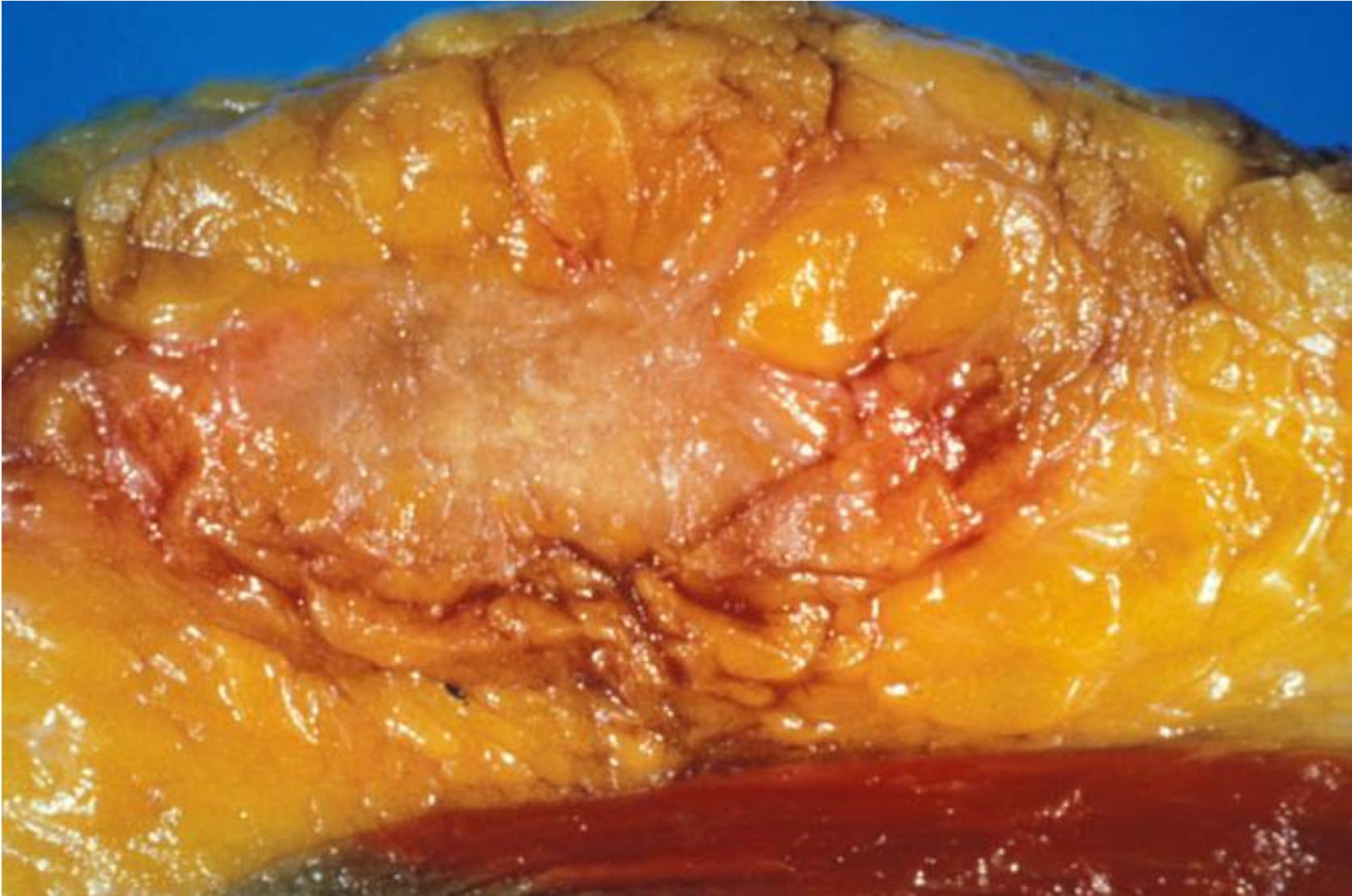
Ref.: Piña-Oviedo S, et al. Human colors—The rainbow garden of pathology: what gives normal and pathologic tissues their color? Arch Pathol Lab Med 2017; 141(3): 445-462. doi: 10.5858/arpa.2016-0274-SA

Pigments causing colors of the tissue and organs

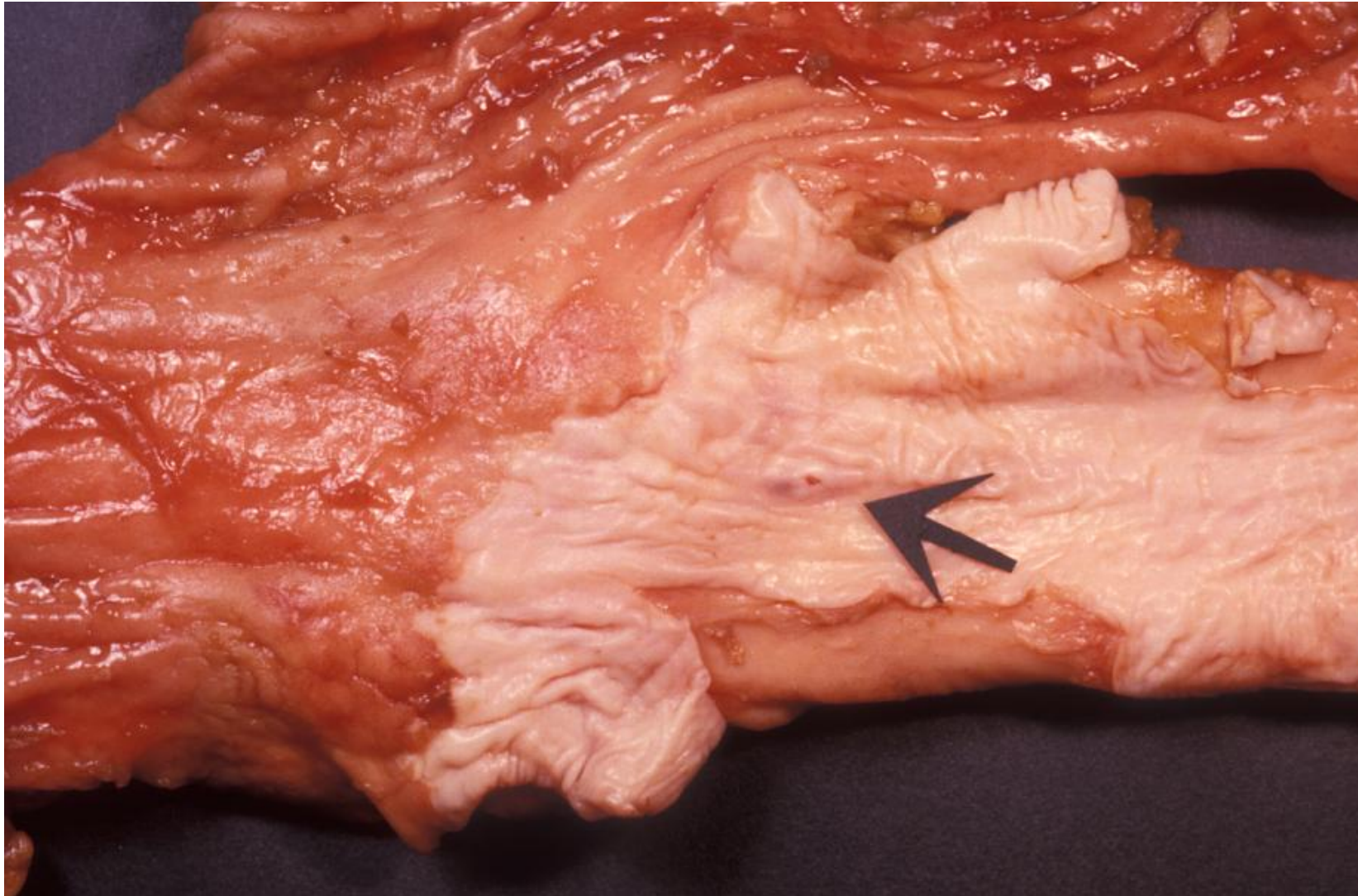
- 1) **Hemoglobin** (heme protein of red blood cells)
- 2) **Myoglobin** (heme protein of striated muscle cells, type
- 3) **Cytochrome** (heme protein of mitochondria)
- 4) **Myeloperoxidase** (heme protein of Azue granules of myeloid cells)
- 5) **Bilirubin** (bile pigment)
- 6) **Biliverdin** (bile pigment metabolite)
- 7) **Hemosiderin** (hemoglobin metabolite with insoluble oxidized/trivalent irons)
- 8) **Melanin** (black pigment of the skin and retina)
- 9) **Lipofuscin/ceroid** (lipid peroxides)
- 10) **Carotenoid** (lipid-soluble retinoid/vitamin A derivative)
- 11) **Carbon particles** (air-derived exogenous pigment)

Medical terms related to the color

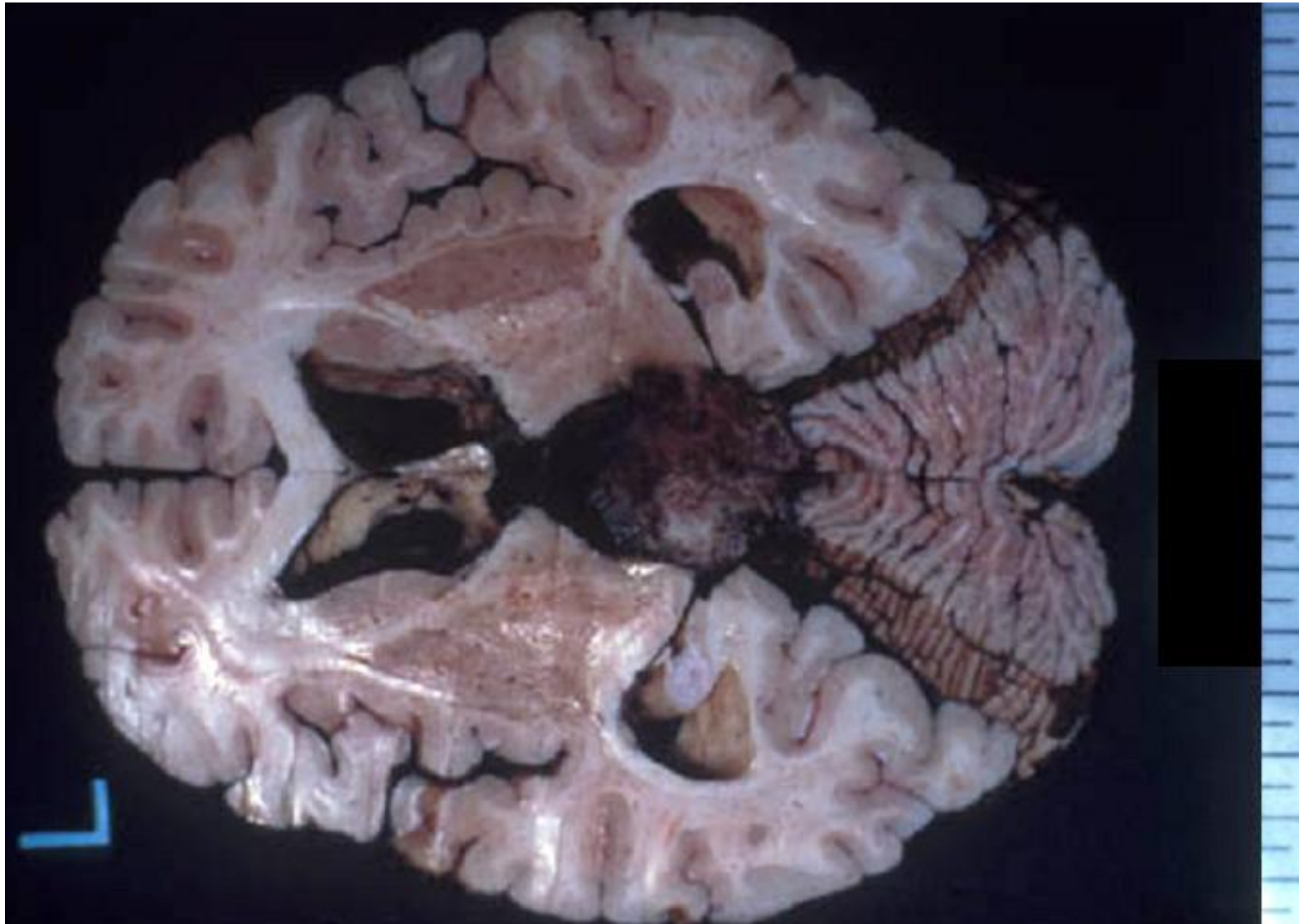
	Greek-origin	Latin-origin	Examples
White	leuko-	albus	leukocyte, leukemia, albinism, <i>Candida albicans</i>
Black	melano-	niger	melanin, melancholy, acanthosis nigricans, <i>Aspergillus niger</i>
Red	erythro-	rubor	erythrocyte, bilirubin, Nucleus ruber
Blue	cyano-	caeruleum	cyanosis, cyanic acid, Nucleus caeruleus
Yellow	xantho-	flavum, luteum	xanthoma, riboflavin, corpus luteum
Green	chloro-	viridis (verde)	chlorophyll, chloroma, biliverdin, <i>Streptococcus viridans</i>
Green-blue	aerugo-	patinus	<i>Pseudomonas aeruginosa</i> , patina
Purple	porphyro-	violaceus	porphyrin, <i>Porphyromonas gingivalis</i> , violacein
Orange	rhodo-	roseus	rhodopsin, rosasea, roseola
Brown	pheo-	pullus, adustus	pheochromocytoma, pheohyphomycosis
Gray	polio-	griseus	poliomyelitis, griseofulvin
Gray-blue	glauco-	caesius	glaucoma, cesium
Gold	chryso-	aureus	chrysolite, aurum (Au), <i>Staphylococcus aureus</i>
Silver	argyro-	argentum	argyrophilia, argentaffin cell, argentum (Ag)



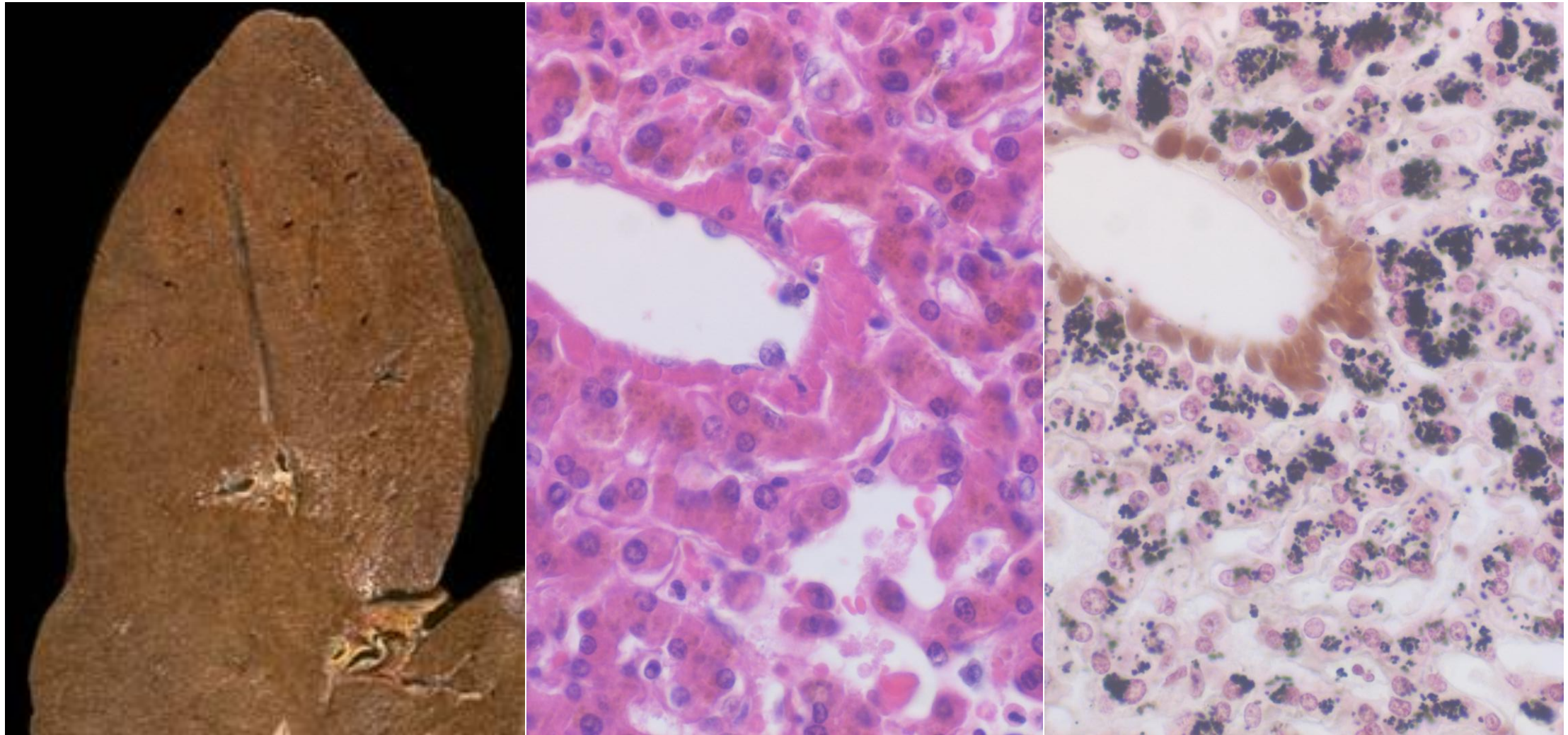
Cut surface of mastectomized breast cancer (invasive ductal carcinoma). Compare the color of the centrally located cancer (white) with the surrounding fat tissue (yellow: carotenoid) and striated muscle tissue (red: right bottom: myoglobin).



Esophagogastric junction of an autopsied case with liver cirrhosis. Ruptured esophageal varix is arrowed. Compare the whitish color of the esophageal squamous mucosa with the reddish color of the gastric columnar mucosa. The reddish color represents transparent capillary vessels beneath the single-layered epithelium.



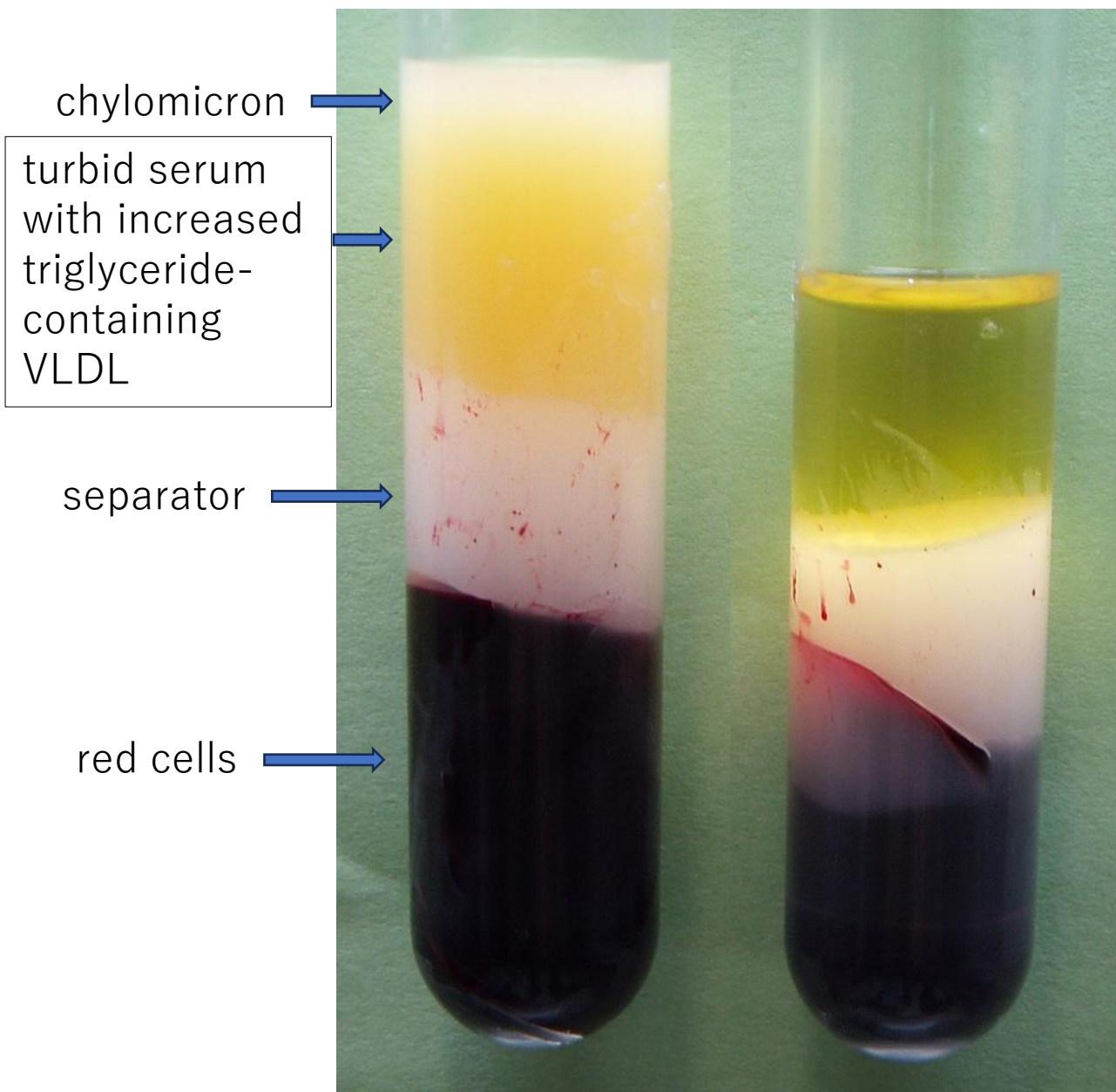
Horizontal section of the formalin-fixed brain with hemorrhagic pineal gland tumor (yolk sac tumor with choriocarcinomatous component). Compare the gray matter (cortex and basal ganglia) with the white matter. The gray color represents the presence of lipofuscin-containing neurons.



Brown atrophy of the liver (left: gross appearance). Brownish color is accentuated by the deposition of brown-colored pigment (lipofuscin) in the hepatocytes (center: H&E). The lipofuscin is visualized with Fontana-Masson's silver (right).



Melanosis coli in a case of cecal adenocarcinoma (type 2). The non-cancerous colonic mucosa is dark brown-colored (left). Adenomatous lesions, as well as the cancerous lesion, are devoid of pigmentation. Ileal mucosa is also free of pigmentation. Microscopically, macrophages in the lamina propria mucosae contain rich ceroid pigment (right: H&E).



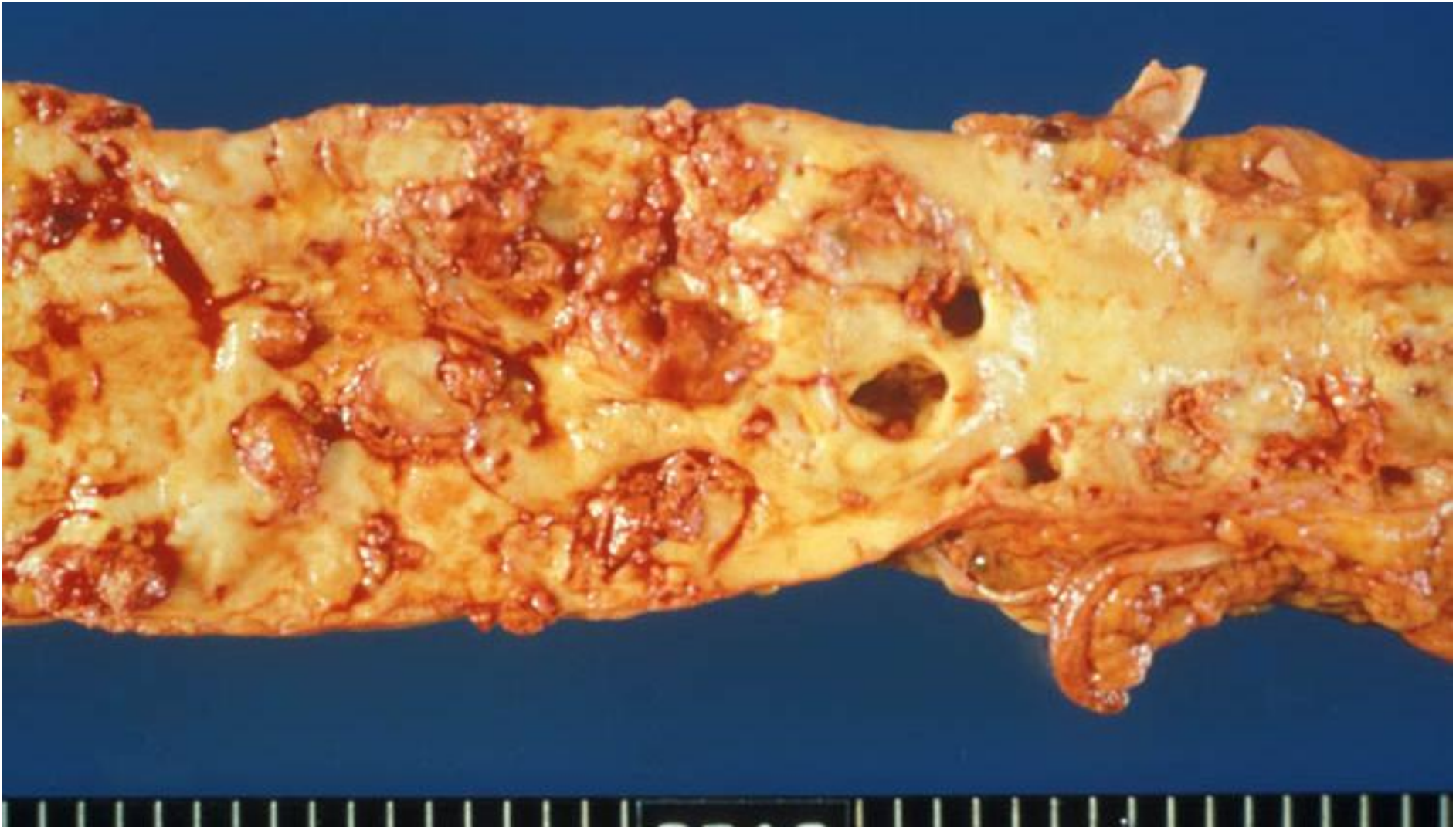
Case : 56 y-o female with obesity (left)
 Total cholesterol 298 mg/dl
 (reference value: 120-219)
 Triglyceride **1,128 mg/dl**
 (reference value : 30-149)

Normal control (right)
 Total cholesterol 135 mg/dl
 Triglyceride 78 mg/dl

Classification of hyperlipidemia

Type I : increase of chylomicron
 Type II a: increase of LDL
 Type II b: increase of LDL and VLDL
 Type III: increase of IDL
 Type IV: increase of VLDL
 Type V : increase of chylomicron and VLDL

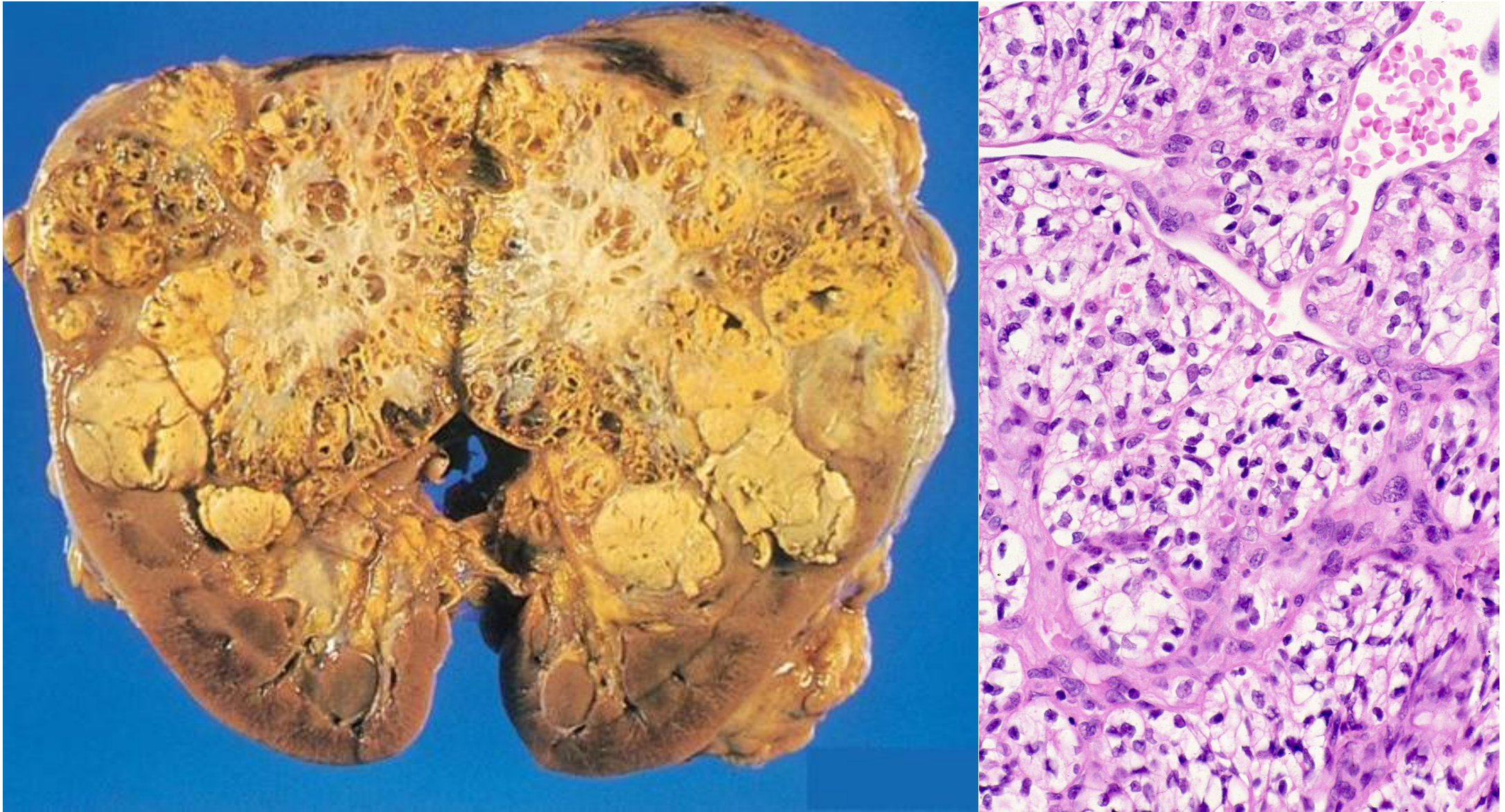
Left: hyperlipidemia type V (with increase of chylomicron and VLDL),
 Right: normal individual. Note the normal and turbid colors of the sera.



Atherosclerosis of the aorta. Yellow-colored atheromatous plaques damage the elasticity of the arterial wall. The yellow color represents accumulation of lipid (cholesterol in the atheroma).



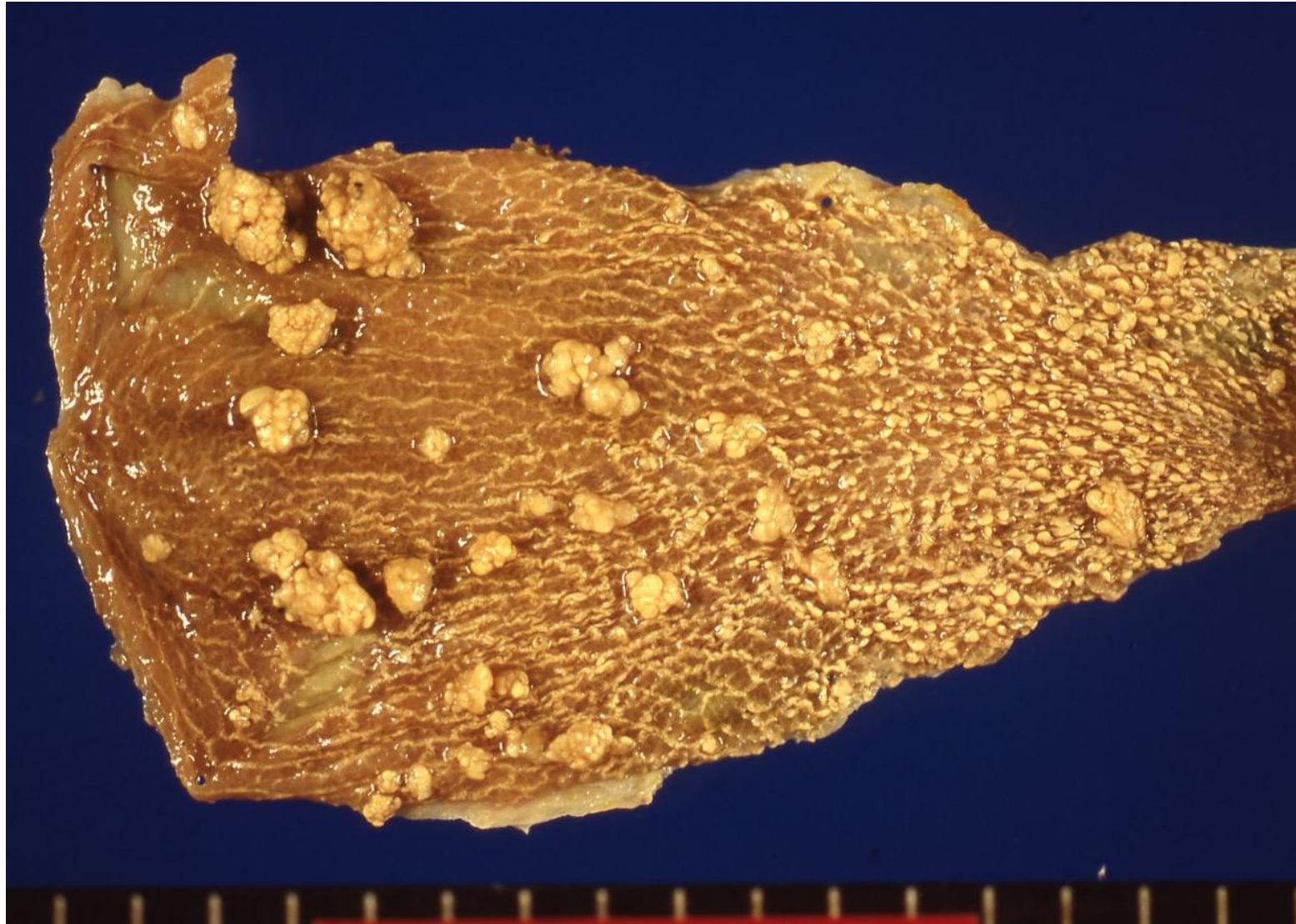
Xanthogranulomas of the liver hilum. The lesion is caused by ectopic migration of *Ascaris lumbricoides* into the bile duct. Xantho- means yellow.



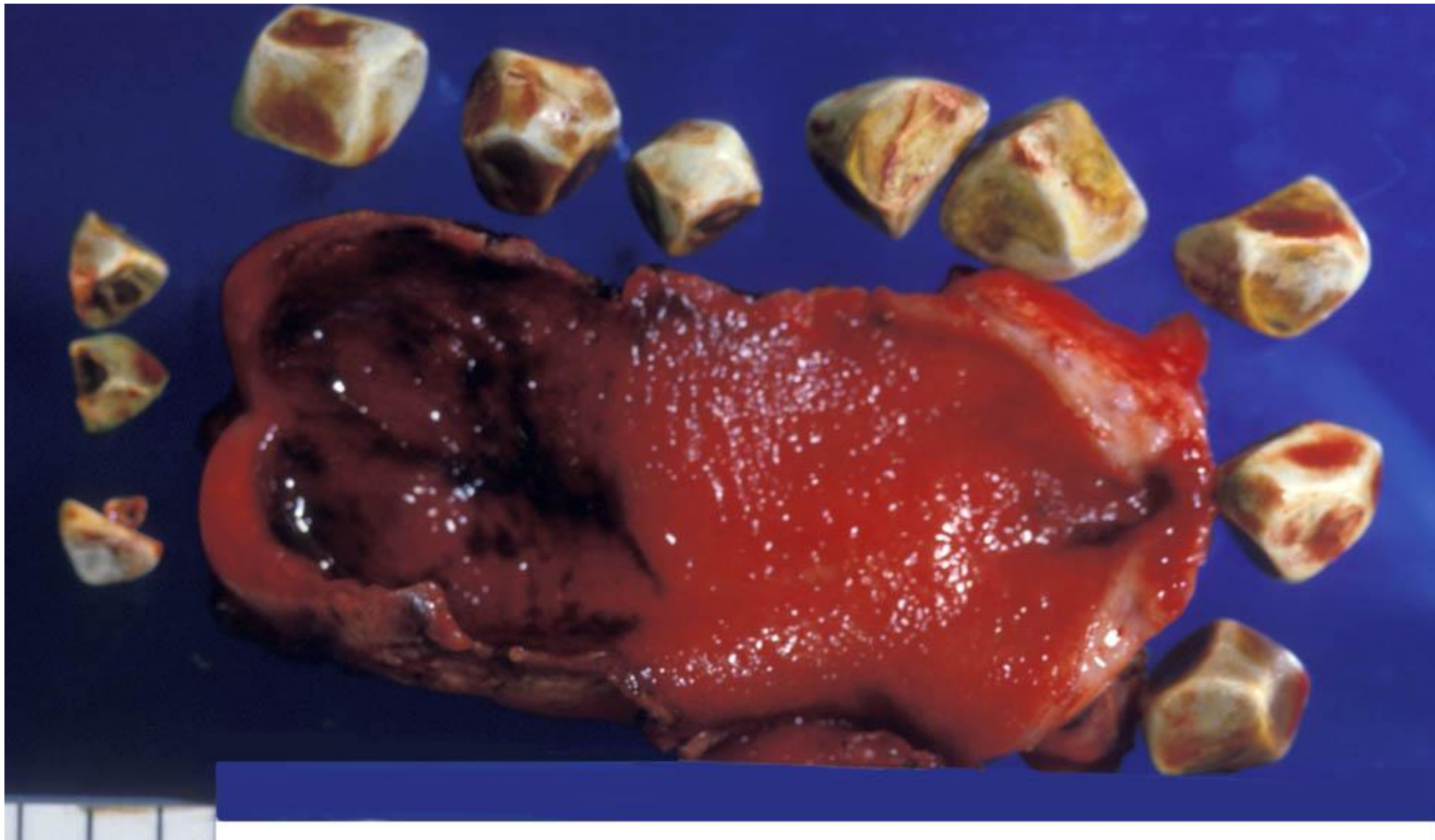
Renal cell carcinoma is featured by its yellow color (left). The clear cells possess rich glycogen and lipid droplets (right: H&E). This tumor is highly invasive with multiple satellite nodule formation, Nuclear atypia is associated microscopically.



Testicular teratoma with a yolk sac tumor component removed from a 33 y-o male patient. The yolk sac tumor has yellowish color with a solid and medullary growth pattern. The teratoma component is white in color with multicystic appearance.



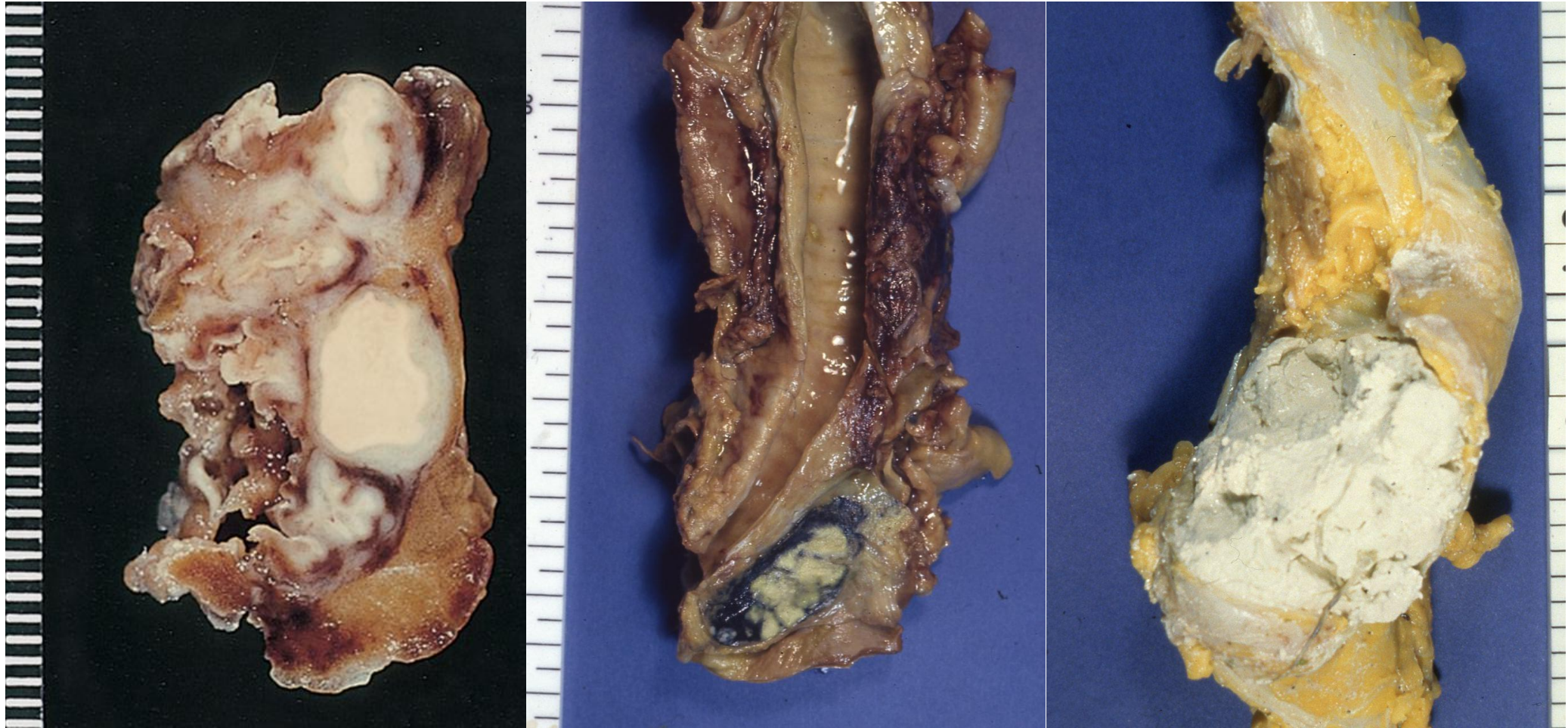
Chronic cholecystitis with mucosal cholesterolosis and multiple cholesterol polyps. The lesions represent high cholesterol content in both the bile and serum.



Cholesterol gallstones in the gallbladder lumen. Dice-like shape and yellow color are characteristic. The cholesterol stones are often seen in obese and middle-aged lady (3Fs: forty fatty female),



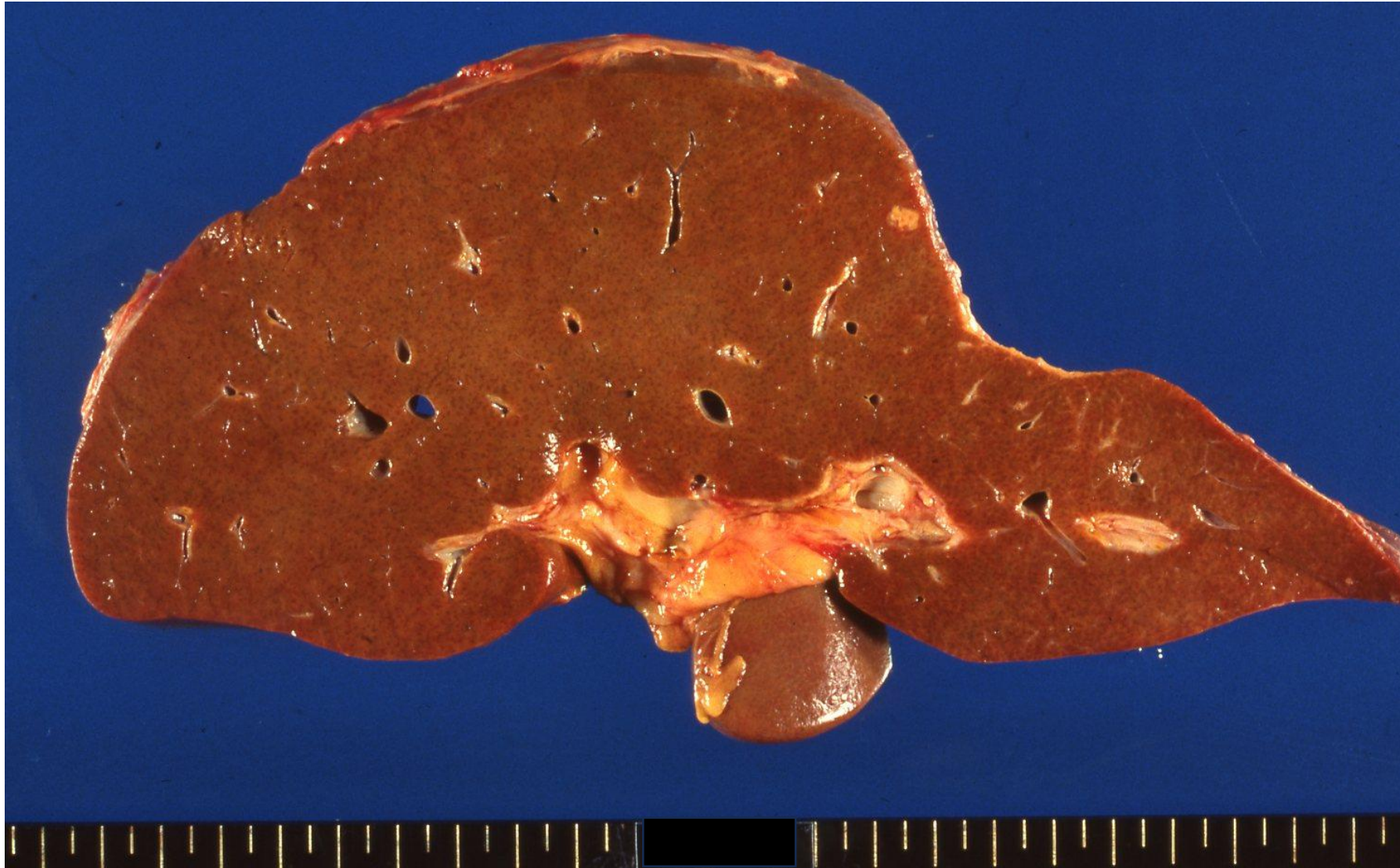
Bilirubin (pigmented) gallstones in the gallbladder lumen. Two global and black stones caused ulcerations. Glucuronate-conjugated water-soluble bilirubin was deconjugated by beta-glucuronidase of bacterial origin to form unconjugated water-insoluble bilirubin. The crystallized condensed bilirubin appear black in color.



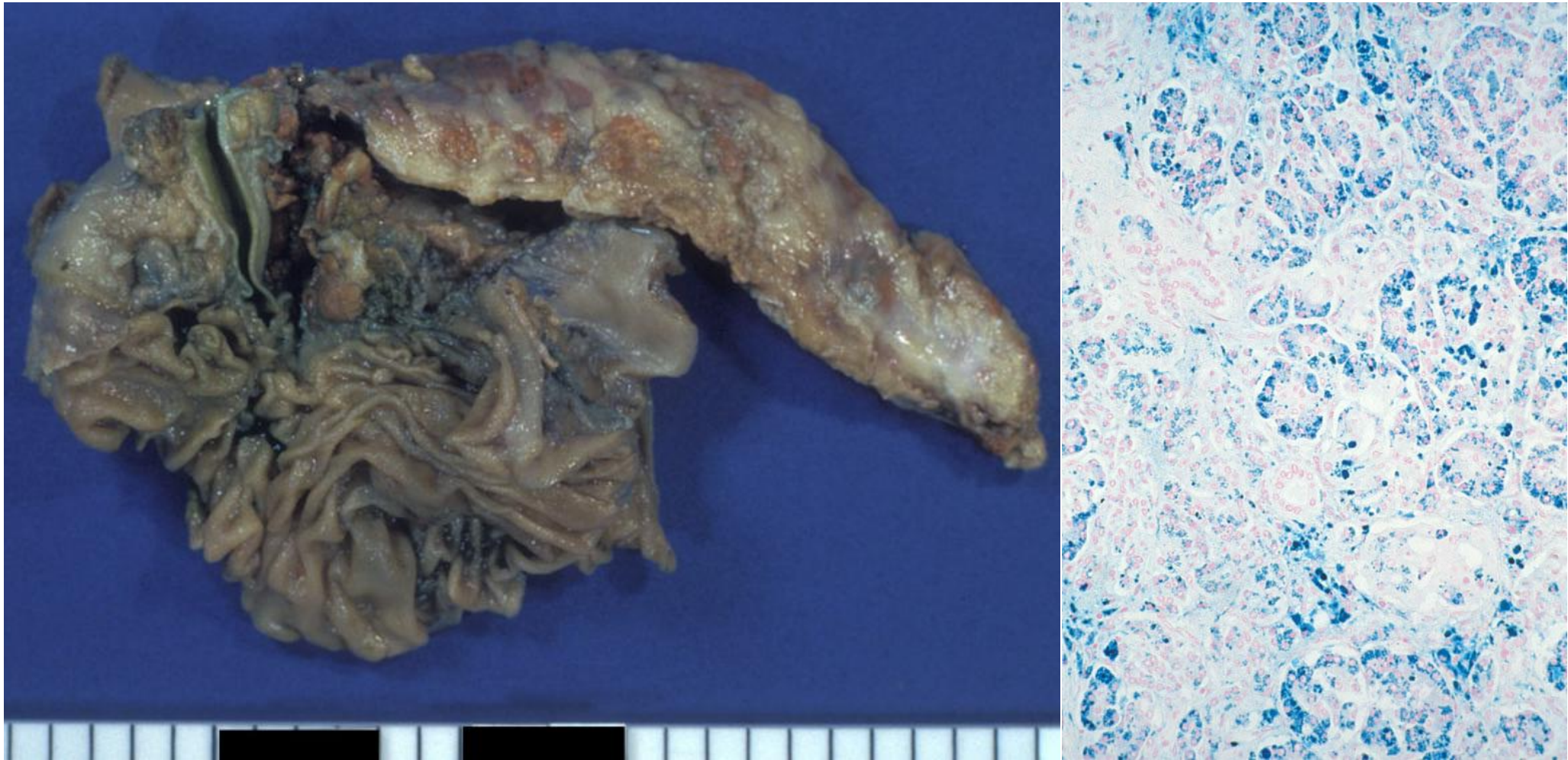
Caseous necrosis in tuberculous lesions are shown. Left: adrenal tuberculosis causing Addison's disease, center: lymph nodal tuberculosis at the lung hilum, right: cold abscess in the psoas muscle draining from the spinal caries. Cheese-like, mildly yellowish color is observed in caseous lesion. In the cold abscess, a mortar-like substance is accumulated.



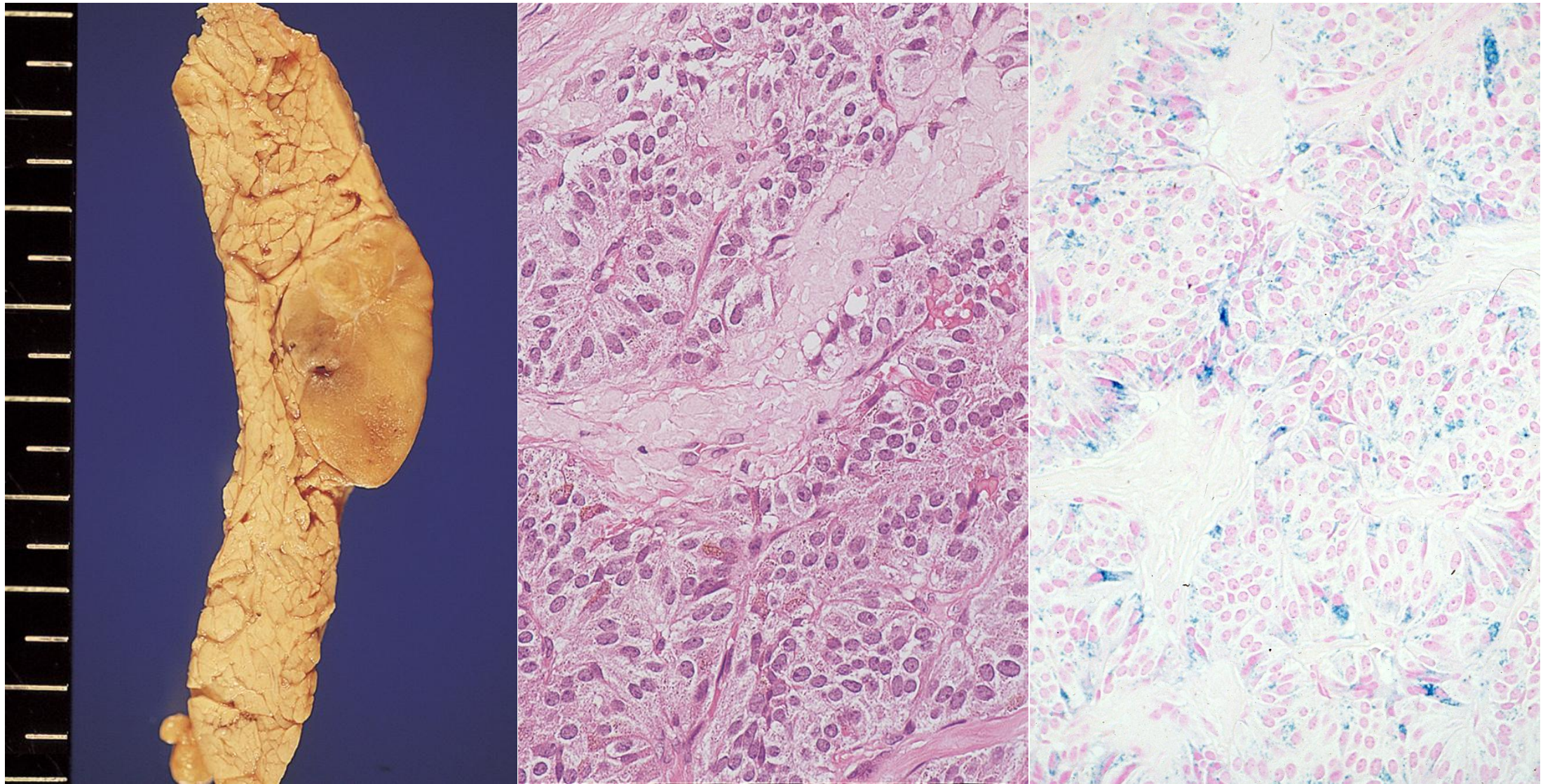
Alcoholic liver disease with marked accumulation of fat droplets in the hepatocytes. Yellowish color and fine regenerative nodule formation are noted. The bile duct is stained bright yellow by deposition of bilirubin in the bile.



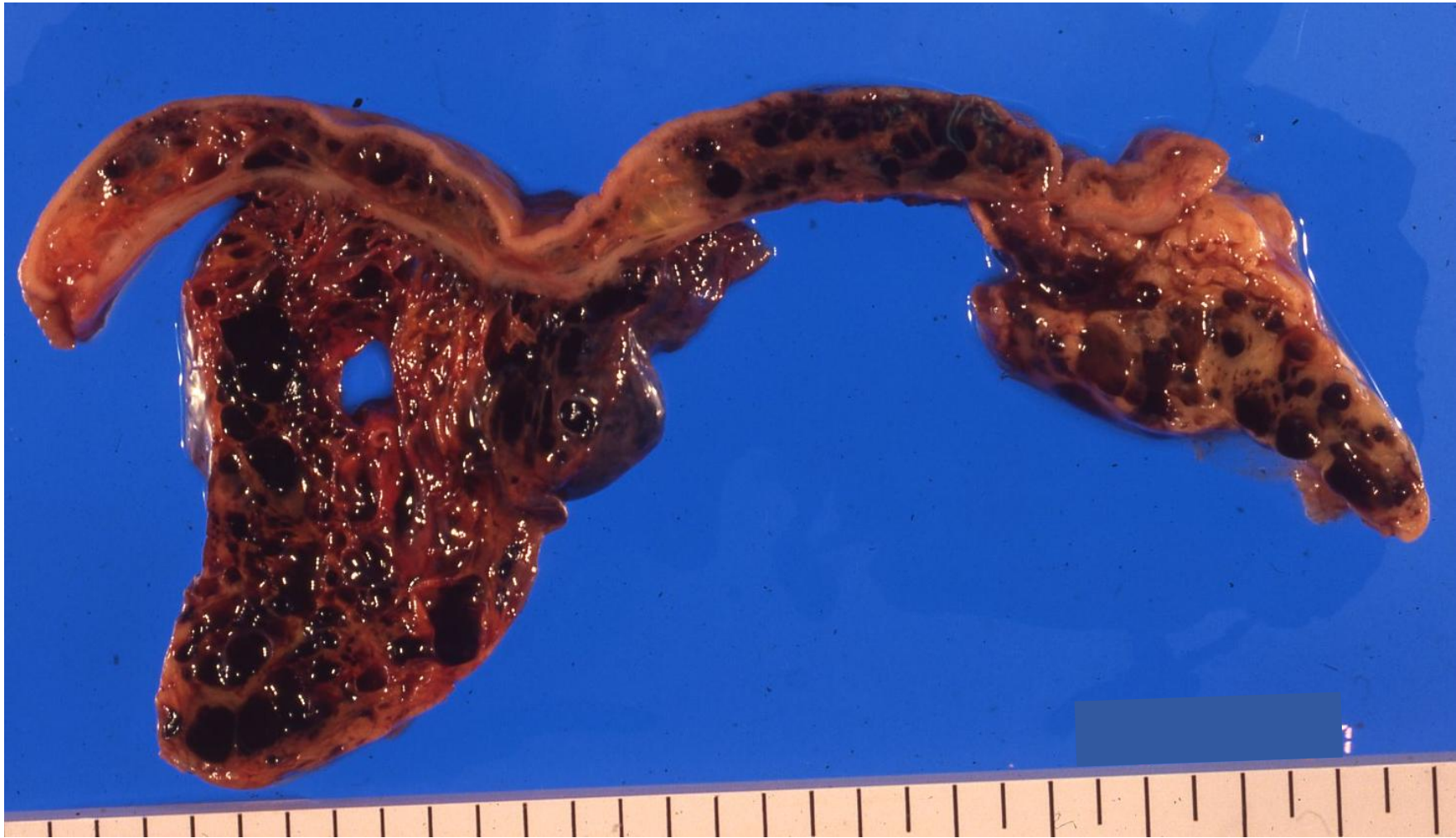
Liver hemosiderosis in treated acute myeloid leukemia. Repeated blood transfusion resulted in hemosiderin deposition in the liver. Brownish color is characteristic.



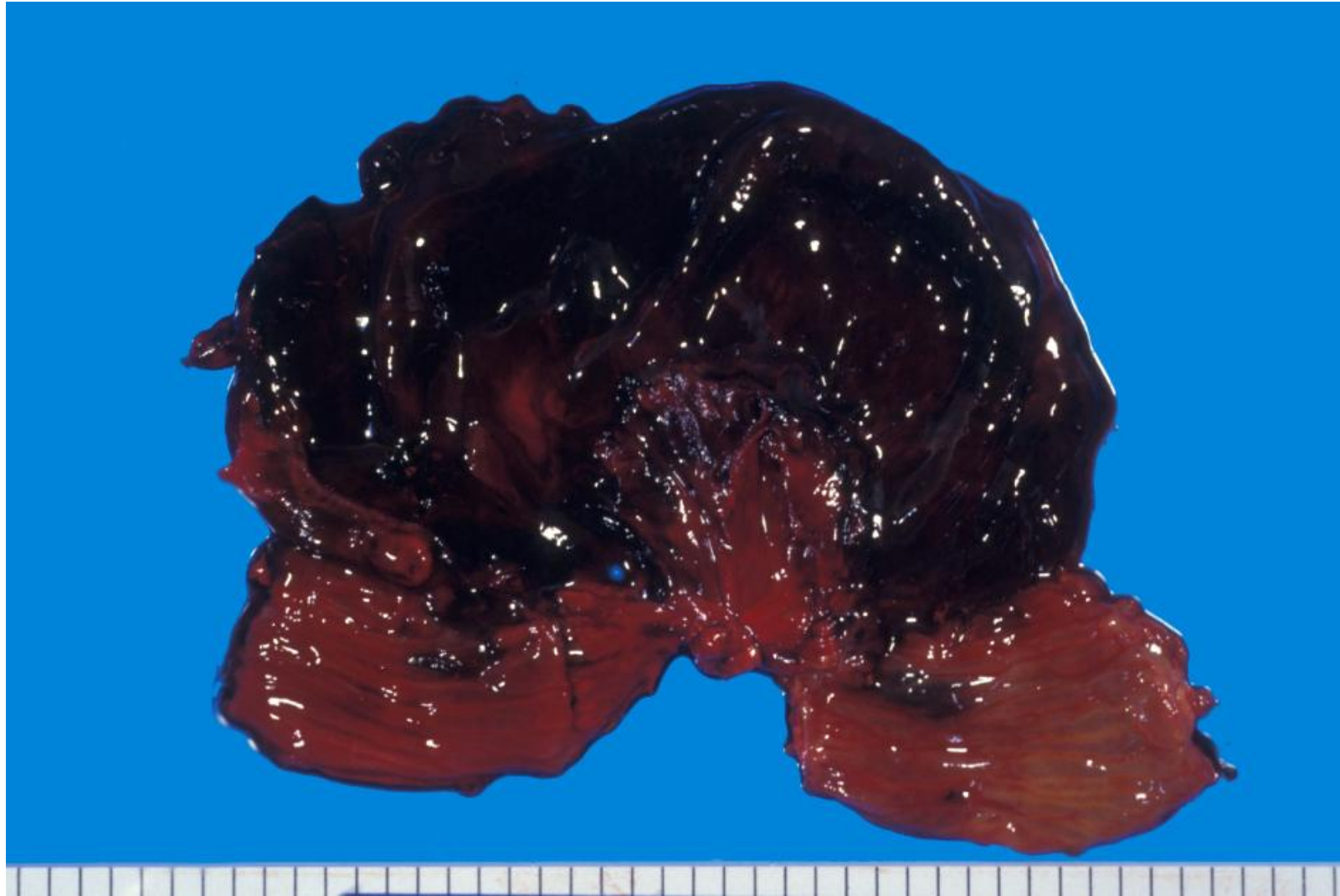
The pancreas in hereditary hemochromatosis. An autopsy specimen after formalin fixation. Brown pigmentation of the pancreatic parenchyma is noted (left). Microscopically, the deposition of hemosiderin is demonstrated by Berlin blue staining (right).



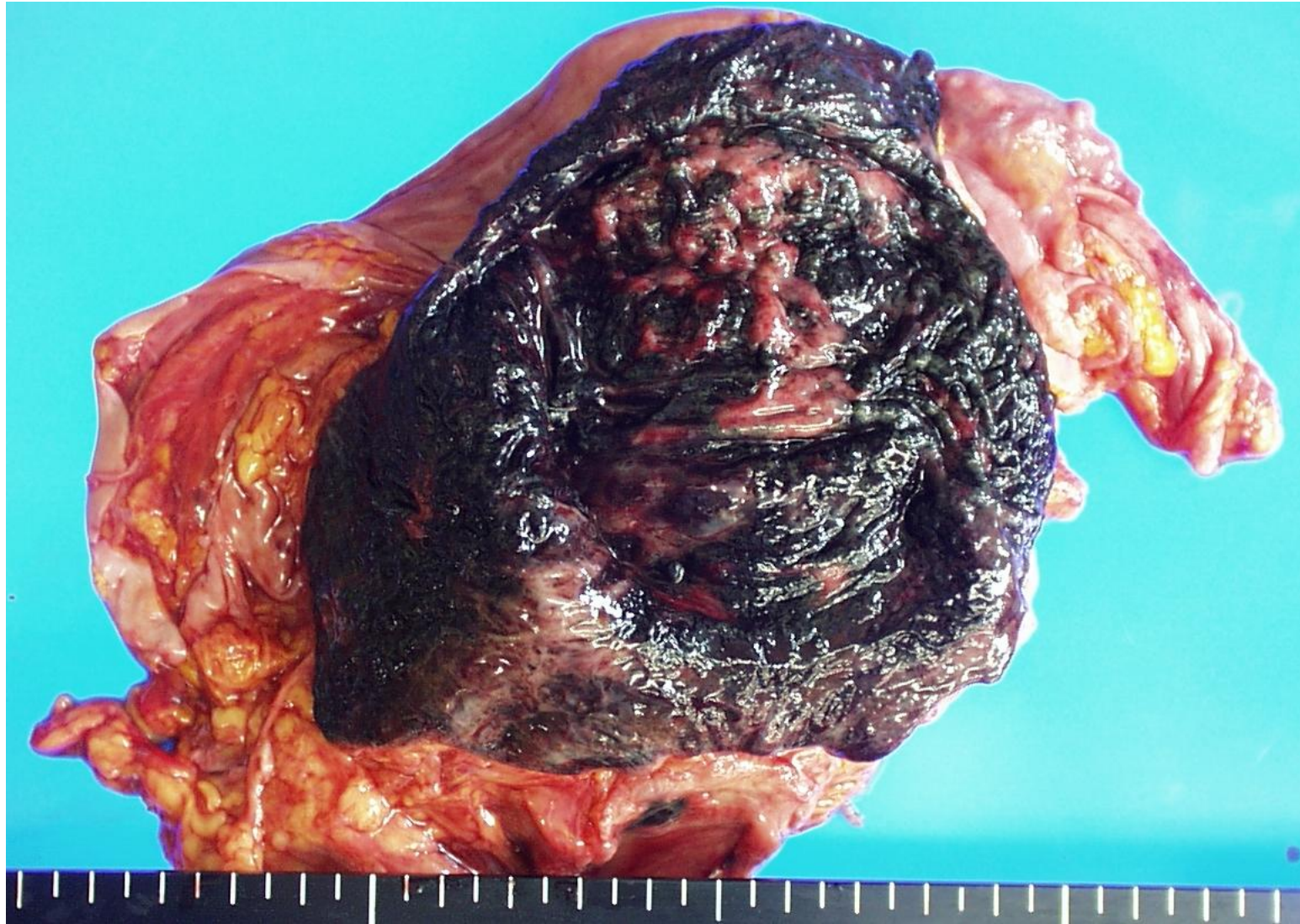
Cut surface of the surgically resected insulinoma at the pancreatic body after formalin fixation. A 3 cm-sized demarcated tumor shows brownish tint (left). Microscopically, monomorphous growth of insulin-secreting tumor cells is seen, in association with amyloid stroma (center: H&E). In the tumor cytoplasm, Berlin blue-positive hemosiderin pigment is deposited, causing brownish coloration (right).



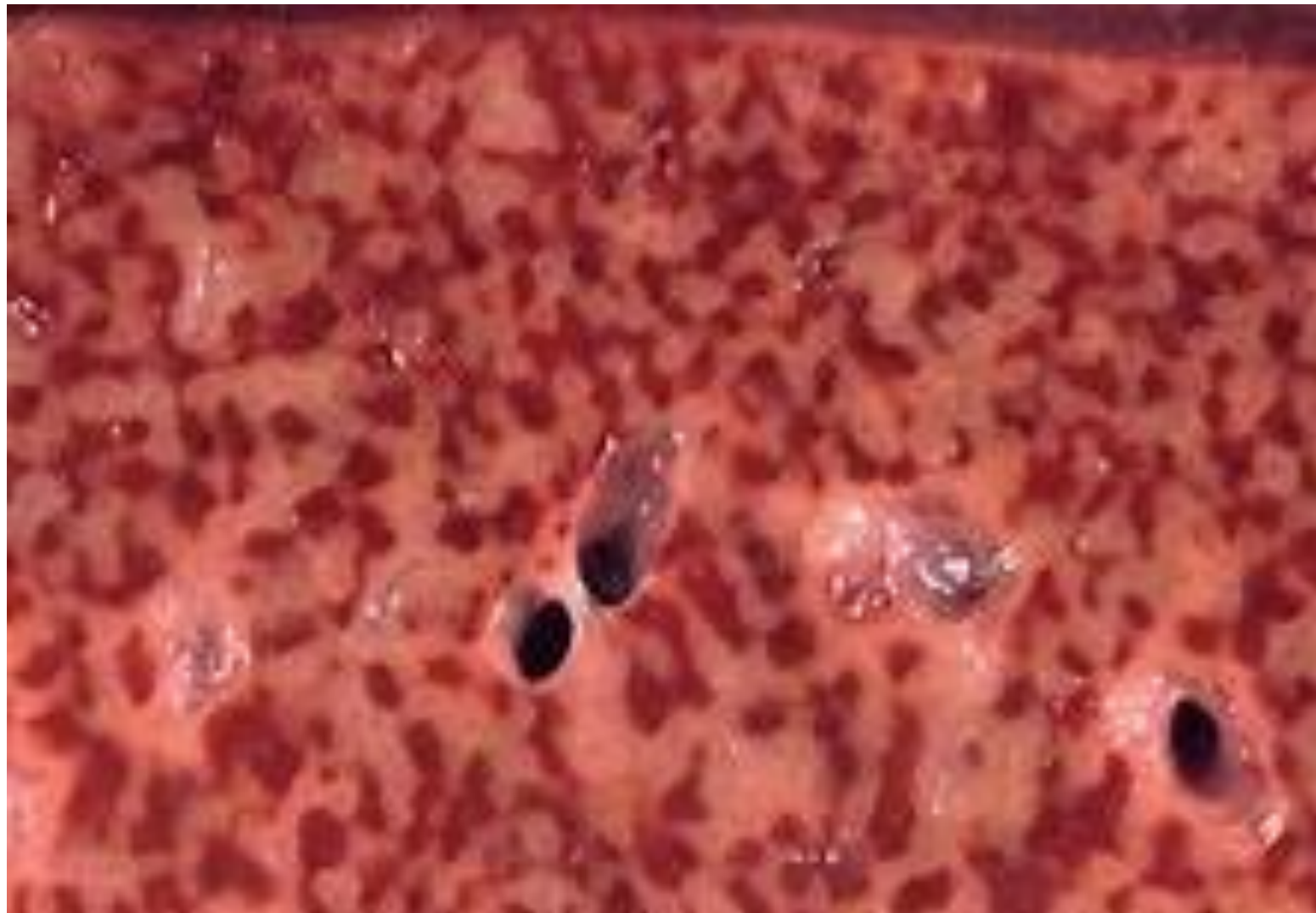
Surgically resected gastric hemangioma. Cavernous vascular spaces filled with red blood cells are distributed in the submucosa through the subserosa.



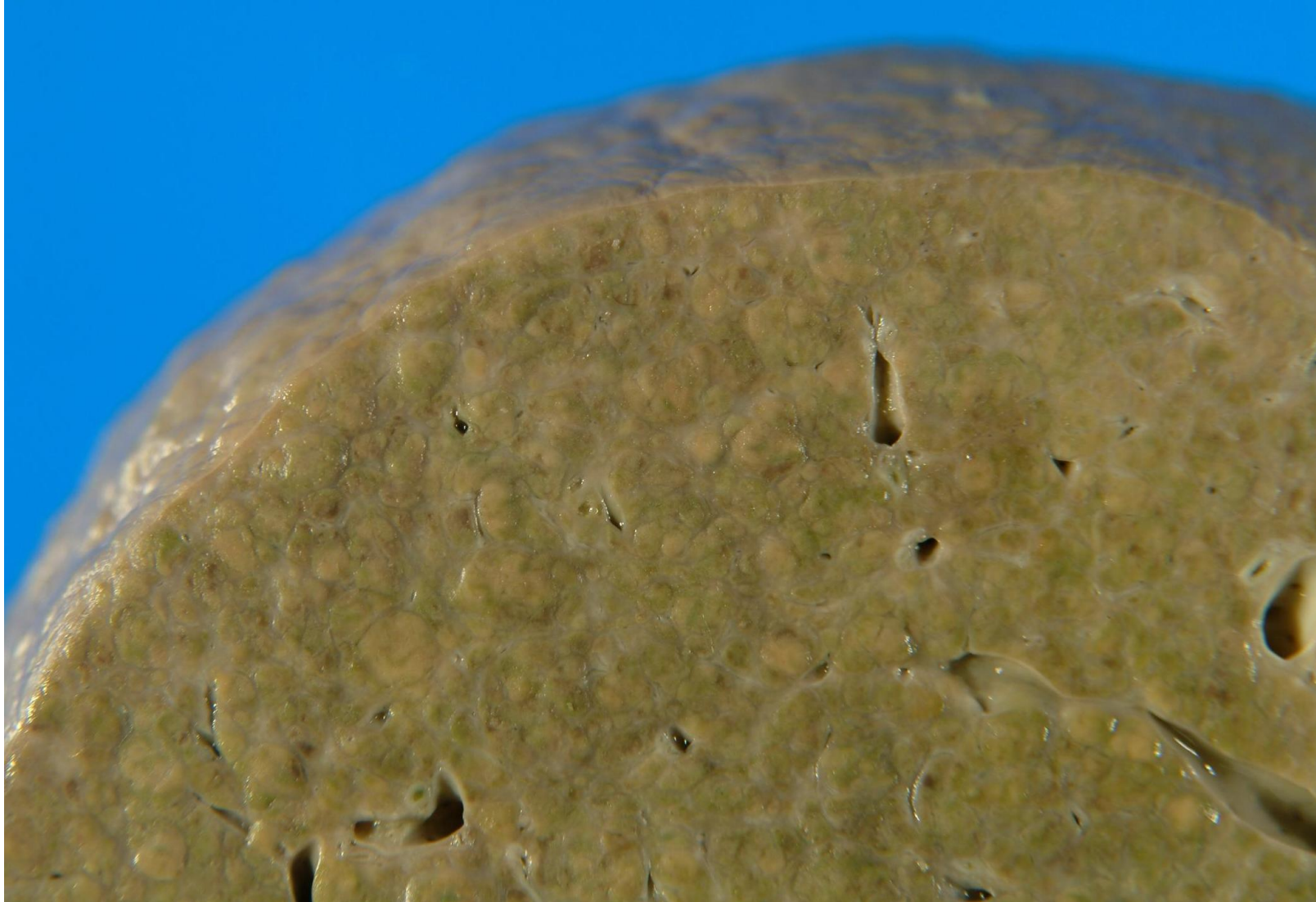
Strangulation ileus seen in the small bowel. In the surgical specimen, hemorrhagic necrosis is seen segmentally.



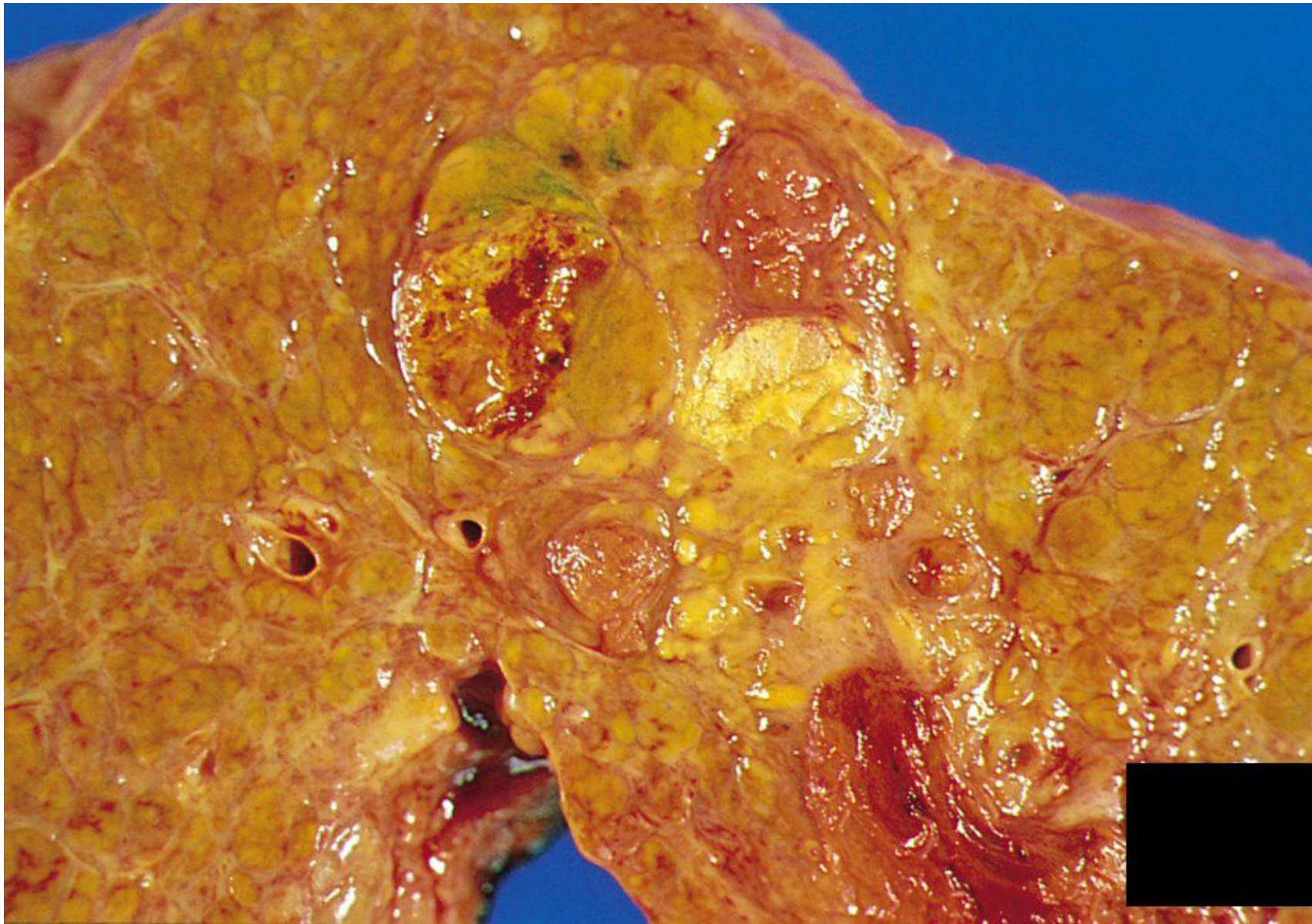
Gross appearance of lethal hemorrhagic cystitis seen in the aged lady, caused by beta-hemolytic *Streptococcus pyogenes* infection. Marked hemorrhage is evident in the urinary bladder mucosa. Systemic dissemination of the bacteria led to the patient's death.



Gross appearance of the cut surface of the liver with chronic passive congestion (nutmeg liver). The centrilobular zone is red-congested, surrounded by yellowish-colored periportal zone. The pattern resemble the cut surface of the nutmeg fruit, hence the name.



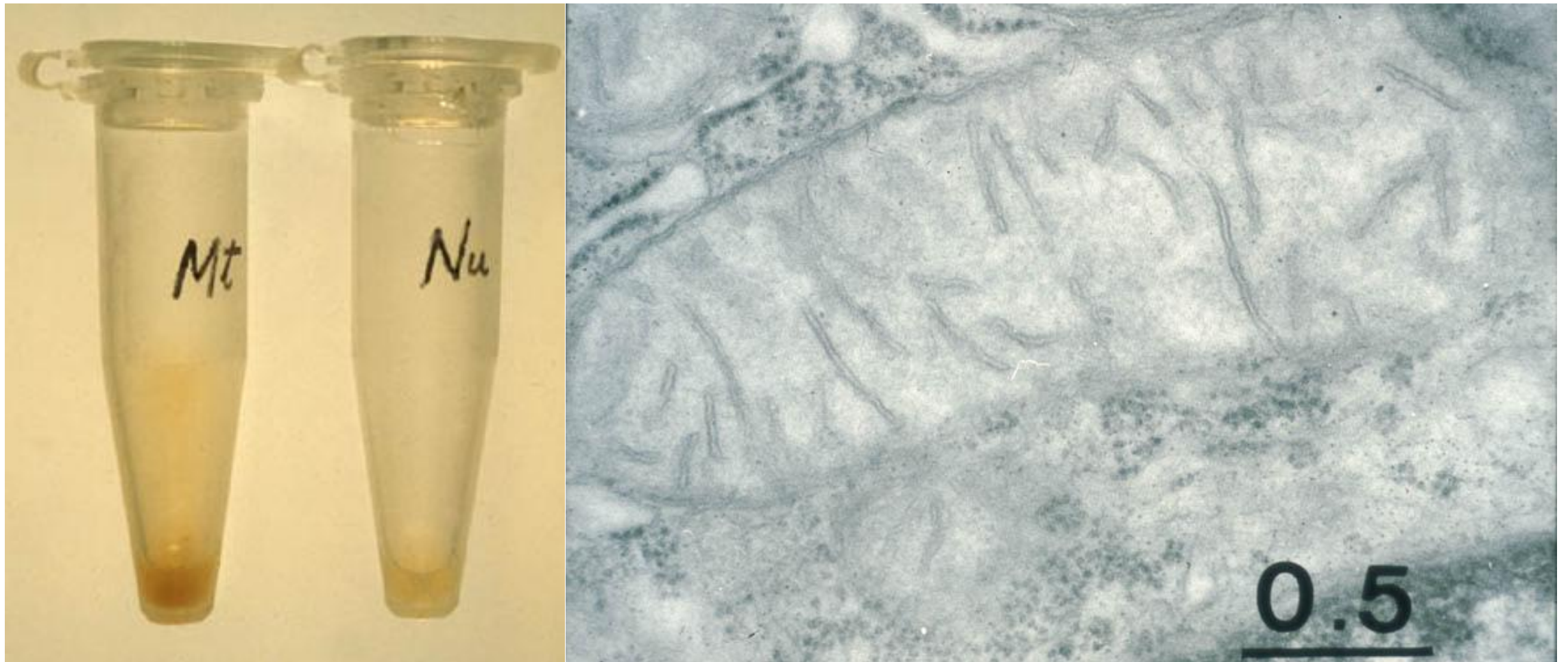
The cut surface of the liver with cholestatic cirrhosis after formalin fixation. Green color is called post-fixation jaundice. By formalin fixation, bilirubin chemically changes to biliverdin. This is a kind of artificial coloration. Verdi- means green.



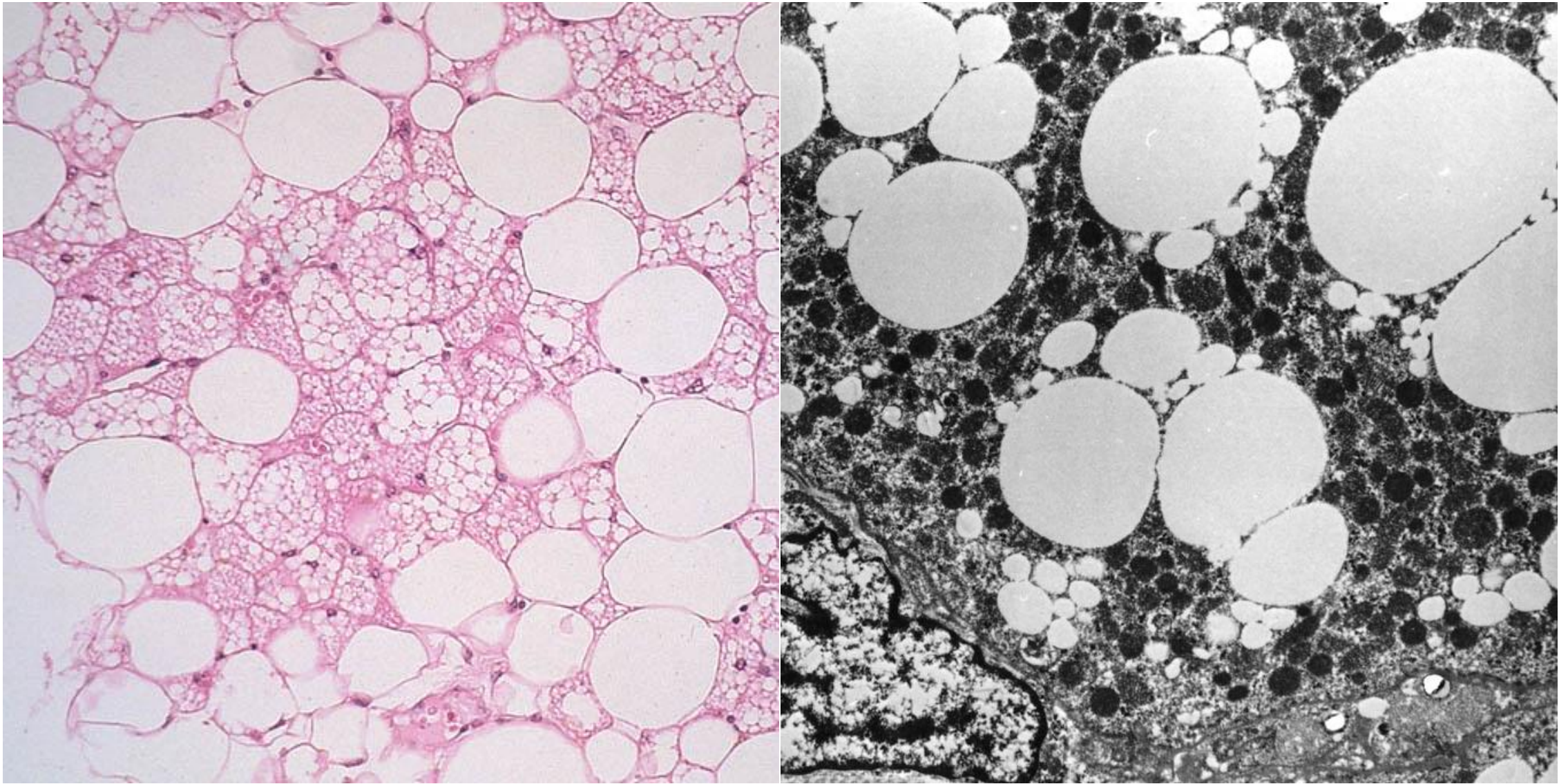
Gross appearance of hepatocellular carcinoma (HCC) arising from liver cirrhosis. A part of the yellowish-colored HCC nodules shows green color, indicating the production of biliverdin by the cancer cells.



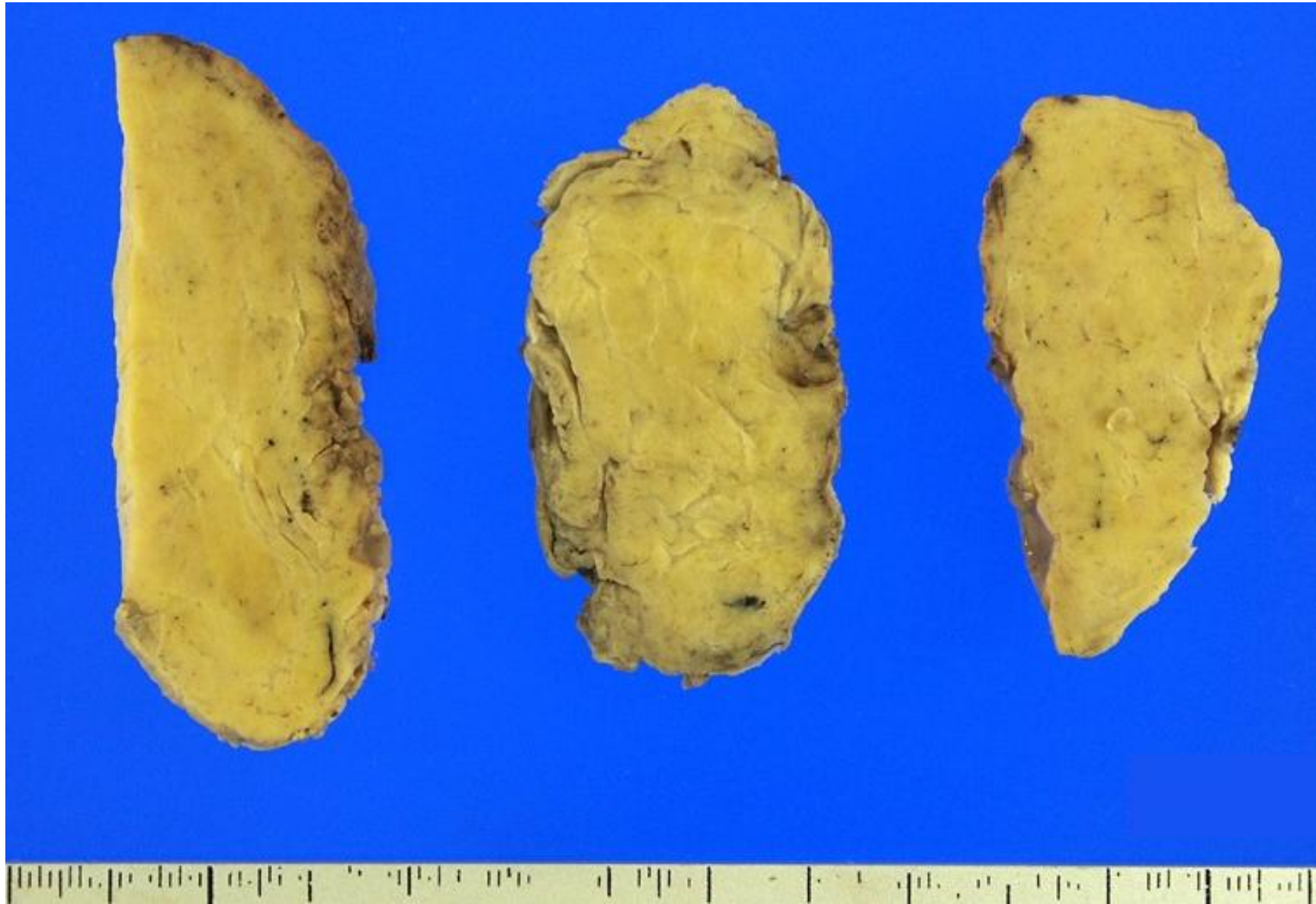
Gross appearance of hepatocellular carcinoma (HCC) arising from liver cirrhosis. Most parts of the HCC nodules are green-colored, indicating the production of biliverdin by the cancer cells. Portal vein invasion is associated. This type of well-differentiated HCC is nicknamed as green hepatoma.



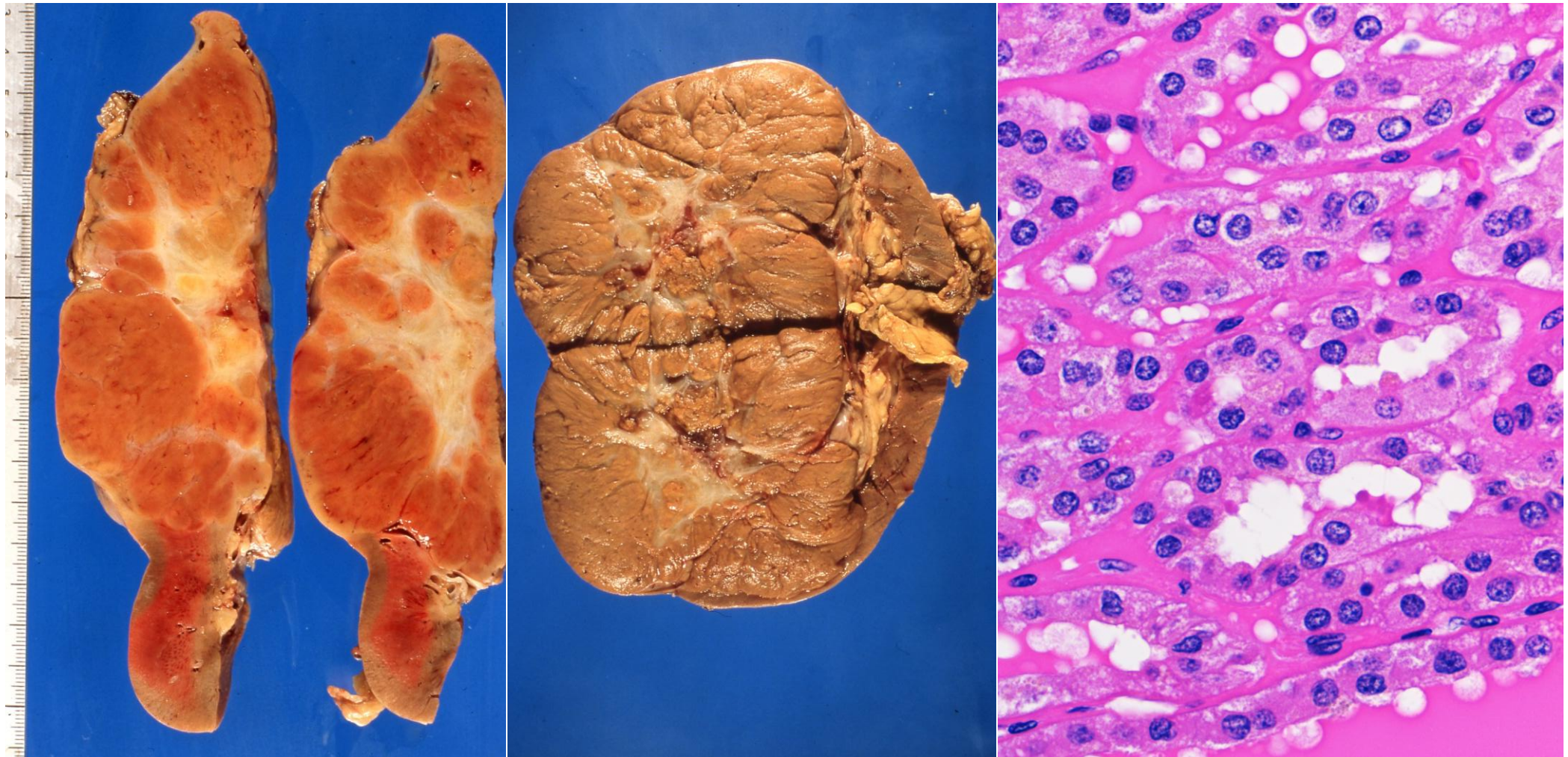
Mitochondrial and nuclear fractions of normal rat brain were obtained by ultracentrifugation (left). Note reddish color of the mitochondrial fraction (Mt), because of the presence heme protein, cytochrome. The nuclear fraction (Nu) is fundamentally non-pigmented. Ultrastructural features of mitochondria of the hepatocyte are shown in the right panel. Cytochrome-rich electron transport chain enzymes are rich on the cristae of the mitochondria.



Brown fat cells in a normal adult. Finely vacuolated cytoplasm is characteristic of brown colored fat cells (left: H&E). Ultrastructurally, the brown fat cells are rich in mitochondria among the fat droplets (right).



Cut surfaces of hibernoma, a benign tumor of brown fat cells after formalin fixation. Brownish yellow color is characteristic.



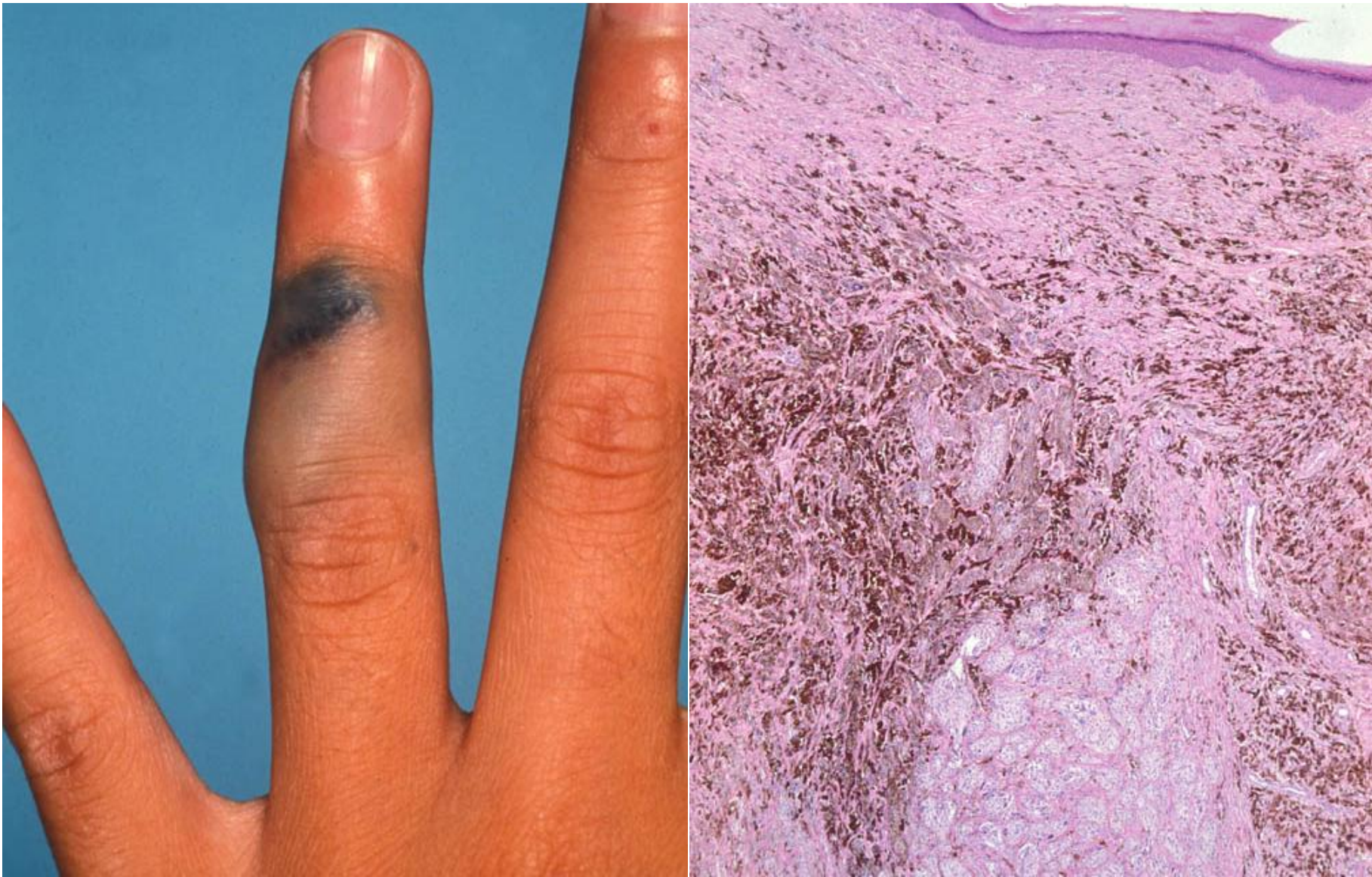
Renal oncocytoma. Cut surfaces of the oncocytoma before (left) and after (center) formalin fixation. Reddish color is noted before fixation, and after fixation brownish color is noted. Microscopically, the tumor cells possess plump eosinophilic and granular cytoplasm due to the rich presence of mitochondria (right: H&E). Oncocytoma is nicknamed as mitochondrioma.



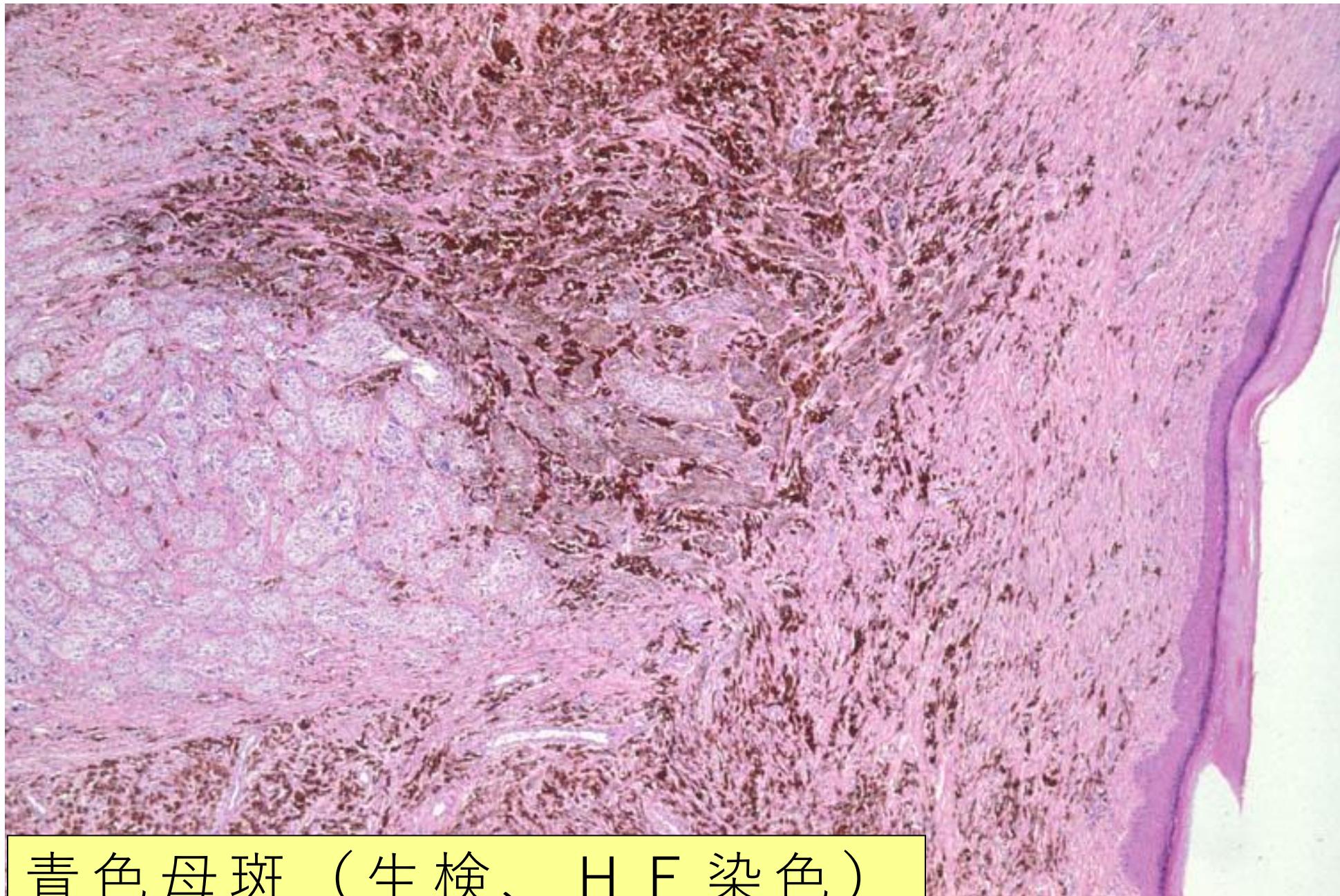
Liver metastasis of malignant melanoma. Black-colored metastatic nodules are dispersed in the liver.



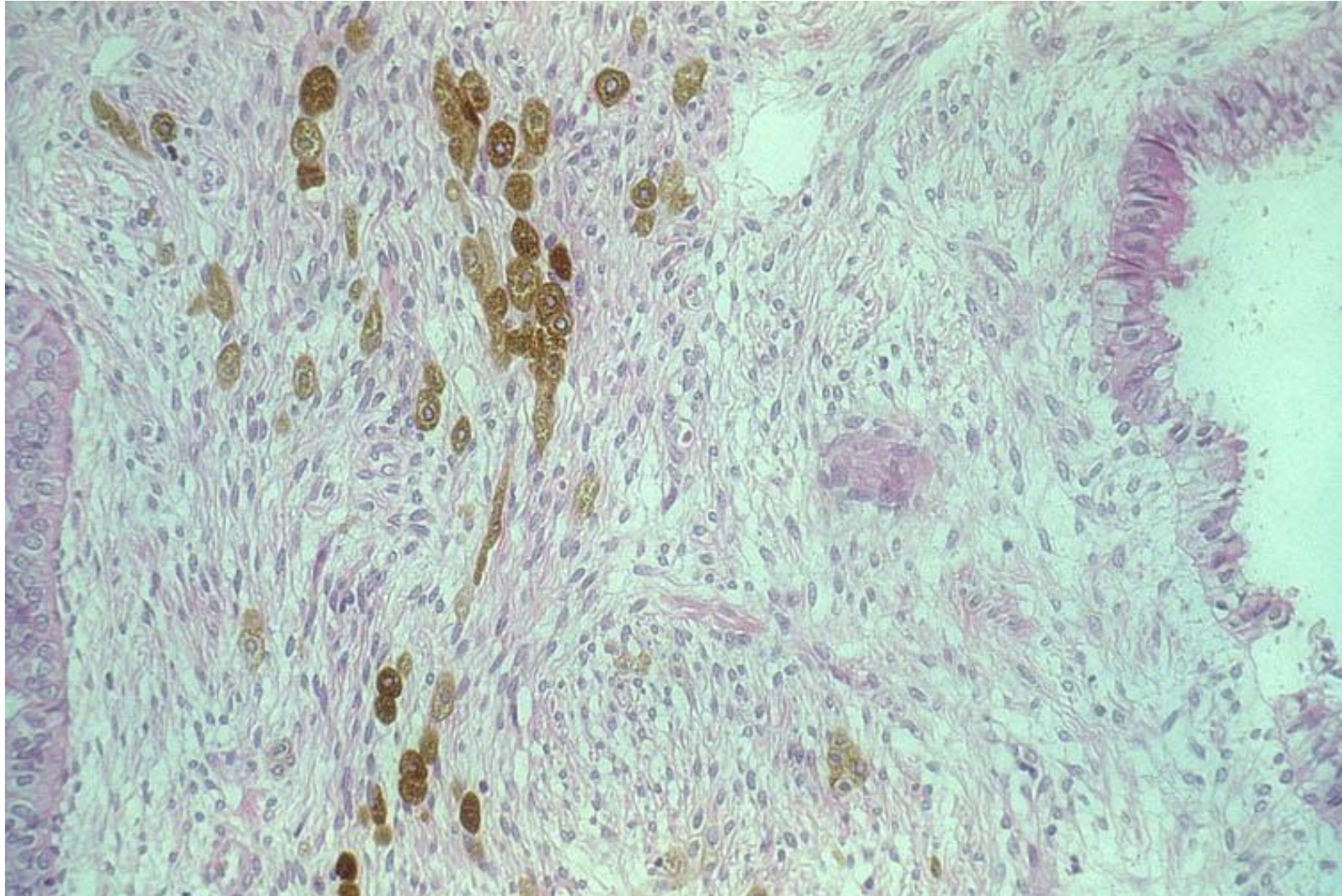
Gross appearance of neurofibromatosis, type I. Multiple polypoid neurofibromas and café au lait spots are seen. The café au lait spots represent basal melanin pigmentation in the epidermis.



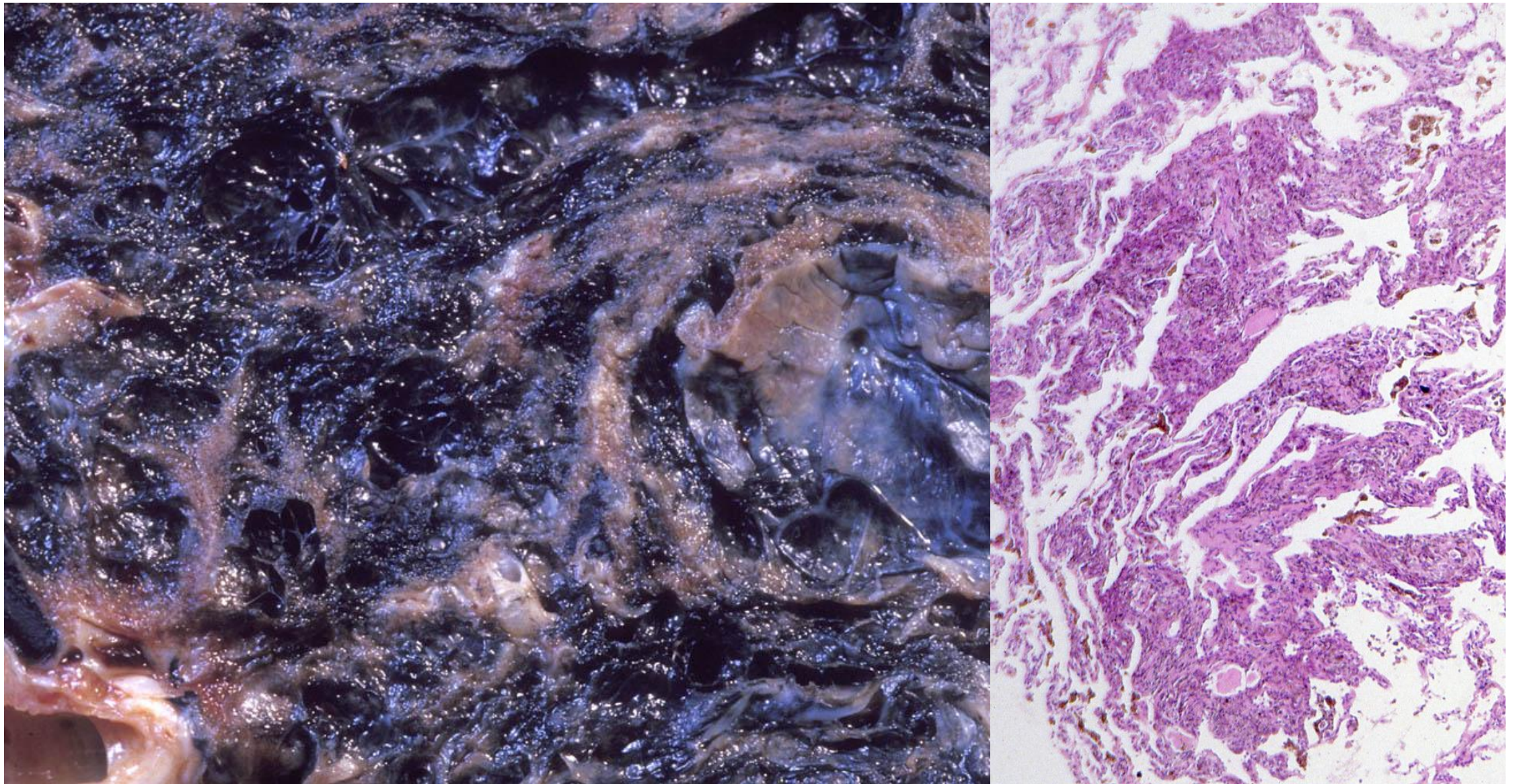
Blue nevus represents intradermal growth of benign melanocytes. When black or deeply colored material (in this case, melanin pigment) is located deep in the tissue, it appears blue, as it is so for the superficial venous branches filled with dark-colored red blood cells.



青色母斑（生検、H E 染色）



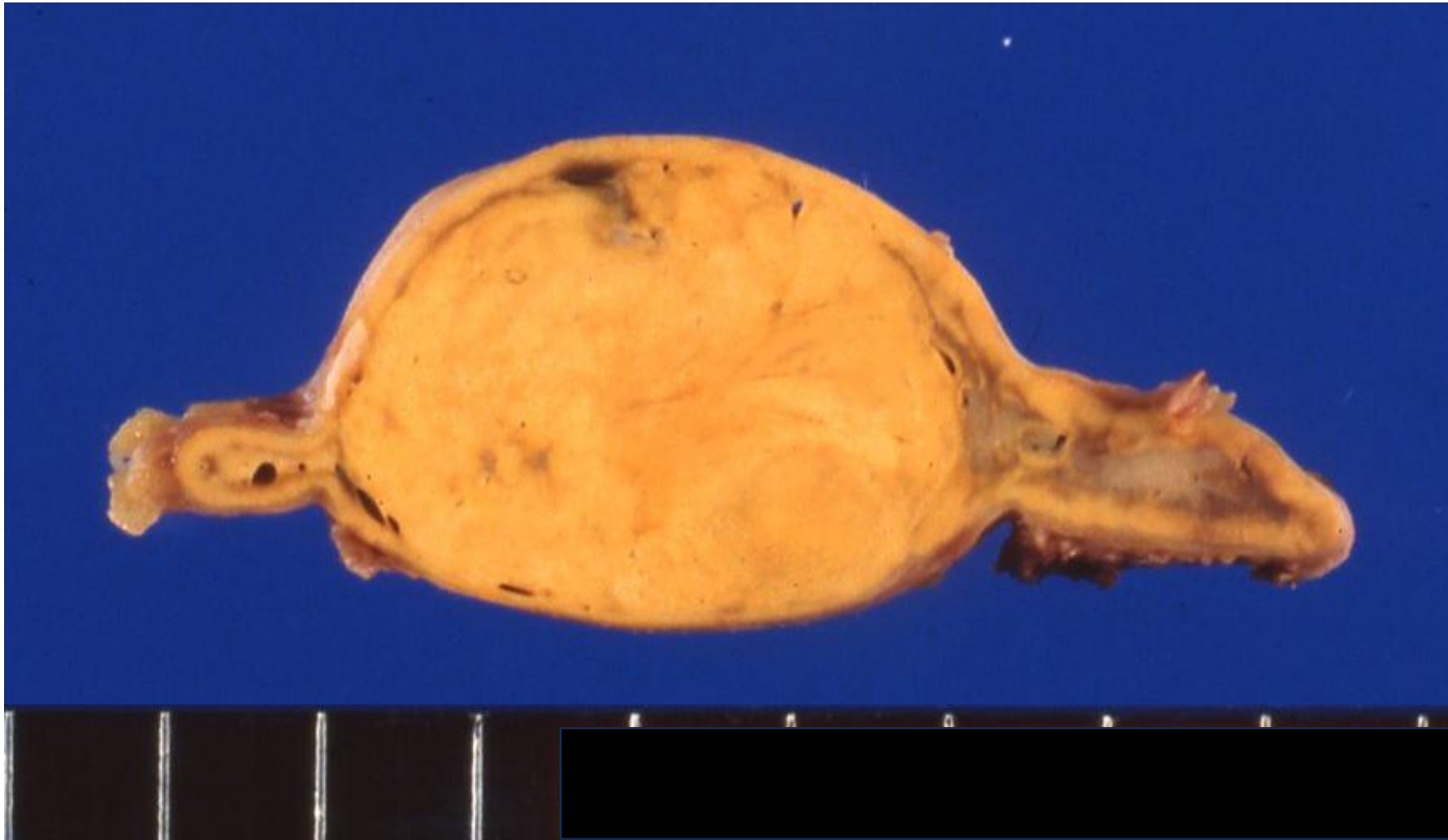
Uterine cervical melanosis. Melanin-containing melanocytes are distributed in the submucosal layer (H&E). With colposcopy, blue cervix can be seen.



Severe anthracosis of the lung in an aged male smoker with pneumoconiosis. Emphysematous lung reveals massive deposition of carbon particles of exogenous origin (right: H&E).



Cut surfaces of the normal adrenal gland after formalin fixation. Note that the adrenal cortex consists of two layers: outer yellowish zona fasciculata and inner black-colored zona reticularis. The adrenal medulla is white in color. The zona reticularis cells possess rich lipofuscin, giving a black color.



Conn's adenoma (primary aldosteronism) after formalin fixation. A 2 cm-sized demarcated tumor shows characteristic canarian yellow color. The surrounding non-neoplastic adrenal cortex is not atrophic.



Cut surfaces of adrenocortical adenoma, manifesting Cushing syndrome, after formalin fixation. Black-colored and mottled appearance is noted in this functioning tumor. The black-colored adenoma cells possess rich lipofuscin.



Hyperadrenocorticism caused by ectopic ACTH production by small cell lung carcinoma. The adrenal cortex is thickened and lacks yellow color components, indicating replacement by the actively functioning adrenocortical cells devoid of lipid droplets in the cytoplasm.