A Comparative Study of Some Staining Properties of Crystals in a Lympho-plasmocytoid Cell, of Russell Bodies in Plasmocytes, and of Amyloids—With Special Emphasis on Their Isoelectric Points

By Arthur F. Goldberg and Helen Wendler Deane

This study was made to characterize intracellular crystals found in unusual lympho-plasmocytoid cells, which have been described elsewhere and for convenience will be termed crystal cells. For comparison, an examination was made of the related inclusions in plasmocytes (Russell bodies), and also of primary, secondary, and senile cardiac amyloids. Their relative isoelectric points were determined by a staining method that effectively titrates the ionizable radicals of the compounds. The results suggest strongly that the crystals and Russell bodies are gamma globulins, whereas the amyloids studied resemble alpha glycoproteins. Two preliminary reports have been made.

Materials and Methods

The test objects were: (a) the intracytoplasmic crystals in lympho-plasmocytoid cells found in a lymph node biopsy and in bone marrow smears; (b) Russell bodies in plasmocytes present in the lamina propria of normal human stomach and small intestine (two cases), as well as in the gastrointestinal tract of a patient with multiple myeloma (one case) and in a biopsy of chronic inflammatory tissue from the external auditory canal; (c) tissues containing secondary amyloids associated with chronic tuberculosis (three cases), chronic osteomyelitis (one case); and (d) specimens of amyloid associated with multiple myeloma (two cases), as well as generalized primary amyloid and senile cardiac amyloid (one case each). The locations of the amyloids studied were as follows: liver and spleen in the tuberculosis cases; spleen in the osteomyelitis case; blood vessels in stomach, intestine, and spleen of the cases of multiple myeloma; and the heart in generalized primary and senile cardiac amyloidosis.

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*Additional data on the cases in which amyloid were found are as follows.

(a) Cases associated with tuberculosis: (1) 73 year old male; total serum protein 4.9 Gm. per cent; albumin 2.8 Gm. per cent, globulin 2.1 Gm. per cent. Serum electrophoresis showed 29.3 per cent albumin, 7.1 per cent alpha-1, 17.7 per cent alpha-2, 11.8 per cent beta, and 34.1 per cent gamma globulin; BUN 60 mg. per cent; no proteinuria; (2) 23 year old female; total protein 7.2 Gm. per cent; albumin 4.5 Gm. per cent, globulin 2.7 Gm. per cent; BUN 6 mg. per cent; no proteinuria; (3) 50 year old female; total protein 6.9 Gm. per cent; albumin 2.9 Gm. per cent, globulin 4.5 Gm. per cent. Serum electrophoretic pattern showed 27 per cent albumin, 7 per cent alpha-1, 13.5 per cent alpha-2, 11.5 per cent beta, and 41 per cent gamma globulin. Four months later total protein was 5.3 Gm. per cent; albumin 1 Gm. per cent, globulin 4.3 Gm. per cent. Serum
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Since Russell bodies are believed to contain gamma globulin, human gamma globulin was also studied. Mayer's egg albumin, used for affixing sections to slides, was examined in some situations.

All blocks of tissue and a portion of the gamma globulin were fixed in 10 per cent formalin and embedded in paraffin. With the exceptions noted, the various staining procedures listed below were performed on deparaffinized, hydrated sections (ca. 5 μ), and except for the preparations stained for lipides, all sections were mounted in Permount.

To determine the apparent isoelectric points of the test objects, the method of Singer and Morrison was employed. Sections were stained overnight (i.e. to equilibrium) at room temperature, in aqueous solutions of eosin Y and methylene blue at concentrations of 10⁻⁴ and 2 X 10⁻⁴ M., respectively, at intervals of about one pH unit over the range 3.1 to 9.3 (see table 1). These dye concentrations were chosen because they permitted comparable staining of nuclei, cytoplasm, erythrocytes, and collagen fibers at pH 5 with that obtained after ethanol or Zenker-acetic fixation. The Walpole acetate buffer, 0.1 M., was used for the solutions from pH 3.1 to 7.5. Propanediol buffer, 0.1 M., was employed for pH 9.3. The sections were dehydrated in a standardized fashion through tertiary butyl alcohol and xylene. Sections containing the various test objects were stained together, so that they could be compared with confidence.

Some sections were subjected to deamination by the Alfert modification of the Van Slyke method. Blockade of carboxyl groups was produced by methylation. After these pretreatments, the sections and appropriate controls were stained with eosin and methylene blue as above.

Other slides were stained by the periodic acid-Schiff (PAS) procedure, by the PAS method after saliva treatment, with crystal violet, and with Congo red. The last preparations were examined with a polarizing microscope as well as the ordinary light microscope.

The Baker acid-hematein stain for phosphatides was performed on material fixed in calcium-formalin: (a) frozen sections of normal human stomach containing plasmocytes, (b) bone marrow smears from the case with crystal cells and (c) aqueous, air-dried smears of human gamma globulin and egg albumin. Control preparations were extracted overnight with pyridine at 60 C. before mordanting and staining.

Frozen sections of the formalin-fixed human stomach having numerous plasmocytes in the lamina propria and bone marrow smears containing crystal cells were stained with Sudan black B and with oil red O for 10 minutes at room temperature, and for 10 and 60 minutes at 60 C.

| Electrophoretic pattern showed 19 per cent albumin, 8 per cent alpha-1, 29.2 per cent alpha-2, 11.8 per cent beta and 32 per cent gamma globulin; BUN 20 mg. per cent; 4 plus proteinuria. |
|---|---|---|---|---|---|
| (b) Case associated with osteomyelitis: 59 year old male; total protein 5.2 Gm. per cent; albumin 2.2 Gm. per cent, globulin 3 Gm. per cent; BUN 28 mg. per cent; trace of proteinuria. |
| (c) Cases associated with multiple myeloma: (1) 90 year old female; BUN 28 mg. per cent, 3 plus proteinuria; (2) 72 year old female; total protein 8.5 Gm. per cent; albumin 3.4 Gm. per cent, globulin, 5.1 Gm. per cent; BUN 10 mg. per cent, 3 plus proteinuria, Bence-Jones protein present. |
| (d) Case with generalized primary amyloidosis: 55 year old female; total protein 5.4 Gm. per cent; albumin 4 Gm. per cent, globulin 1.4 Gm. per cent; BUN 40 mg. per cent; no proteinuria. |
| (e) Case with senile cardiac amyloidosis: 77 year old male; BUN 24 mg. per cent; trace of proteinuria. |

*A sample of purified Fraction II was obtained from the Mann Research Laboratories, New York.*
Observations

The intensity of staining of the various test objects with eosin and methylene blue was judged visually, as indicated in table 1. In addition to the Russell bodies (fig. 1), gamma globulin, the crystals (fig. 2), and amyloids (fig. 3), the tabulation includes collagen fibers, erythrocytes, eosinophile granules, and the basophilic cytoplasm (ergastoplasm) of plasmocytes. These additional objects have been studied by others,13-15 and therefore provided comparisons for our results. For each object, the zone of equal, weak staining by the acid and basic dyes was taken to represent its isoelectric point under the conditions of preparation.4

For the Russell bodies and gamma globulin, the average isoelectric range appeared to lie between pH 6.2 and 7.5 (table 1). The slopes of the curves of dye uptake fell off for the acid dye between pH 6.2 and 7.5 and for the basic dye between pH 9.3 and 7.5 (fig. 1). There was no residual staining at pH 9.3 with eosin or at pH 5.1 with methylene blue. The crystals stained quite similarly, but they seemed to have a slightly more acid isoelectric point (table 1, fig. 2).

Individual crystals and Russell bodies always stained uniformly. At a given pH of staining, however, some would appear darker than others. Near neutrality, some were stained while others were almost unstained (e.g., figs. 1b and 2c).

The eight cases of amyloids studied reacted essentially alike and had apparent isoelectric points at about pH 5 (table 1, fig. 3). The slopes of their staining curves seemed more gradual than those of the crystals and Russell bodies.

The remaining data listed in table 1 are compatible with the results of others who have used the controlled-pH staining method, in that the isoelectric point of collagen appeared to be near pH 613 (fig. 3); the acidophilia of erythrocytes and eosinophile granules extended to high pH14 (fig. 2); and staining of ergastoplasm with methylene blue dropped between pH 4 and 315 (fig. 1).

Deamination and methylation treatments were performed on sections containing crystals (lymph node), Russell bodies (gut and external ear), three examples of secondary amyloid (spleen, in cases with tuberculosis), and two

Table 1.—Staining of various objects with acid and basic dyes at different pH’s*†

<table>
<thead>
<tr>
<th>OBJECTS</th>
<th>pH 3.1 E MB</th>
<th>pH 4.1 E MB</th>
<th>pH 5.1 E MB</th>
<th>pH 6.2 E MB</th>
<th>pH 7.5 E MB</th>
<th>pH 9.3 E MB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystals</td>
<td>+++ 0</td>
<td>+++ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
</tr>
<tr>
<td>Russell bodies</td>
<td>++ 0</td>
<td>++ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
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<tr>
<td>Gamma globulin</td>
<td>++ 0</td>
<td>++ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
</tr>
<tr>
<td>All amyloids</td>
<td>++ 0</td>
<td>++ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
</tr>
<tr>
<td>Collagen fibers</td>
<td>++ 0</td>
<td>++ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
</tr>
<tr>
<td>Erythrocytes</td>
<td>++ 0</td>
<td>++ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
</tr>
<tr>
<td>Eosinophile</td>
<td>++ 0</td>
<td>++ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
</tr>
<tr>
<td>Ergastoplasm of</td>
<td>++ 0</td>
<td>++ 0</td>
<td>+ 0</td>
<td>+ 0</td>
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<td>+ 0</td>
</tr>
<tr>
<td>plasmocytes</td>
<td>± 0</td>
<td>+ 0</td>
<td>++ 0</td>
<td>+++ 0</td>
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<td>+++ 0</td>
</tr>
</tbody>
</table>

*Sections stained with eosin (E) at 10^-5 M., and methylene blue (MB) at 2 x 10^-3 M.
†Scale of dye binding: 0 = no dye binding; ± = negligible dye binding; + to ++++ = slight to very intense dye binding.
Fig. 1.—Degree of basophilia of Russell bodies in plasmocytes present in chronic inflammatory tissue in external ear. Methylene blue, 2 X 10⁻⁴ M.; X 900. Staining is (a) absent [O] at pH 5.1, (b) negligible [±] at pH 6.2, (c) slight [+] at pH 7.5, and (d) intense [++++] at pH 9.3. Some plasmocytes contain one or two large Russell bodies, others contain many smaller ones (arrows). The nucleus tends to be displaced to the periphery of the cell. Strands of basophilic cytoplasm (ergastoplasm) surround the Russell bodies; this material remains basophilic at pH 5.1.

cases of amyloid associated with multiple myeloma (spleen). For all objects, deamination consistently increased uptake of methylene blue at each pH, producing detectable staining even at pH 3.5. In contrast, blockade of carboxyl groups increased the uptake of eosin, so that all these objects stained at pH 9.3. No changes appeared in the relative intensity of staining of the several test objects.

All of the amyloids stained red-orange with Congo red and exhibited the typical birefringence in polarized light.¹⁰⁻¹¹ The crystals, Russell bodies, and gamma globulin stained only light orange with Congo red and did not become birefringent.

Likewise, all the amyloids stained metachromatically with crystal violet. There were no significant differences in the reactivity of these 8 cases. The
crystals, Russell bodies, and gamma globulin stained orthochromatically with crystal violet.

Sections containing crystals and amyloids and smears of gamma globulin all stained with moderate intensity by the PAS method (fig. 4). Many Russell bodies reacted more intensely than the other objects when stained in the same run.

Russell bodies and crystals showed no dye uptake when exposed to either Sudan black B or oil red O. A negative reaction for Russell bodies has been reported by many others. Grundner-Culemann and Diezel, however, found that some Russell bodies do stain with Sudan black B.

It has been reported that cell inclusions in plasmocytes stain by the Smith-Dietrich procedure for phosphatides. Because we believe these inclusions to have been Russell bodies, we also applied a method for phosphatides. The Baker method has the advantage that it uses a parallel control preparation in which lipides are pre-extracted, so that staining attributable to nonlipide acidic substances may be recognized. Frozen sections of stomach including plasmocytes, smears of bone marrow containing crystal cells, and smears of gamma globulin and egg albumin were stained by this method. All of the test objects except egg albumin reacted positively. Moreover, Russell bodies (fig. 5) and crystals became intensely stained even when the preparations were extracted with hot pyridine before being exposed to the mordant and

Fig. 2.—Degree of acidophilia of crystals in the lympho-plasmocytoid cells present in a lymph node biopsy. Eosin, $10^{-1}$ M.; X 900. Dye uptake is (a) intense at pH 5.1, (b) slight at pH 6.2, and (c) negligible at pH 7.5. Arrows point to representative crystal cells. Erythrocytes (e) are still acidophilic at pH 7.5.
Staining with dilute solutions of acid and basic dyes at a series of pH's allows the determination of the relative isoelectric points of various compounds. It should be emphasized that to do this, staining must be continued until equilibrium has been attained (18–24 hours). Also, the subsequent washing and dehydration of the sections must be kept uniform so that dye is not removed in differing amounts. If such preparations are analyzed with a spectrophotometer, accurate pH "signatures" (titration curves) may be ob-
Fig. 4.—PAS positive reaction in (a) crystals [lymph node biopsy], (b) Russell bodies [chronic inflammatory tissue in external ear], (c) amyloid associated with multiple myeloma [wall of splenic artery], and (d) secondary amyloid [spleen, chronic pulmonary tuberculosis]. All preparations lightly counterstained with dilute Harris's hematoxylin; (a) and (b) X 900, (c) and (d) X 400.

and these provide even more information about the kinds of ionizable groups present. In this study, however, we have limited ourselves to visual assessment.

**Russell Bodies and Crystals**

For *Russell bodies*, the isoelectric points ranged between 6.2 and 7.5. This is approximately the range exhibited by undenatured human gamma globulins. Furthermore, when we tested fixed gamma globulin by our procedure, it exhibited staining properties similar to those of Russell bodies. That its isoelectric range proved to be the same with the staining methods as by biophysical measurement indicated that the dye concentrations selected were appropriate. Otherwise the *relative* isoelectric points of the various objects in the sections, although valid, might not have conformed to the range exhibited by undenatured proteins.
Fig. 5.—Russell bodies in plasmocytes in a human stomach. Pyridine-extracted frozen section; Baker's acid-hematein reaction; X 900. The Russell bodies remain stainable. The base of a gastric gland occurs at (g).

There is abundant evidence from other types of methods that Russell bodies contain gamma globulin, the most direct being that they react with fluorescein-labeled antibodies to human gamma globulin. The variation of stainability observed in different Russell bodies is consistent with the known fact that there are a number of gamma globulins with a range of isoelectric points between pH 6 and 8. These variations, which sometimes occur within a single cell, have been seen by others using different staining methods.

Pearse was perhaps the first cytologist to show that Russell bodies consist of glycoprotein. He found that this substance ceased to bind methylene blue in dilute solution at pH 6.0 and that it was PAS positive. Human gamma globulin contains about 3 per cent carbohydrate.

The crystals in the lympho-plasmocytoid cell exhibited nearly the same isoelectric range as the Russell bodies and gamma globulins. This result suggests that the crystalline material was a gamma globulin or a protein with a similar isoelectric range. The supposition of identity is reinforced by the other similarities in staining properties. Thus, the crystals, like Russell bodies and gamma globulin, also give the PAS reaction. Furthermore, the crystals, like Russell bodies, stained by the Baker acid-hematein test, even after pyridine extraction. The significance of this reactivity remains obscure, but for our present purposes it indicates the similarity of these two intracellular inclusion bodies. Gamma globulin seemed to react in the same way, although the thin smears used decolorized more readily than did the intracellular inclusions in sectioned material. Ordinarily it is assumed that materials stainable after pyridine extraction are nonlipides having strong acid radicals.
The high isoelectric point of the Russell bodies and crystals makes this explanation improbable. And the complete absence of staining by oil-soluble dyes makes it extremely unlikely that an unextractable acidic lipid accounts for the stainability with acid hematein. Certainly the results do not support the assumption that inclusions appearing to be Russell bodies contain phospholipid.21

“Basophilia” and “acidophilia”

The conflicting reports in the literature concerning the staining properties of inclusions in plasmocytes warrant comment. It seems to us that the variability in the staining properties of Russell bodies has been unduly exaggerated. (a) As we have shown here, in any one preparation, Russell bodies may exhibit slightly differing dye uptakes (fig. 1), probably because the constituent gamma globulins vary slightly in isoelectric point. (b) More importantly, the influence of pH on stainability with Romanovsky stains (mixtures of methylene blue, azures, and eosin) is inadequately recognized. Russell bodies have been described or illustrated as staining pale blue,16,19,29,32-34 darker blue,16,19,29,32-35 violet or purple,17,29,33,36 pink,29,36,37 or red.29,32,38 Knowing the isoelectric point of gamma globulin helps explain these discrepancies, since Romanovsky mixtures (if buffered at all) are used anywhere between pH 5.5 and 7. Frequently a buffer is not employed, and Wright’s stain may be quite alkaline because of the bicarbonate present. Thus it is understandable that sometimes the dye bath is on the alkaline side of the isoelectric points of Russell bodies, making them stain basophilically (blue); sometimes near the isoelectric point, making them appear amphoteric (violet or purple); sometimes on the acidic side, making them acidophilic (pink or red). Furthermore, the Romanovsky mixtures are concentrated, so that staining is not carried to equilibrium; consequently relative stainability may not be valid.6

We believe, as Bessis concluded on other grounds,39 that the tendency to distinguish between the inclusions in plasmocytes associated with different diseases is unwarranted on the basis of present information. This tendency still continues.50,34 Unless preparations have been fixed and stained exactly alike, tinctorial differences may not be significant. Certainly it is impossible to compare preparations that have been made in different laboratories when no standardized procedures exist.

Finally, the fact that Russell bodies often stain somewhat basophilically with Romanovsky mixtures but are uniformly acidophilic in H & E preparations is explicable on two grounds. (a) Hematoxylin is not a basic type and generally stains chromatin only. Unless the solution is very old (S. H. Bensley, personal communication), it has little tendency to stain other basophilic substances. (b) H & E preparations are generally stained with a strong, alcoholic solution of eosin, which is taken up by almost all materials in sections, regardless of their isoelectric points. Amyloids

All specimens of amyloid studied reacted similarly, having an apparent isoelectric point at about pH 5. Earlier, Carnes and Forker40 showed that
uptake of another basic dye, toluidine blue, by both primary and secondary amyloids was extinguished at pH 4.5. These results support the concept that various amyloids are closely related and that their classification into different types, although useful, is still quite arbitrary.

The plasma proteins having similar isoelectric points are the alpha-1 and alpha-2 glycoproteins and beta-1 globulins. In extraction studies on tissues containing amyloids, it has been shown that amyloids consist of a glycoprotein fraction and an acid mucopolysaccharide. The glycoprotein stains by the PAS technic and the acid mucopolysaccharide stains metachromatically with toluidine blue or crystal violet. Both of these components migrate electrophoretically like the alpha and beta globulin fractions. There is at least one case in the literature in which amyloid was analyzed chemically and found to have an amino acid composition similar to beta globulin.

Current studies reveal that the acid mucopolysaccharide component of amyloids does not contain chondroitin sulfate or hyaluronic acid, and that the acidic moiety is probably carboxylated. A known acidic component of certain mucoproteins and mucopolysaccharides is sialic acid. This substance is present as a significant constituent of the plasma alpha-2 globulins, and as a lesser constituent of the alpha-1 and beta globulin fractions. Sialic acid has been found in extracts of organs containing amyloids as well as in the appropriate globulin fractions. Since sialic acid may induce metachromasy of basic dyes, it may be the major substance responsible for the characteristic metachromatic staining of amyloid.

One of the inherent defects of the controlled-pH staining method, employed here to determine the isoelectric point of amyloids, is that it measures only the net available ionizable groups. When a test object contains a mixture of substances, it is impossible to determine how many ionizable radicals are contributed by each component. Without differential extraction, it would be impossible to determine the isoelectric points of the protein and carbohydrate moieties separately.

A long-standing hypothesis has been that tissue amyloids may result from the local deposition of certain circulating plasma globulin fractions. In the cases just listed, the patients had elevated serum globulin fractions with properties corresponding to those of the amyloids extracted from the tissues. These cases represented both primary and secondary amyloids. In two of our cases of secondary amyloidosis, on whom serum electrophoretic patterns were performed, the alpha globulin fraction was elevated.

Other clinical and laboratory studies on patients or experimental animals with amyloidosis have shown similar serum electrophoretic patterns. Besides the slight-to-moderate elevation of the alpha or beta globulin fractions, the serum albumin fraction is frequently reduced in such patients. The gamma globulins are usually slightly elevated early in the disease. In long standing cases, the total globulin is generally not elevated. This is particularly true in cases of multiple myeloma with amyloidosis.

If the protein component of amyloid is an alpha or beta globulin, then what is its origin? It has long been suggested, especially for cases of amyloidosis associated with multiple myeloma, that the amyloid is a product of
plasmocytes. While there is no definitive evidence that the plasmocyte produces alpha or beta globulins, there is indirect evidence that this is so. In agammaglobulinemia, where plasmocytes are absent, some alpha and beta globulins may not be produced. In multiple myeloma, the reverse situation may occur, in that there is a marked elevation of serum alpha or beta globulins. It is usually presumed that these abnormal proteins arise from the proliferating myeloma plasmocytes. Even in those cases of multiple myeloma in which the major protein elevation is gamma or beta globulin, the alpha globulins may also be moderately elevated, suggesting that these globulins too are being produced by the myeloma plasmocytes. In the same category are the rare cases of multiple myeloma associated with amyloidosis in which the amyloid is surrounded by myeloma cells, suggesting its local production. Protein inclusions taking positive amyloid stains have also been described in myeloma cells. Furthermore, since in multiple myeloma with amyloidosis there is usually a fall in serum globulins, there may be a block in the production of these plasma proteins by myeloma plasmocytes and possibly a shift in ratio of production of the several globulins.

On the other hand, the liver has been implicated as the primary source of most alpha and beta globulins. It is possible, therefore, that certain forms of amyloidosis may result from a disturbance of protein metabolism in that organ. The low serum albumin, so frequently found in amyloidosis, may likewise be a reflection of this derangement. Possibly hepatic cells also produce the mucopolysaccharides associated with the globulin fractions and with amyloid.

Finally, it should be pointed out that there is some evidence in the literature that amyloids may differ from one another. Notably, primary amyloid associated with multiple myeloma sometimes exhibits little or no metachromatic staining (e.g., with crystal violet). Since patients with multiple myeloma frequently exhibit reduced serum mucoprotein levels, it seems reasonable to assume that in such cases as described above, little acid mucopolysaccharide was available to be deposited in the amyloid complex. Our particular cases, however, all exhibited significant metachromasy with crystal violet. The conditions that may produce secondary amyloidosis all appear to be associated with an elevation of such serum mucopolysaccharides, thus explaining the consistent intense metachromasy of the deposits with crystal violet.

SUMMARY

A staining procedure for determining the approximate isoelectric points of substances has been applied to tissue sections containing (a) intracytoplasmic crystals in a lympho-plasmocytoid cell, (b) Russell bodies of plasmocytes, and (c) secondary and primary amyloids. The same method was also applied to sections of human gamma globulin.

The results indicate the similarity of Russell bodies, the crystals, and gamma globulin, all of which showed an isoelectric range between pH 6 and 7.5. Other staining methods employed tended to confirm this identity.

The discrepancies reported in the literature on the staining properties of Russell bodies are discussed.
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All of the amyloids tested had an apparent isoelectric point near pH 5. Various suggestions in the literature about the nature and origin of amyloid are summarized.

Summario in Interlingua

Un metodo de tincturation pro determinar le approximative punctos iso-electric de substantias esseva applicate a sectiones tissular que contineva (a) crystallos intracytoplasmic in un cellula lympho-plasmoctyoide, (b) corportes de Russell in plasmocytos, e (c) amyloides secundari e primari. Le mesme metodo esseva etiam applicate a sectiones de globulina gamma human.

Le resultatos indica le similaritate de corpores de Russell, de crystallos, e de globulina gamma que omnes monstrava un gamma isoelectric inter pH 6 e pH 7,5. Altere methodos tincturatori que esseva empleate tendeva a confirmar iste identitate.

Es discutite le discrepantias que se trova reportate in le litteratura con respecto al proprietates tincturatori de corpores de Russell.

Omne le amyloides testate habeva un apparente puncto isoelectric in le vicinitate de pH 5. Es summarisate le suggestiones in le litteratura relative al natura e al origine de amyloide.

REFERENCES


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A Comparative Study of Some Staining Properties of Crystals in a Lympho-plasmocytoid Cell, of Russell Bodies in Plasmocytes, and of Amyloids-With Special Emphasis on Their Isoelectric Points

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