3.8 CASTS

Casts are made up of protein material that has been precipitated into the tubular lumen. At least some of this material is the Tamm-Horsfall urinary protein [36,51], produced primarily by the renal tubule in the ascending limb of the loop of Henle.
This endotubular precipitation is favored by highly concentrated urine with a low pH. With an alkaline pH the hyaline matrix of the casts either does not form at all or dissolves. Hence, in advanced chronic renal failure, with polyuria and a urinary pH tending to be alkaline, the number of casts decreases, irrespective of the extent of the damage to the parenchyma. It is also possible for there to be a large number of casts in the renal parenchyma, and yet a very low number of casts in the urine. This happens in chronic pyelonephritis and in other interstitial nephropathies in which these elements are blocked in the kidney and only a small number are passed out in the urine.
On the basis of their structure, casts can be classified as:

- hyaline
- cellular (red blood cell, epithelial or granulocytic)
- granular
- waxy
- mixed and with inclusions (cellular and acellular).

Other distinguishing features of casts are their pigmentation and diameter (pages 114-118).

123 Hyaline cast (250x).

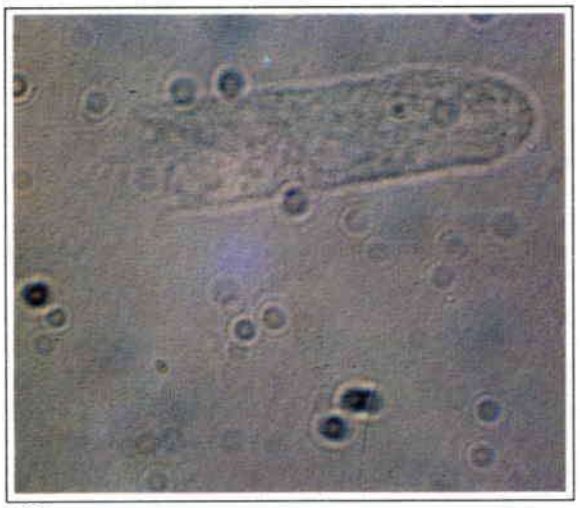
124 Red cell granular cast (400x).

125 Cellular cast (160x).

126 Granular cast (400x).

127 Waxy casts (100x).

128 Mixed hyaline cellular cast with fatty droplets (160x).



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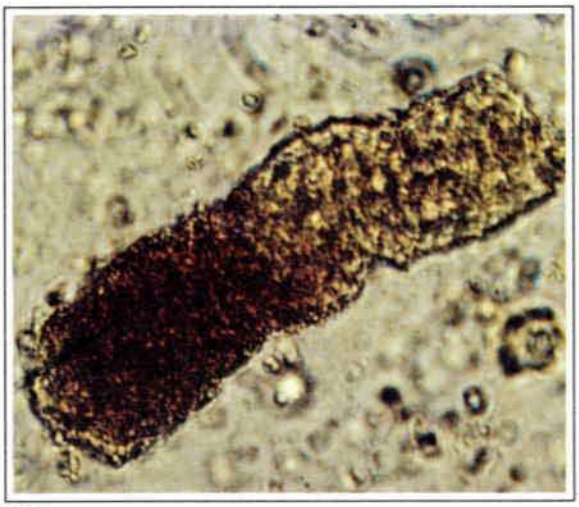

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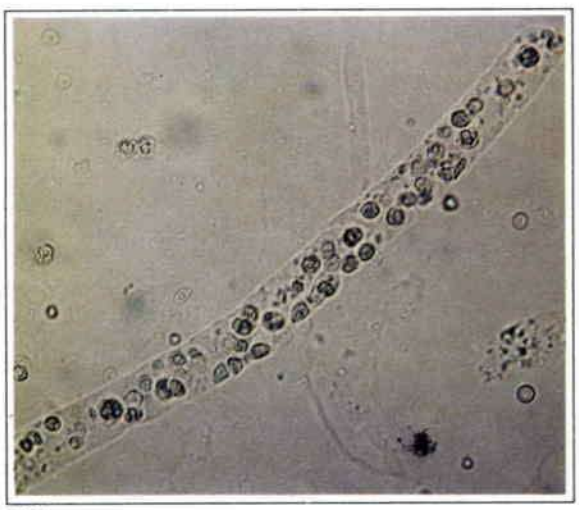

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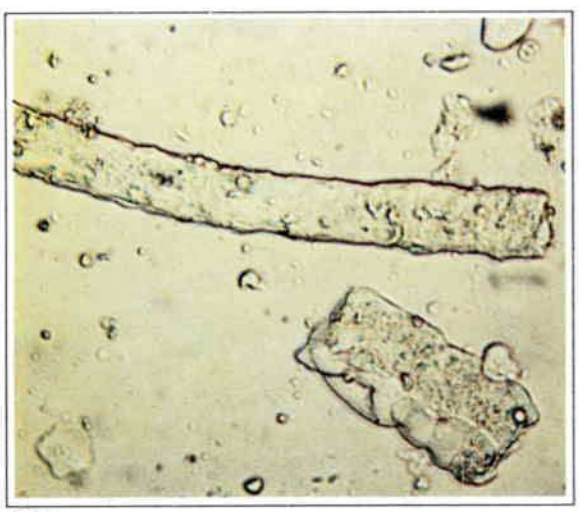

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128

3.8.1 HYALINE CASTS

Hyaline casts vary considerably in appearance. Some have a «delicate» appearance and are difficult to see clearly in bright light, so that they may escape notice on cursory examination; others, more clearly visible, have a more solid appearance; still others, the «glassy» casts, are elements that are changing into waxy casts. While hyaline casts are generally straight, they may sometimes take on a convoluted appearance. Such casts,and particularly those that are smaller and transparent, are more easily recognized by phase-contrast microscopy.

It should be emphasized that the transitory presence of small delicate hyaline casts in urine has no specific significance; casts of this kind can occasionally be found in the urinary sediment of healthy people under normal conditions, and they are frequently found, even in healthy people, after strenuous physical exercise or acute dehydration. Moreover it is quite common to find a large number in some cases of heart failure and in hyperthermia, where, in the absence of any other pathological findings in the sediment, they have the same significance as proteinuria.

Hyaline casts can be found in all nephropathies, with or without proteinuria. Though they are occasionally an isolated finding, they very often appear in the sediment together with other abnormal components of greater diagnostic importance.

129 Hyaline casts of delicate appearance and small diameter, not easily seen with ordinary light microscopy (160 x).

130 Same field. Phase-contrast examination makes identification considerably easier (160 x).

131 Hyaline cast of medium diameter (160 x).

132 The same cast in phase-contrast (160x).

133 A large number of hyaline casts (250 x).

134 Hyaline casts. Dense hyaline casts of this kind are found only rarely in healthy people (160 x).

129

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Hyaline casts can have inclusions of various kinds. A very clear granular component enhances the pathological significance of the cast; the presence of cells or fat droplets always indicates some renal damage.

135 Firm hyaline cast («glassy» cast). Elements like this generally point to an anatomical renal lesion. Chance, isolated findings of these casts in old people may indicate nephrosclerosis (100x).

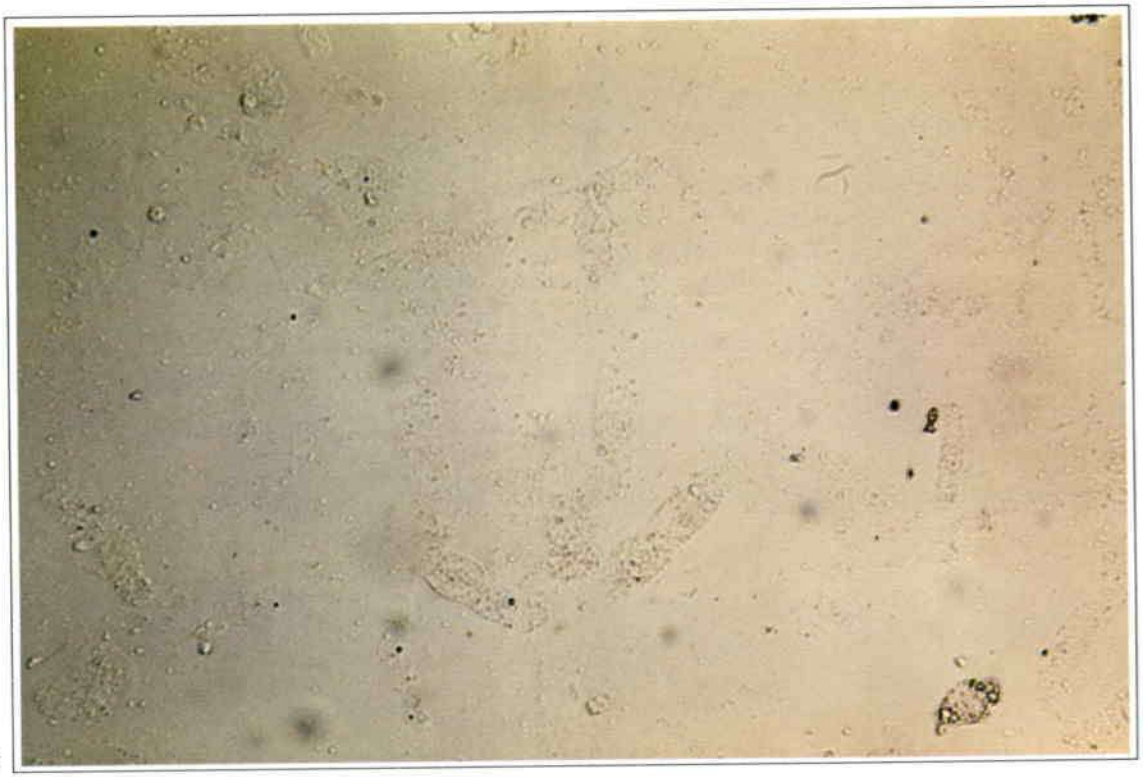
136 Convoluted waxy hyaline cast; microhematuria. This is a definitely pathological finding; the slight granular component is of no particular significance (400x).

135

136

137 Granular hyaline casts. At a hurried glance in bright light some of these elements may escape notice (160x).

138 Phase-contrast examination facilitates the identification of these casts (160x).



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138

3.8.2 CYLINDROIDS

Hyaline casts must be distinguished from mucous threads and cylindroids, which are less transparent formations with longitudinal striations and often blunted ends or flagellar projections.
It used to be thought that cylindroids were formed only in the lower urinary tract, and their frequency in patients with various kinds of inflammation at this level was emphasized. They can, however, often be found in renal diseases, sometimes together with various kinds of casts; this happens particularly but not exclusively after improvement in acute glomerulonephritis.

139 Cylindroid. In some parts it resembles a true cast (100x).

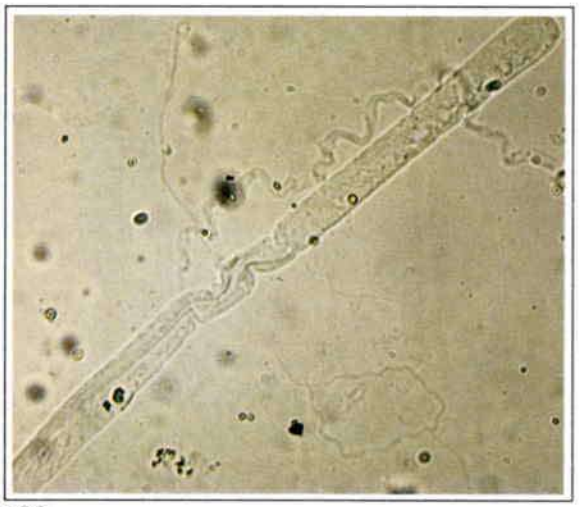
140 Threads of mucus, partly of cylindroid appearance (100x).

141 Cylindroid (100x).

142 Cylindroid (100x).

143 Threads of mucus (160x).

144 The same field in phase-contrast (160x).



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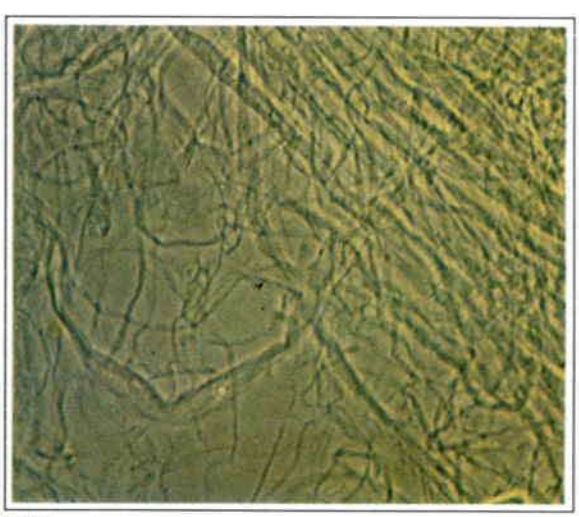
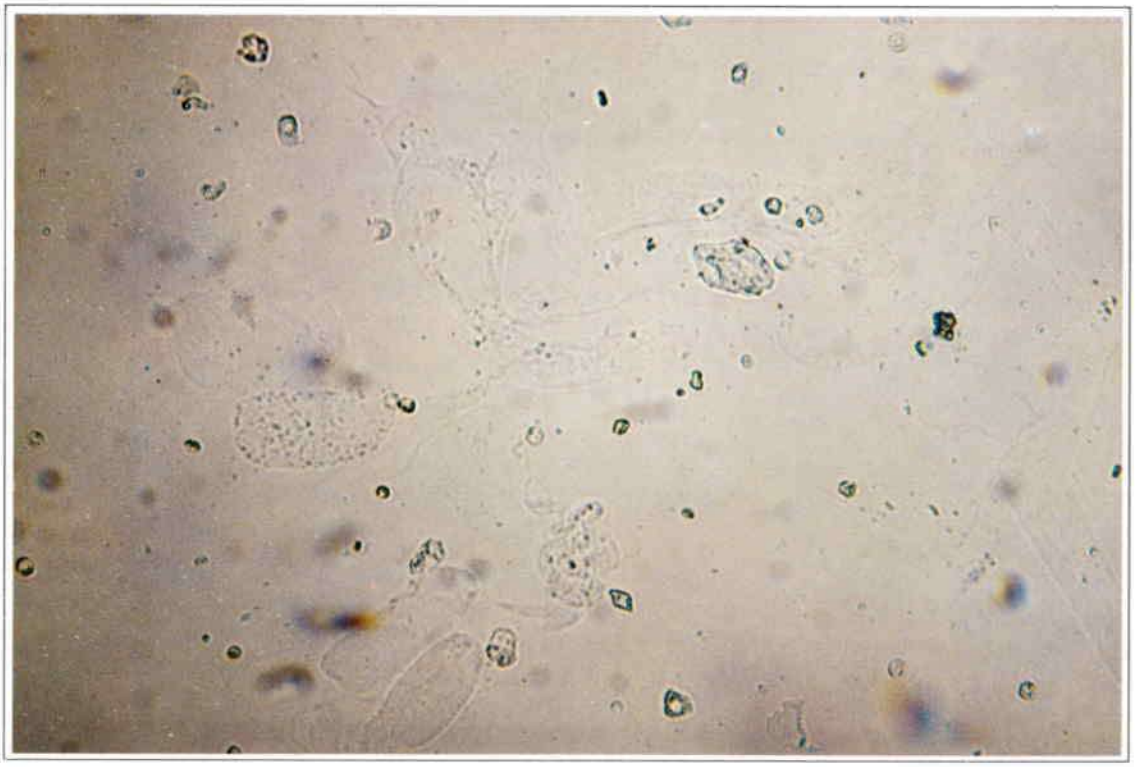


144

145 Mucous threads, casts and cylindroids. Microhematuria. Nucleated cells which cannot be clearly identified at this power (nephrotic syndrome; focal glomerulosclerosis) (160 x).

146 Phase-contrast examination makes this sediment easier to interpret (160 x).



145

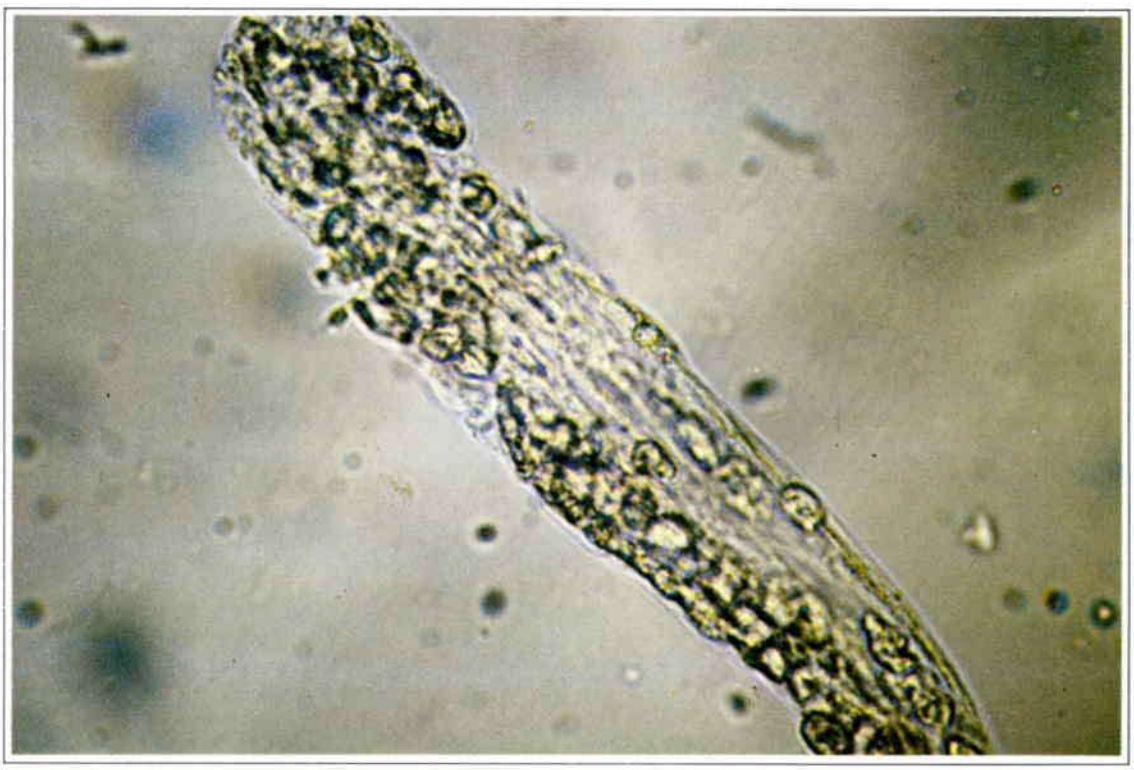
146

Cylindroids may have cellular inclusions, which can sometimes give a quite accurate indication of where they were formed.

147 Large cylindroid with cells, probably from the male genital tract (prostatitis) (100 x).

148 An enlarged detail (250 x).

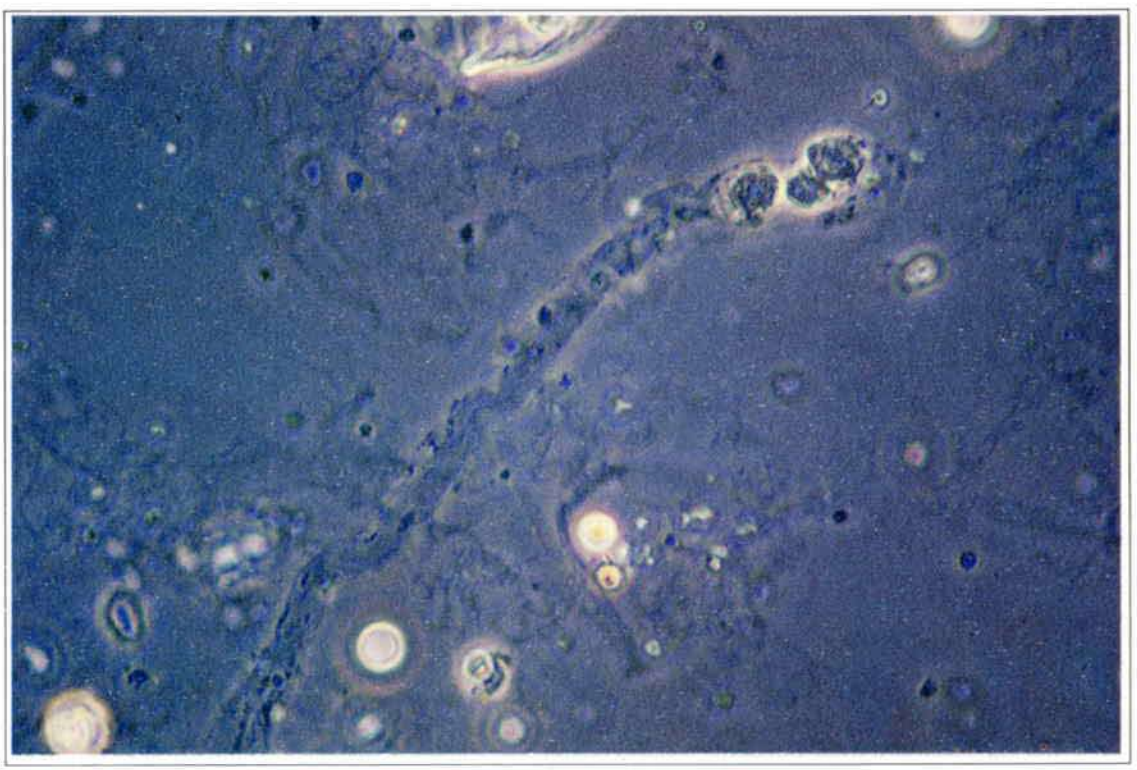
147



148

149-150 Cylindroids with cellular inclusions, devoid of any diagnostic significance here (phase-contrast) (250 x), (250 x).

149



150

3.8.3 GRANULAR CASTS

Granular casts may be made up of granules of very varied diameter; these granules are believed to be mainly derived from cellular debris and tend to become progressively more homogeneous.
Casts of small diameter and with small granules can be found in rapidly reversible pathological conditions (e.g. febrile diseases with increased catabolism) and, very rarely, also in healthy people. For these reasons, no precise pathological significance can be attributed to the occasional finding of a few such granular casts, unless there are also other signs of urinary tract disease. In contrast, however, persistent granular casts, particularly if the granules are large, always have a pathological significance.
«Shock» casts [63] are special, loosely packed granular structures, often oval in shape and of medium or large diameter, which appear in the course of acute renal ischemia (p. 192). They generally disappear rapidly once a good renal flow is reestablished.

151 Mixed granular-waxy cast. Specimens such as this suggest that the granules in these casts can be transformed from large to small, until they become uniformly waxy (small lateral band) (400x).

152 Fissured granular cast with large granules turning to waxy. This cast with its large diameter seems to have been formed, probably in a collecting tubule, by the adhesion of two granular cast fragments of smaller diameter (400x).

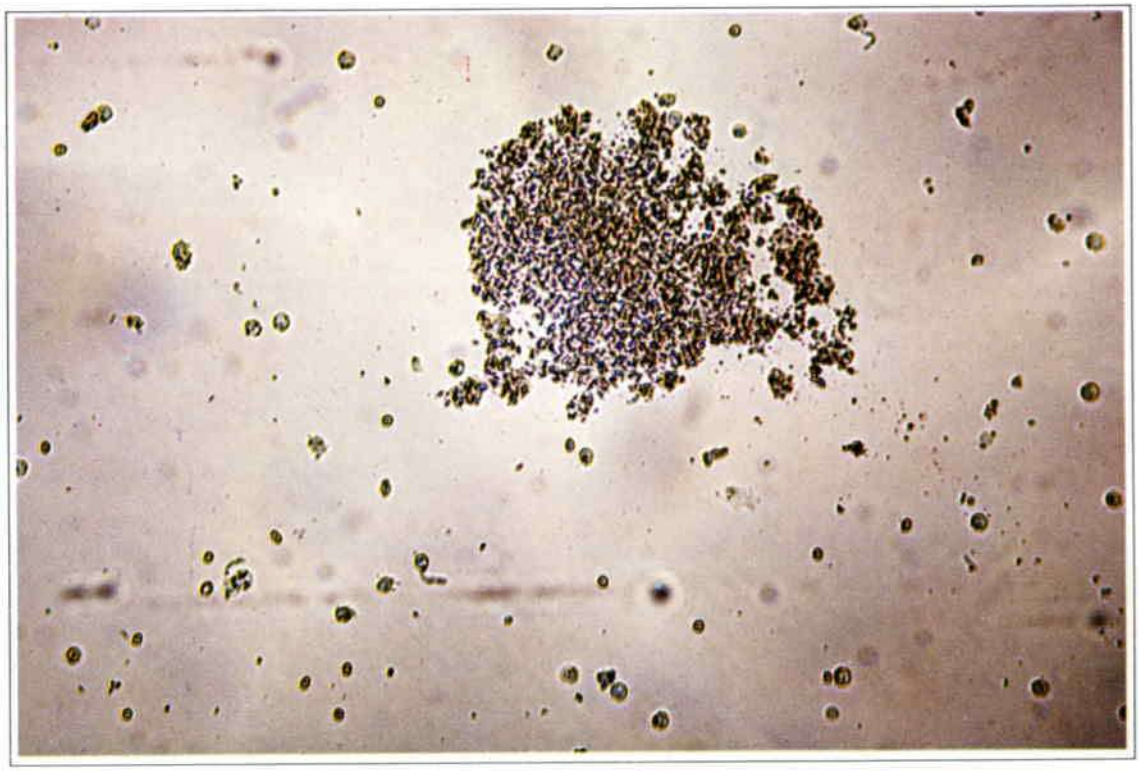
151

152

153 Granular cast with medium-sized granules (400x).

154 Granular shock cast. Note the lack of texture of the matrix (100x).

153



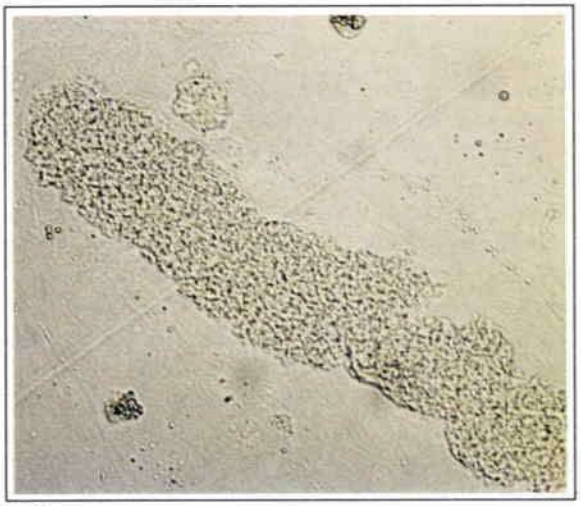
154

155 Granular cast of medium diameter with large granules; it is taking on a waxy appearance (400 x).

156 Granular cast with fine granules (160 x).

157-160 Granular casts. Various morphological types (160 x), (100 x), (160 x), (160 x).

155



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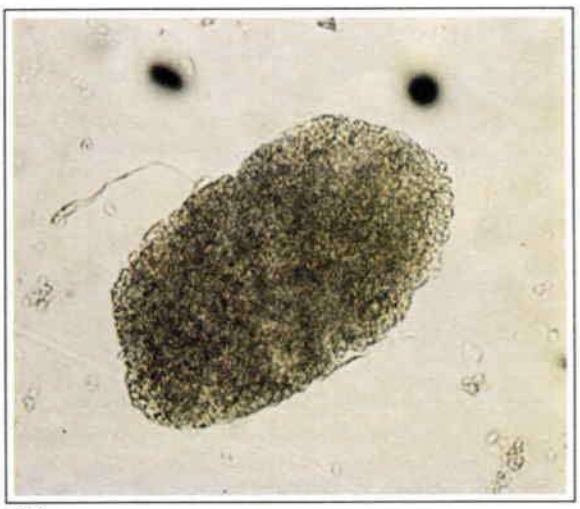

160

3.8.4 HEMOGLOBIN AND HEMOSIDERIN CASTS

Hemoglobin and hemosiderin casts are two interesting kinds of granular cast.
Hemoglobin casts appear in acute hemolysis, for example, following transfusion of incompatible blood or in some other acquired hemolytic disorders (such as disseminated intravascular coagulation, some infections, etc.) or in some inherited hemolitic diseases (as in glucose-6-phosphate dehydrogenase deficiency and exposure to oxidizing agents). Under these circumstances the urine takes on a typical dark brown colour; if the patient is not adequately treated and remains in shock with oliguria and acid urine, a large number of hemoglobin casts usually appear, formed of finely granular «foamy» material. These casts are very fragile and tend to conglomerate if the sediment is centrifuged rapidly (in these circumstances it is advisable to examine the unspun sediment in the collecting flask). With adequate anti-shock therapy, forced diuresis, and intravenous sodium bicarbonate administration to produce a urinary pH of up to 7 or greater, this finding generally disappears in a few hours, and in this case the absence of casts and hematuria can be taken as a sign of a good prognosis.
Unstained hemosiderin casts are similar to red cell granular casts and are not generally associated with hematuria. Free, scattered, pigmented granules, in the absence of red cells, are a clue to their identity, which can be confirmed by staining with Prussian blue.
Hemosiderin casts are a sign of a chronic hemolysis. A good example of this was common in patients with old types of prosthetic heart valves.

161 Hemosiderinuria with scattered granules and casts. No hematuria. The suspicion of hemosiderinuria is confirmed by staining with Prussian blue (chronic hemolysis in a patient with a prosthetic heart valve) (400x).

162 Hemosiderin granules free and within a cast (400x).

163 Cast with inclusion granules identical to the free granules (400x).

164 Prussian blue staining (400x).

165 Granular cast with slight hemoglobulin pigmentation; no hematuria. Very extensive hemolysis as a result of aniline poisoning (400x).

166 Hemoglobin granular cast. Paroxysmal nocturnal hemoglobinuria (250x).

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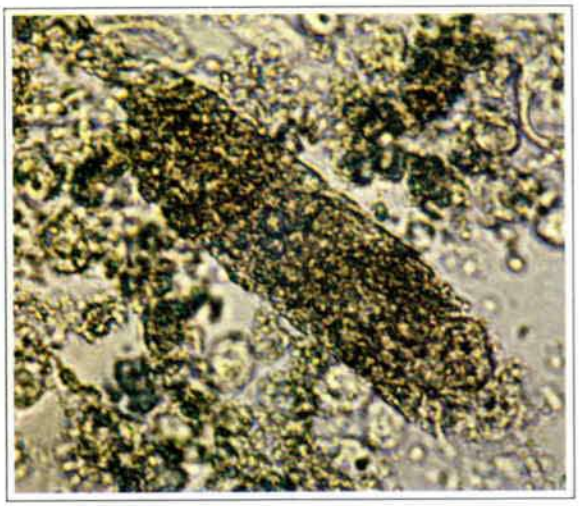

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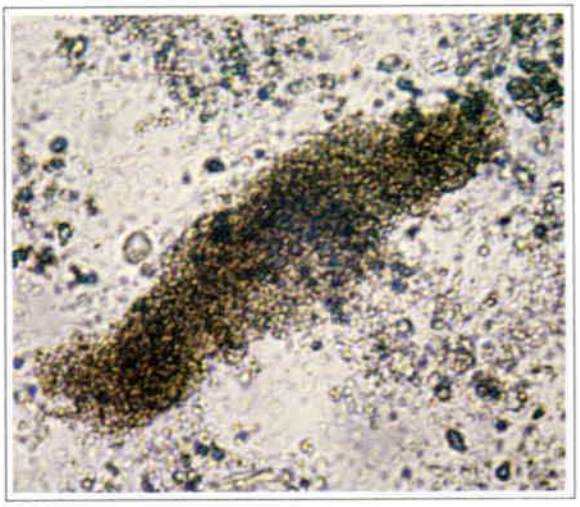


166

3.8.5 RED CELL CASTS

They are characterized by the presence of erythrocytes in a hyaline matrix. The red cell inclusions show morphological alterations of various types and degree, up to an extensive fragmentation.
Typical erythrocyte casts, a whole series of intermediate casts, and granular red cell casts in which the erythrocytes are being transformed or have already been completely transformed into granular material, can all be found in the same sediment.
Red cell casts often keep their original pigmentation which, sometimes, takes on a deeper shade or, under low power, a blackish appearance.

167 Cast of conglutinated red cells (400 x).

168 Red cell cast (400 x).

167

168

169 Red cell cast. The outlines of the erythrocytes can still be made out clearly. Free red cells. Numerous other nucleated cells not clearly identifiable at this power (160x).

170 Red cell granular cast (400x).

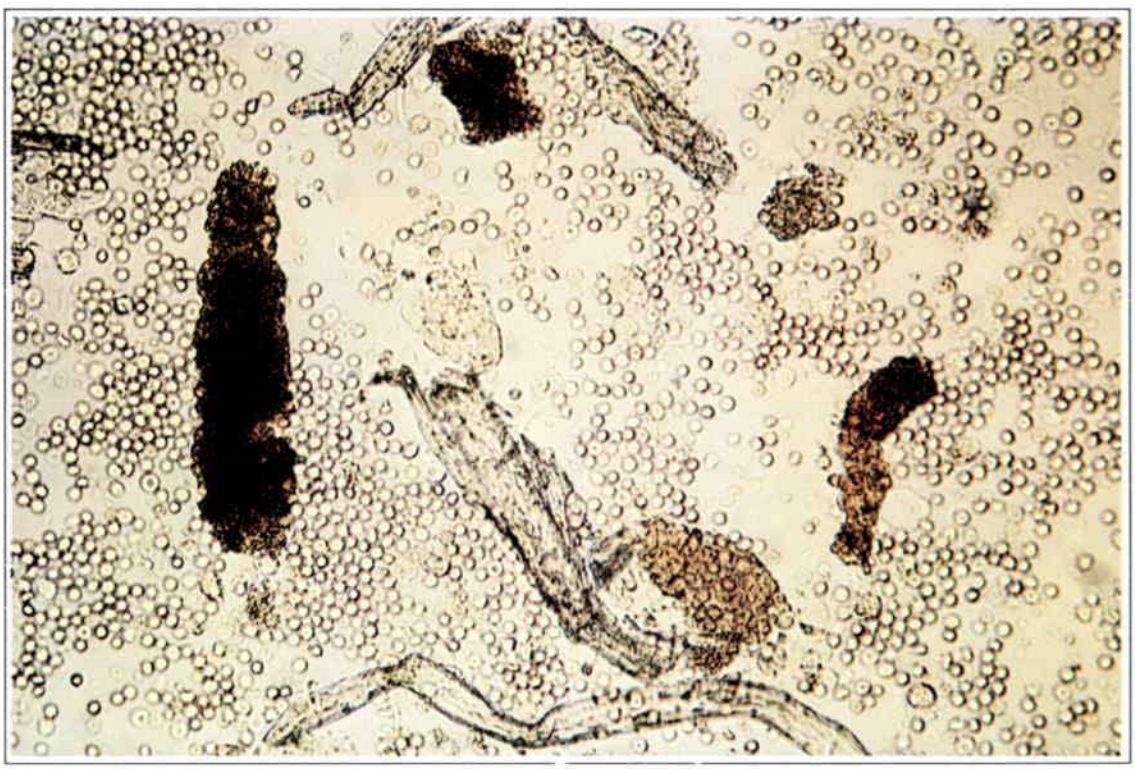
169

170

171 Red cell finely granular cast. Free erythrocytes (400x).

172 Numerous erythrocytes. Hyperpigmented red cell granular casts (160x).

171



172

Red cell casts, as well as erythrocytes, may have varying degrees of depigmentation, and their characteristic reddish or yellowish colour can sometimes only be seen at low power. Glomerular diseases, in the active stages, are the most frequent cause of red cell casts in the urine, but they can be found in all the nephropathies that cause hematuria, including amyloidosis, acute renal failure arising from ischemia or nephrotoxic substances, diabetic nephropathy and, though only occasionally, acute and chronic interstitial renal diseases. Red cell casts should be distinguished from clusters of erythrocytes (not always an easy matter) and from red cells trapped in threads of mucus.

173 Red cells in a thread of mucus (160x).

174 Cluster of red cells, mostly of normal appearance. Unlike red cell casts there is no hyaline matrix (160x).

175 Hyaline red cell cast. In this case there is a hyaline matrix, which is difficult to see by ordinary light microscopy (400x).

176 Red cell granular cast, partially depigmented with a waxy band (400x).

177 Red cell granular cast (400x).

178 Oval-shaped red cell granular cast (400x).

173

174

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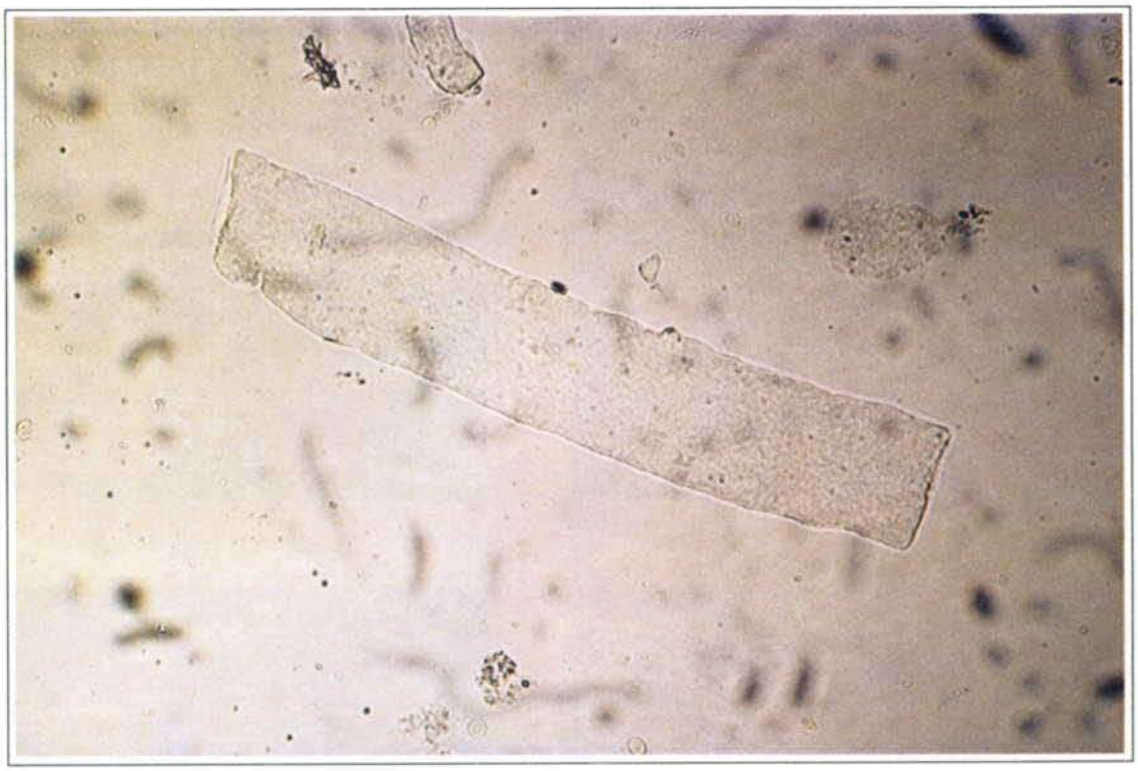
178

3.8.6 WAXY CASTS

These casts always have clear-cut, «sharp» edges, and quite often have fissures. They have long been considered to be the final transformation of all kinds of cast: cellular, granular and hyaline. They are probably casts that have been in the parenchyma for a long time; they always point to severe renal impairment in at least one area.
Their significance as markers of severe damage is still greater if they are of medium size or large diameter.

179 Waxy cast. The clear-cut edges and the waxy, dense appearance are clearly visible (160x).

180 Convoluted waxy cast (100x).



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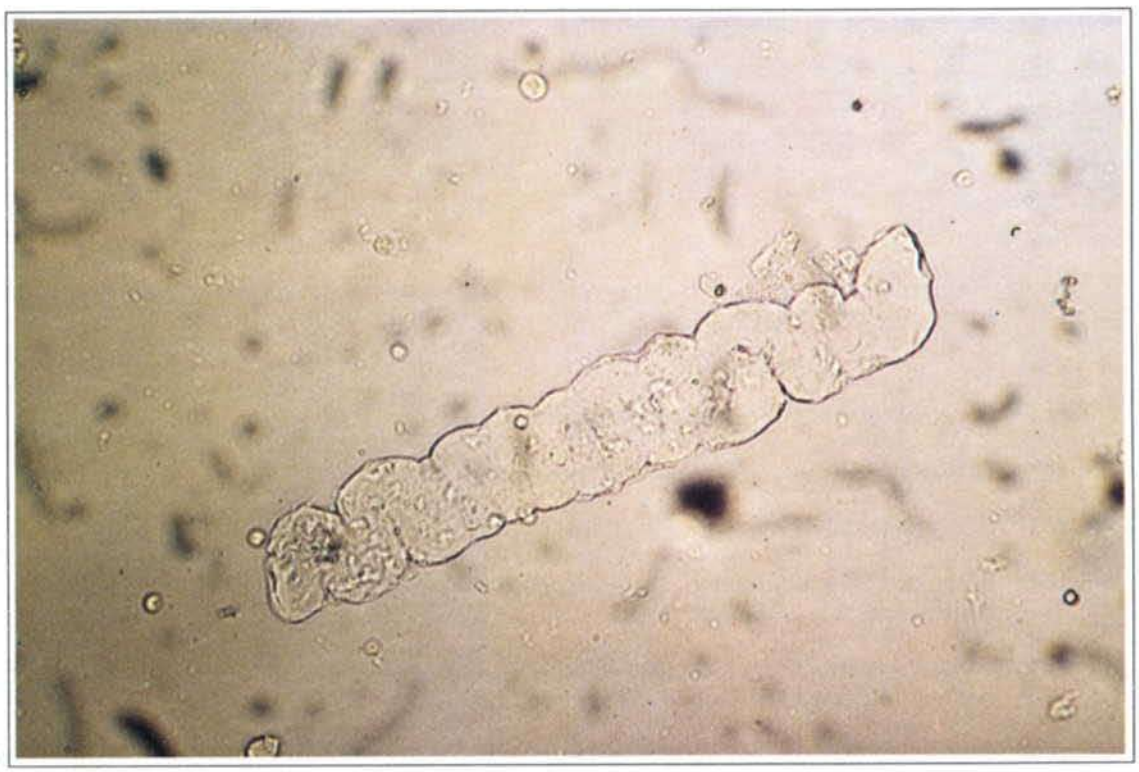


180

181 A convoluted and a rounded waxy cast side by side (160 x).

182 Broken waxy cast; the fracture is clearly visible (160 x).

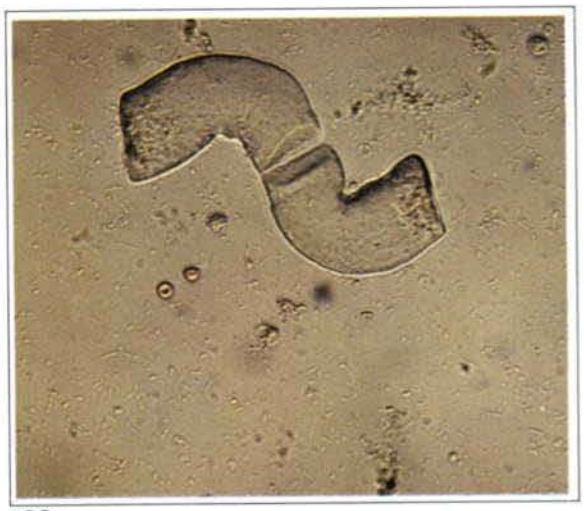
183 Waxy cast split longitudinally (100 x).

184 Polymorphic erythrocytes. Long waxy cast of medium diameter, showing the confluence of two tubules (100 x).

185 Coarsely granular cast in the process of transforming into a waxy cast. Polymorphic red cells. Numerous nucleated cells (160 x).

186 Waxy cast with a granular component (100 x).

181



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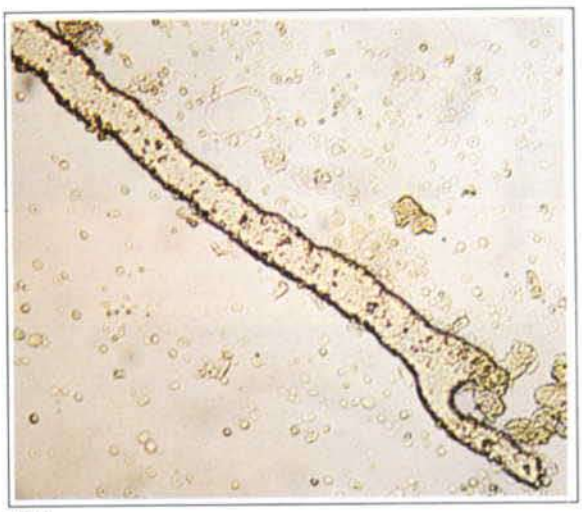

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186

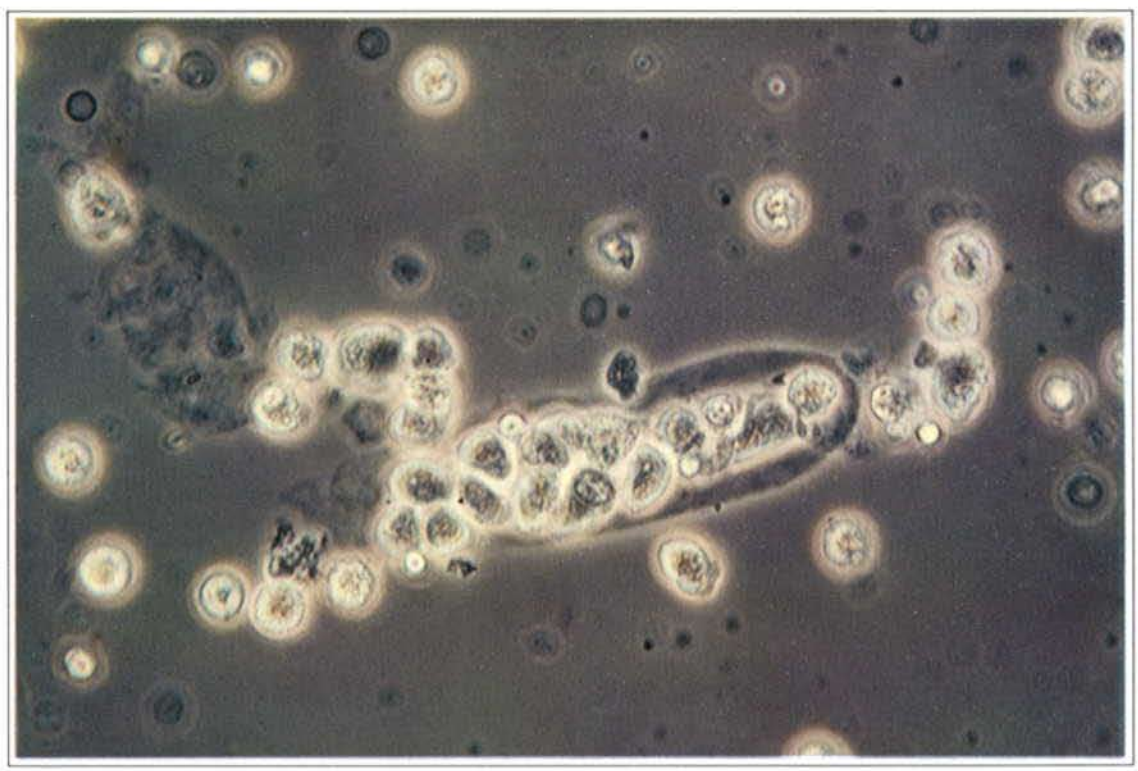
3.8.7 RENAL TUBULAR EPITHELIAL CASTS

These casts are made up of desquamated tubular cells, included in a protein matrix. Sometimes they can be identified readily even when unstained, but phase-contrast may give a clearer image.
We have found, however, that phase-contrast examination is of little advantage here, as it only occasionally makes it possible to determine the nature of the cells with greater precision.

187 Cellular cast. Most of the cells are probably of tubular epithelial origin. Some of the free cells also have the same characteristics (400x).

188 Same field in phase-contrast (400x).

187



188

189 Epithelial cast (phase-contrast) (400x).

190 Cellular cast; there is probably an epithelial component (400 x).

189

190

191 Cellular hyaline cast. Note the hyaline matrix which incorporates rounded or polygonal mononuclear cells with a fine chromatin network, probably of tubular origin (400x).

192 The same field in phase-contrast (400x).

193 Epithelial cast; the morphology of the epithelial cells can be seen clearly (400x).

194 The same cast in phase-contrast (400x).

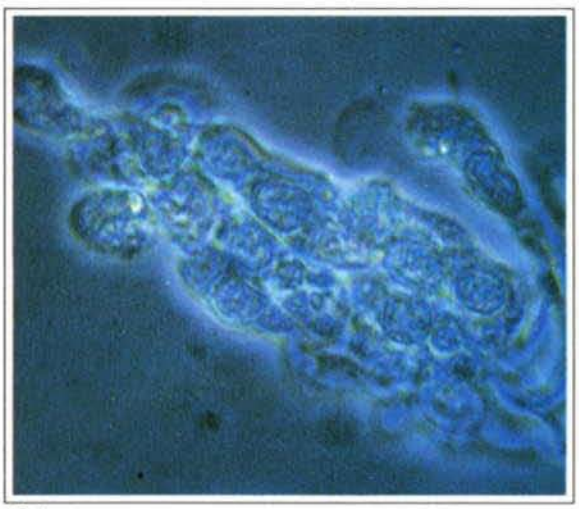
195 Cast probably of epithelial origin. The cytological features are less clear here (400x).

196 The same cast in phase-contrast (400x).

191

192

193



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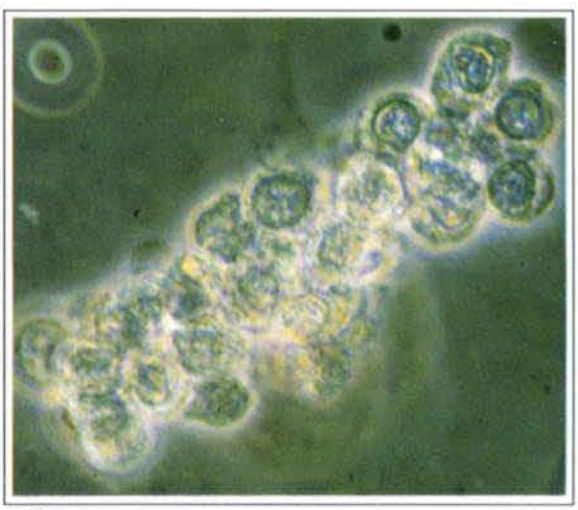


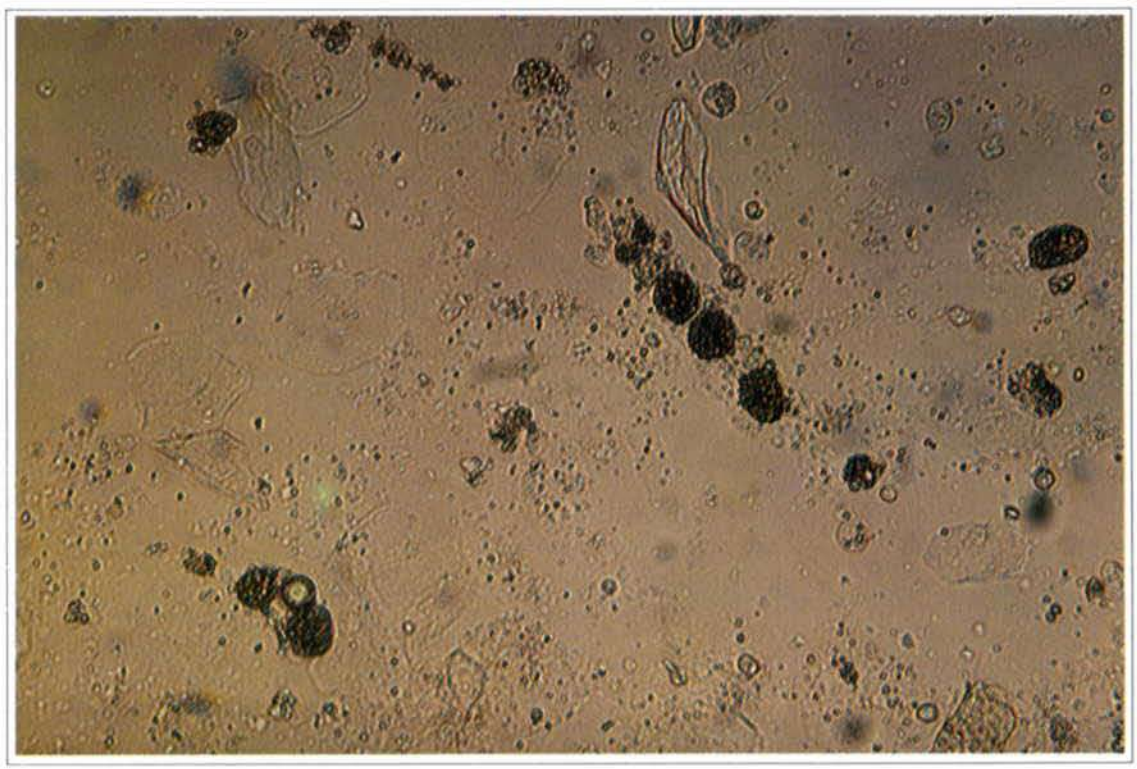
196

A reliable method of identifying epithelial casts is to recognize the lipid content of the cells. If lipids are absent and the degenerative processes in the cells are not too advanced, a single staining of fresh or fixed material can give good identification.
In doubtful cases the term «cellular casts» or «casts with cellular inclusions» is preferable to the term epithelial casts.
Epithelial casts always indicate active or acute renal disorders. They can be found in primary and secondary glomerulonephritis, in interstitial nephritis, in «acute tubular necrosis», in severe non-renal arterial hypertension and in vasculitis.

197 Epithelial hyaline cast. The epithelial inclusion cells, transformed into «oval fat bodies», can be identified by their characteristic fatty content (p. 44). A cast of this kind is a sign not only of a renal lesion but also of a nephrotic syndrome (400 x).

198 Epithelial hyaline cast with oval fat bodies. Lipuria and free oval fat bodies (160 x).

197



198

199 Probably an epithelial cast (Kova stain) (400 x).

200 Epithelial cast (Papanicolaou) (400 x).

199

200

201 Cellular cast. Despite the signs of degeneration, the arrangement and morphology of the cells suggest that these are tubular epithelial cells (400x).

202 Hyaline-cellular cast. The nature of the inclusion cells cannot be defined exactly. Casts of this kind always have a pathological significance. Hematuria with most cells of normal appearance (400x).

201

202

3.8.8 GRANULOCYTE CASTS

These elements can generally only be identified definitely by using stains such as the Papanicolaou, or the less satisfactory Kova stain. The granulocyte cast has long since lost the significance previously attributed to it as a marker of pyelonephritis, and it has been recognized that this type of cast is relatively rare even in this disease, except in the acute stages. Moreover, as in the case of free granulocyturia, it has been established that granulocyte casts are also frequent in some exudative glomerular diseases.
Despite their interest, they are so non-specific that they do not seem to be worth staining in routine examination.

203 Granulocyte cast (Papanicolaou) (160x).

204 Waxy granulocyte cast (Papanicolaou). Specimens of this kind may show a cellular reaction to the presence of the casts (160x).

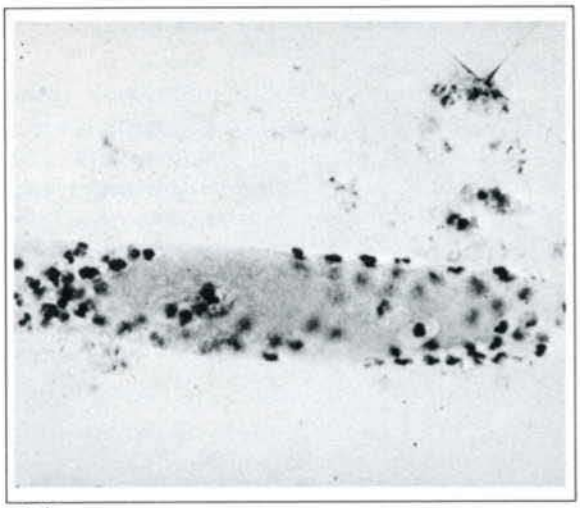
205 Cast with granulocyte inclusions (Papanicolaou) (400x).

206 Cellular hyaline cast. Some cells are definitely granulocytes (400x).

207 Cellular cast (400x).

208 Phase-contrast examination indicates at least one granulocyte inclusion in the cast (400x).

203



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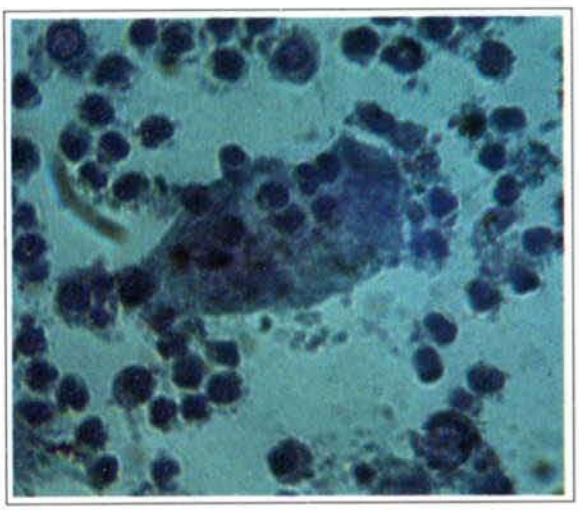

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208

3.8.9 FATTY INCLUSION CASTS

Of the various acellular inclusions found in casts, fatty droplets are of considerable diagnostic interest, as they generally indicate a nephrotic syndrome. They are highly refractile. When they are small it may be difficult to distinguish fatty casts from granular casts; in such cases the brightness of the edges, and any free fat droplets in the sediment, are helpful indications. The fatty nature of some of the larger granules may be confirmed by a specific stain, or by the appearance of «Maltese crosses» under polarized light.

209 Hyaline cast with fatty inclusions (nephrotic syndrome) (160 x).

210 Hyaline cast with fatty inclusions. Note the characteristic grey shade here. Considerable lipuria (nephrotic syndrome) (160 x).

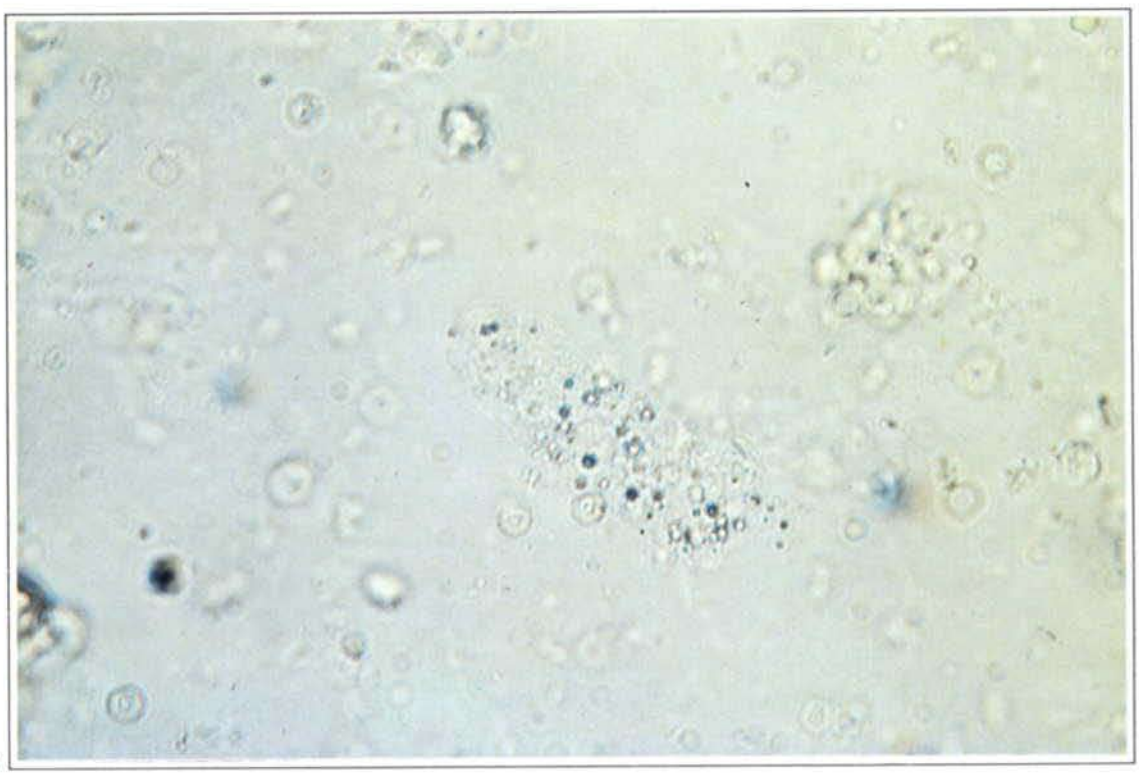
209

210

211 Hyaline cast with fatty inclusions (400x).

212 Hyaline cast with small, but significant fatty inclusions (400x).

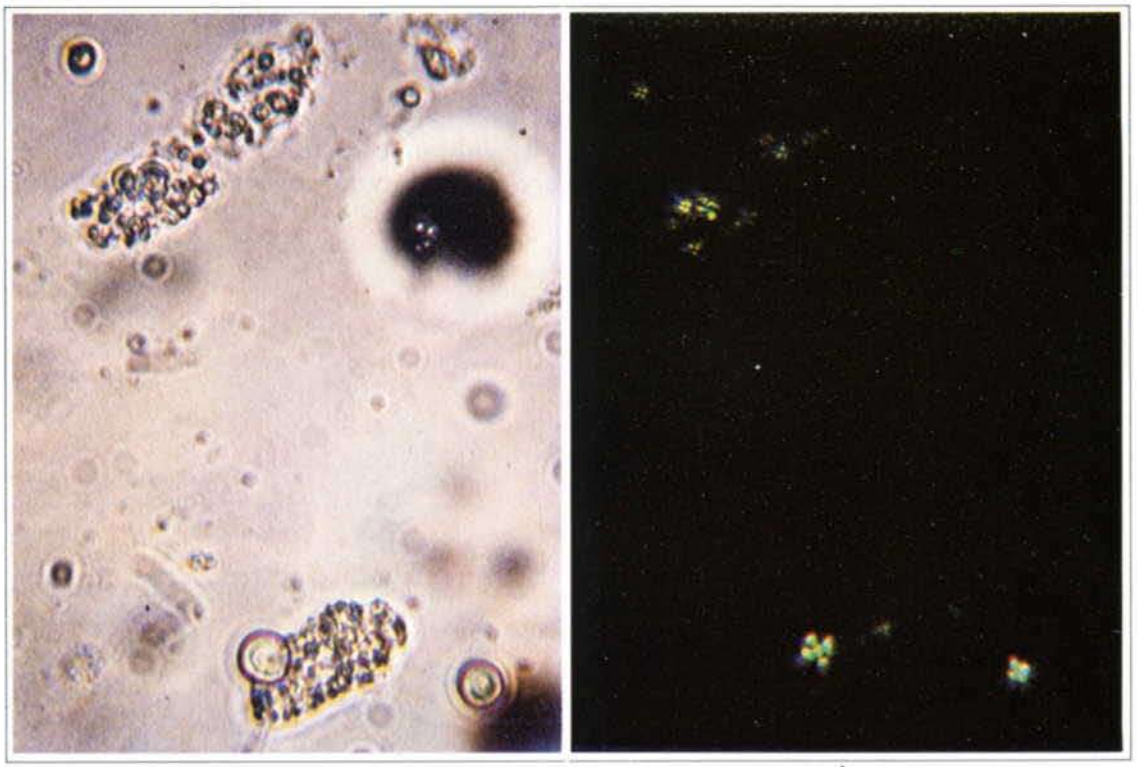
211



212

213 a-b Lipuria, free and in casts. Bright field image (a) and image in polarized light in which the «Maltese crosses» can be seen in the larger droplets (b) (400 x).

214 Fatty droplets in casts, after staining with Sudan III (400 x).



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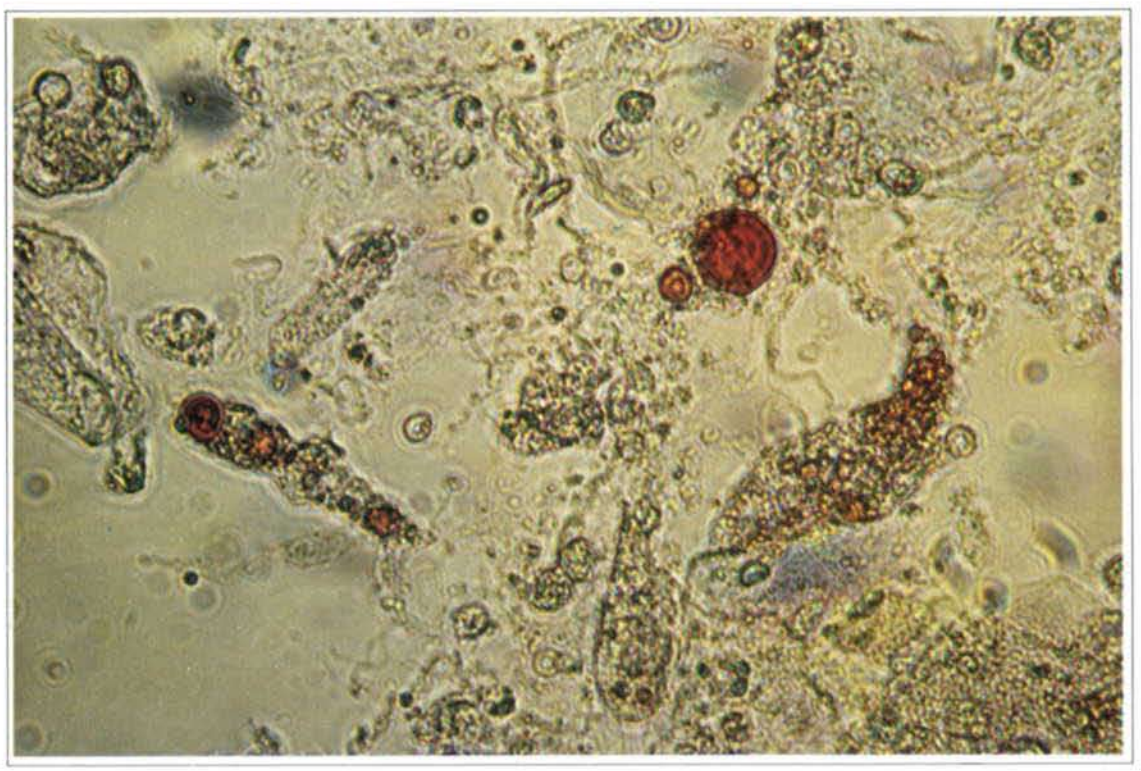
a b



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3.8.10 BACTERIAL INCLUSION CASTS - ACELLULAR INCLUSION CASTS

Salts are among the acellular inclusions of interest.
When urates precipitate they can do so in the form of a pseudocast, but they are distinguished from true casts as they have no hyaline matrix (p. 120).
In our experience bacterial inclusion casts are very rare; they should not be mistaken for «bacterial pseudocasts» (p. 122).

215 Urates within a cast (250x).

216 The same field in phase-contrast (250x).

217 Uric acid crystals within a cast (phase-contrast) (250x).

218 Oxalate in a formation with characteristics intermediate between a cylindroid and a cast (250x).

219 Bacteria within a cast (250x).

220 The same field in phase-contrast (250x).

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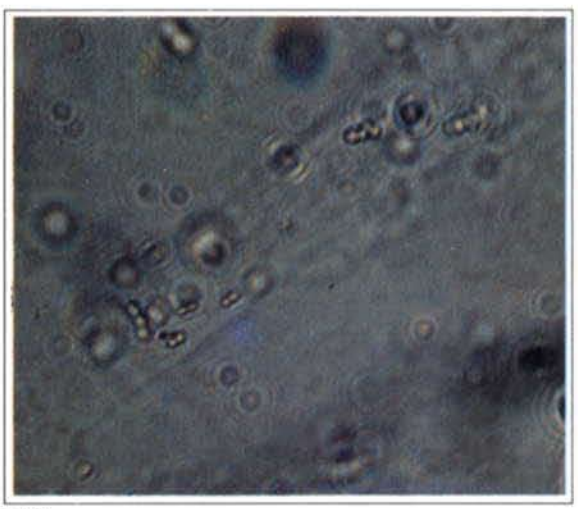

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3.8.11 MIXED CASTS

Although the materials of which mixed casts are composed may be present in all possible combinations, the dominant component determines the significance of an individual cast. For example, a hyaline red cell cast indicates the presence of hematuria of renal origin, a waxy hyaline cast has the same significance as its waxy component, and so on.

221 Granular hyaline casts (160x).

222 Hyaline granular red cell cellular cast (100x).

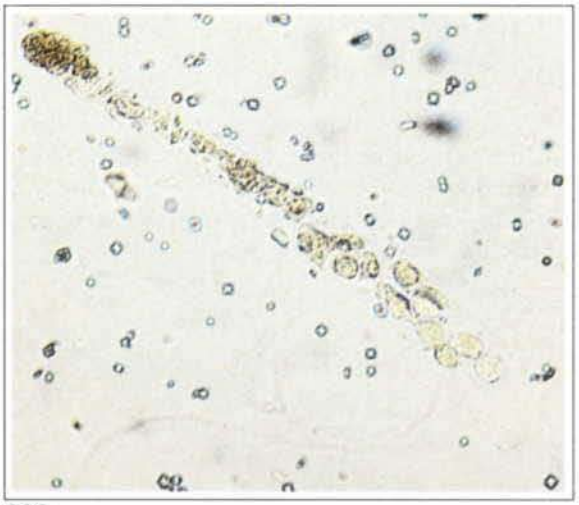
223 Pigmented granular waxy cast (jaundice) (100x).

224 Cellular hyaline cast with fatty inclusions (160x).

225 Cellular waxy cast (100x).

226 Pigmented granular waxy cast, partly of erythrocytic origin (100x).

221



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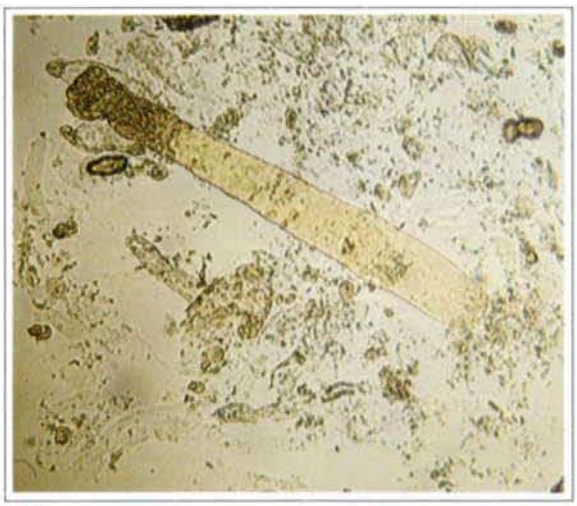

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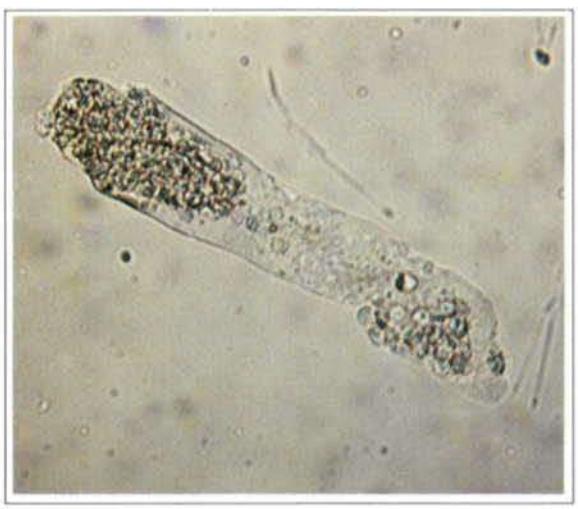

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3.8.12 PIGMENTATION OF CASTS

The pigmented casts most commonly found are of erythrocytic origin. Pigmentation may also be observed when chromogenic drugs have been administered and also in cases of jaundice; in the latter case, the more severe the icterus is at the time the casts are formed, the darker their colour. Whether due to jaundice or to chromogenic drugs, the yellow colour of the casts is generally accompanied by a similar colour in the free nucleated cells and in some of the debris.

227 Pigmented cellular hyaline cast (jaundice) (400 x).

228 Pigmented cast: note the different pigmentation of its components. This sediment was obtained a week after icterus had subsided (membranoproliferative glomerulonephritis; acute hepatitis B) (400 x).

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229 Pigmented casts (hepato-renal syndrome) (100 x).

230 Pigmented cast and pigmentation of some of the free cells. This is probably a drug effect (400 x).

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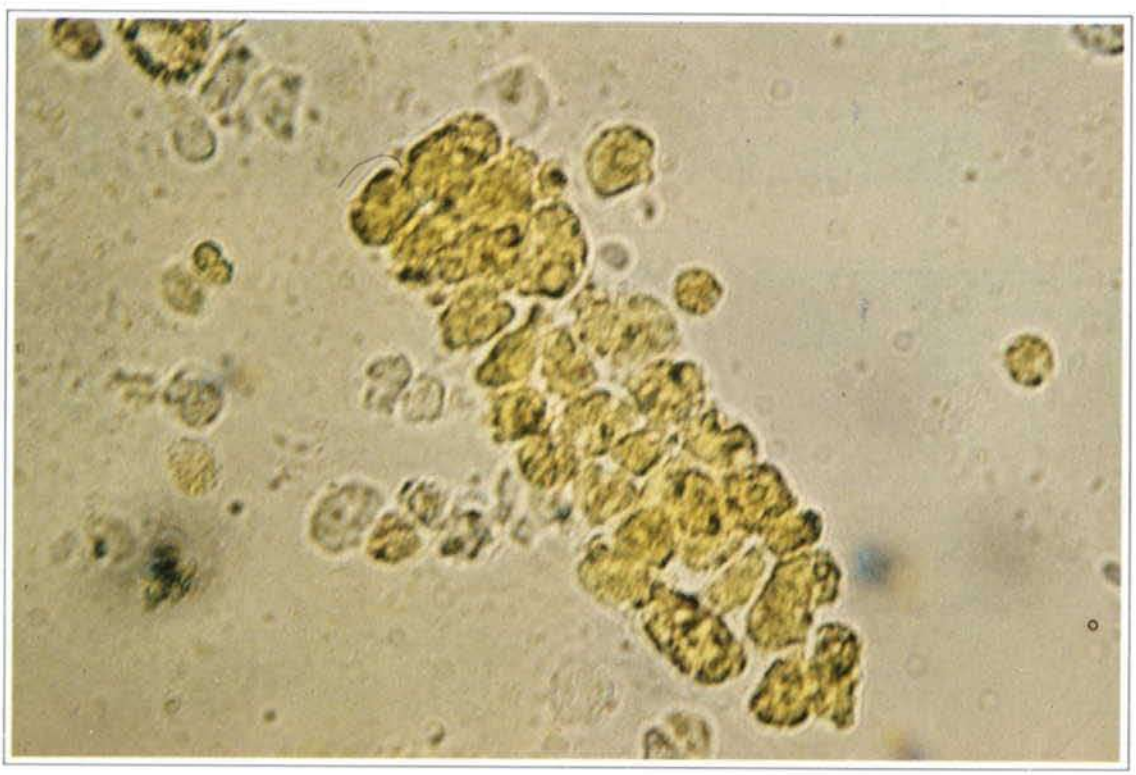

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3.8.13 DIAMETER OF CASTS

Casts can be classified according to their diameter. The significance of «small» casts (of about 20 μ in diameter) depends on their composition (hyaline, granular, red cell, etc.). In «medium» and especially in «large» casts (sometimes over 150 μ) the diameter of the cast is in itself an indication of severe renal impairment, at least in one area (such casts are formed in the distal and collecting tubules) [1].
«Large» casts are frequent in severe renal failure, especially in rapidly progressive nephropathies. If the renal function is normal or only slightly impaired, their presence suggests a lesion in a specific area, such as neoplasms or infarction.

231-232 «Small» casts (160 x), (400 x).

233-234 «Medium» to «large» casts (160 x), (160 x).

235-236 «Large» casts (100 x), (100 x).

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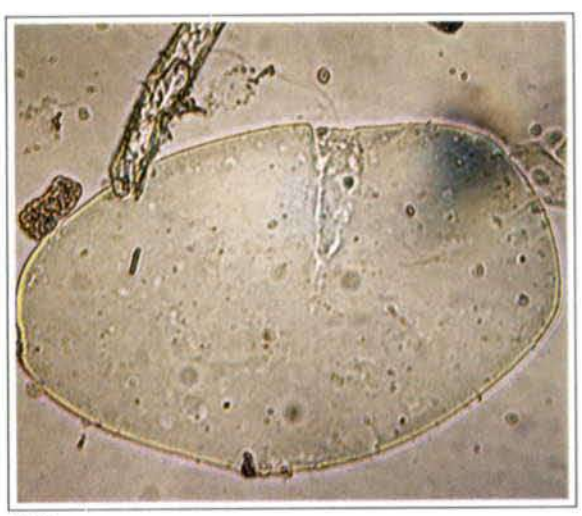

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3.8.14 MISCELLANEOUS ELEMENTS AND PSEUDOCASTS

Casts should be distinguished from other structures to which they bear some resemblance. These include:

– cylindroids: transparent structures with longitudinal striations, often with frayed or flagellate ends (p. 62);

– threads of mucus;

– threads of fibrin;

– pseudocasts of urates: these are clumps of salts which may look like true casts;

– fiber of animal origin (hair or wool);

– fiber of vegetable origin;

– elongated cellular elements.

237 Cylindroid with inclusions (160x).

238 Elongated cellular element (160x).

239 Pseudocast of urates deposited on mucus (160x).

240 Pseudocast of urates (160x).

241 A hair (100x).

242 Vegetable fiber (the cells of which it is composed can be distinguished clearly) (160x).

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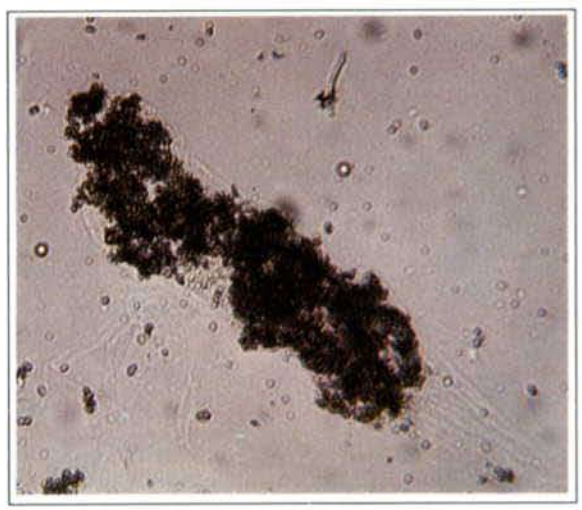

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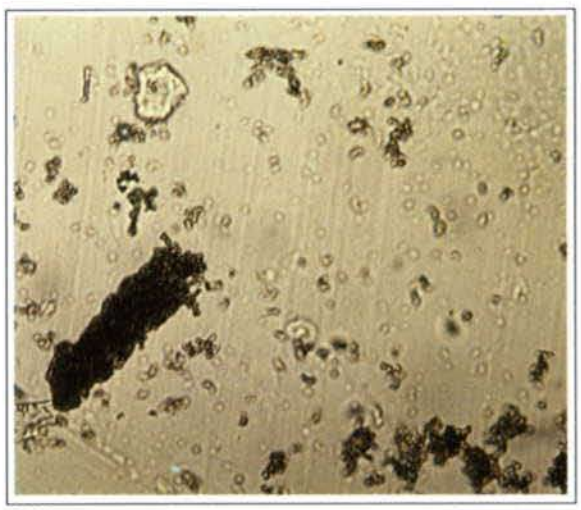

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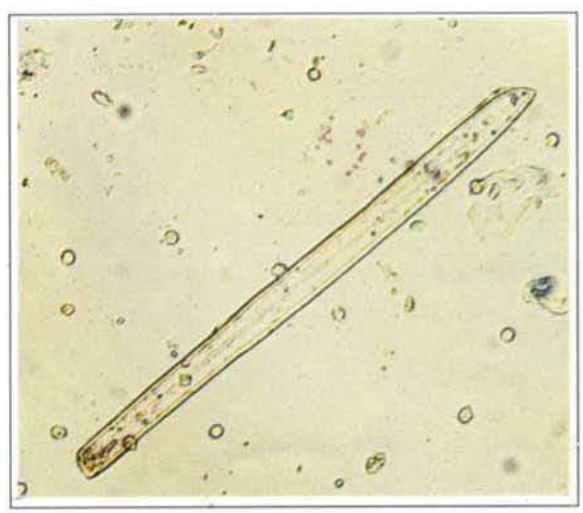

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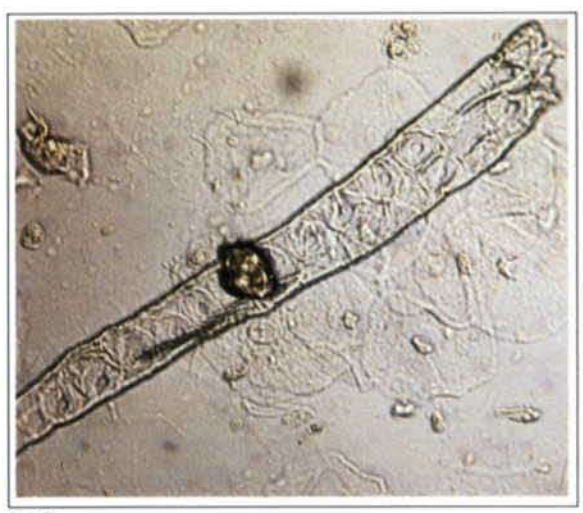

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Other formations that may be mistaken for casts are:

- plaques of calcium phosphate;
- pseudocasts of fungi, leukocytes and bacteria;
- material of menstrual origin.

243-244 Plaques of calcium phosphate resembling waxy casts (160x), (160x).

245 a-b Free fungi with others clumped together to form pseudocasts (250x).

246 Clumped leukocytes (160x).

247 Pseudocast of bacteria (100x).

248 Pseudocast of menstrual material. These elements can sometimes be found a number of days after the menstrual period. In such cases the absence of hematuria is significant (100x).

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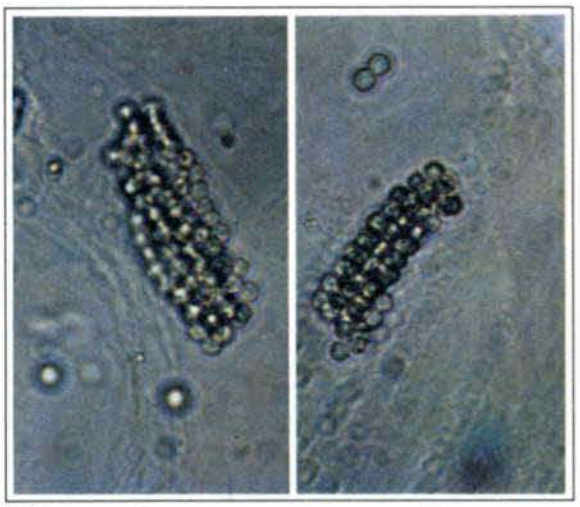

245 a b

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247

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