Schümann (1959) identified the amine in seven organs of dog, sheep and ox, and found that the concentration of 3-hydroxytyramine relative to that of noradrenaline in brains of dogs was exceeded in liver and intestine, whereas Montagu (1957, 1959) and Bertler & Rosengren (1959) found only smaller and 'very small' amounts respectively in tissues of non-ruminant animals other than brain, suggesting a special role in this organ. Unlike noradrenaline and adrenaline (Vogt, 1954), the concentration of hydroxytyramine is highest in the corpus striatum (Bertler & Rosengren, 1959; Ehringer & Hornykiewicz, 1960).

3,4-Dihydroxyphenylalanine and the acidic catechol compound have not been identified in other than human brains or in rat tissues, but even quite large amounts, especially of 3,4-dihydroxyphenylalanine, could escape detection in analyses of extracts by the ethylenediamine method. The estimated concentration of the acidic catechol compound was about the same in the first human brain and in the sample from the second, but there was no evidence for the presence of 3,4-dihydroxyphenylalanine in the latter. Since there were (unidentified) non-basic catechol compounds in rabbit brains, which were extracted immediately after death, it seems unlikely that their presence in human brain is due to post-mortem change.

SUMMARY

1. 3-Hydroxytyramine constituted between 50 and 80% of the total catecholamine concentration of the whole brains of male rats, guinea pigs, rabbits, cockerels and man. In human brain 3,4-dihydroxyphenylalanine and an acidic catechol compound were also present.

I thank Dr H. Weil-Malherbe for advice and Dr D. C. Caldwell for supplying two human brains. Poultry Packers (Essex) Ltd. very kindly supplied the heads of cockerels within 30–40 min. of death.

REFERENCES

Bertler, A. & Rosengren, E. (1959). *Acta physiol. scand.* **47**, 350.
Carlsson, A., Lindquist, M., Magnusson, T. & Waldeck, B. (1958). *Science*, **127**, 471.
Ehringer, H. & Hornykiewicz, O. (1960). *Klin. Wschr.* **38**, 1236.
Euler, U. S. von & Floding, I. (1955). *Acta physiol. scand.* **33**, suppl. 118, p. 45.
Holzer, G. & Hornykiewicz, O. (1959). *Arch. exp. Path. Pharmak.* **237**, 27.
Markham, R. & Smith, J. D. (1949). *Biochem. J.* **45**, 294.
Markham, R. & Smith, J. D. (1951). *Biochem. J.* **49**, 407.
Montagu, K. A. (1956). *Biochem. J.* **63**, 559.
Montagu, K. A. (1957). *Nature, Lond.*, **180**, 244.
Montagu, K. A. (1959). *Biochem. J.* **71**, 91.
Partridge, S. M. (1948). *Biochem. J.* **42**, 238.
Schümann, H. J. (1959). *Arch. exp. Path. Pharmak.* **236**, 474.
Vogt, M. (1954). *J. Physiol.* **123**, 451.
Weil-Malherbe, H. & Bone, A. D. (1954). *Biochem. J.* **58**, 132.
Weil-Malherbe, H. & Bone, A. D. (1956). *Lancet*, ii, 282.
Weil-Malherbe, H. & Bone, A. D. (1957). *J. clin. Path.* **10**, 138.

Biochem. J. (1963) **86**, 11

α-Glucosidase Deficiency in Generalized Glycogen-Storage Disease (Pompe's Disease)

By H. G. HERS
Laboratory of Physiological Chemistry, University of Louvain, Belgium

(*Received* 16 *July* 1962)

The term 'glycogen-storage disease' covers a group of congenital hereditary diseases characterized by an abnormal accumulation of glycogen in tissues. Several forms can be recognized from their clinical manifestations and a greater variety is revealed by the biochemical analysis of tissues. As was shown in the review by Hers (1961), deficiencies of glucose 6-phosphatase, amylo-(1→6)-glucosidase or phosphorylase have been described and can be taken as responsible for the abnormal glycogen deposition. Up to now, no abnormality of the enzymes involved in the classical scheme of glycogen degradation has been observed in the generalized cardiomegalic form of glycogen disease. This form, also known as Pompe's disease or as type 2 in Cori's classification (Cori, 1957), is the most severe type of glycogenosis, as it causes the death of the patient during the first years of life.

In this paper, the existence of an α-glucosidase (maltase) in human tissues and its absence in Pompe's disease are reported. These observations have already been briefly mentioned (Hers, 1961).

MATERIALS AND METHODS

Chemicals

Pure maltose was prepared from commercial (Merck) maltose by preparative paper chromatography in butanol–ethanol–water (105:64:31, by vol.). Uniformly labelled [U-^{14}C]glucose and maltose were supplied by The Radiochemical Centre, Amersham, Bucks. [^{14}C]Maltose, labelled specifically on its reducing glucose moiety, was prepared by transglucosylation from unlabelled maltose on [^{14}C]glucose, as described by Edelman & Keys (1961). Glycogen was extracted from mussels by hot 30% KOH and purified according to Somogyi (1934). Isomaltose was a gift of Dr A. Dahlqvist. α-Methylglucose was supplied by British Drug Houses Ltd., cellobiose and turanose by the Pfanstiehl Laboratory Inc., Waukegan, Ill., U.S.A., glucose oxidase and peroxidase by the Sigma Chemical Co., St Louis, Mo., U.S.A.

Determination of α-glucosidase activity

Chemical method. α-Glucosidase activity was measured by the formation of glucose from maltose or glycogen. The reaction mixture contained 0·5 mg. of maltose or 1 mg. of glycogen, 5 μmoles of buffer and the tissue extract in a total volume of 0·25 ml. The buffers used were lactic acid–NaOH at pH 3·0 and 3·5, acetic acid–sodium acetate from pH 4·0 to 5·5, sodium cacodylate–HCl at pH 6·0 and 6·5, imidazole–HCl from pH 7 to 8, glycylglycine–NaOH at pH 8·5 and glycine–NaOH at pH 9 and 9·5. When not otherwise stated, the reaction was run at pH 4 and 37° for 0·5 to 4 hr. and stopped by heating for 2 min. in a boiling-water bath or by the addition of equimolecular amounts of $Ba(OH)_2$ and $ZnSO_4$ according to Weichselbaum & Somogyi (1941). The concentration of glucose in the protein-free extract was determined according to Huggett & Nixon (1957), with the exception that the glucose-oxidase reagent was dissolved in 0·025M-tris–HCl buffer instead of phosphate. This modification has been introduced (Dahlqvist, 1961; White & Subers, 1961) to inhibit the maltase present in the commercial preparations of glucose oxidase. When necessary, the method was made more sensitive by reducing the volume of the reagents and making use of a Beckman Spinco microphotometer. The α-glucosidase activity was measured by the difference between the amounts of glucose present in the medium at the beginning and at the end of the incubation period. When [^{14}C]maltose was used as substrate, the glucose formed was isolated by paper chromatography and counted as indicated below. It has been checked that the activity was proportional to both enzyme concentration and the length of incubation.

Isotopic method. Maltase activity was also measured by the incorporation of [^{14}C]maltose into glycogen: 20 μg. of uniformly labelled [U-^{14}C]maltose (0·5 μc), 40 mg. of glycogen, 5 μmoles of buffer and 1 mg. of liver were incubated for 4 hr. at 37° in a total volume of 0·4 ml. The buffers used were those listed in the preceding paragraph. At the end of the incubation period, 0·5 ml. of 2M-trichloroacetic acid, 2 ml. of water and 4 ml. of 95% ethanol were successively added. The glycogen was spun down, redissolved in 2 ml. of water and reprecipitated with ethanol. After centrifuging it was redissolved in 2 ml. of 20% KOH and heated at 100° for 30 min. It was precipitated three more times with ethanol and finally dissolved in 0·6 ml. of water. The radioactivity was determined either by plating a portion of the solution on an aluminium disk and using a Geiger–Müller counter, or by mixing the solution with a scintillating mixture and making use of a liquid-scintillation counter. The scintillating mixture contained 10% naphthalene, 1% 2,5-diphenyloxazole, 0·025% 2,2-*p*-phenylenebis-(5-phenyloxazole) and 20% (v/v) ethanol dissolved in dioxan. The fact that glycogen precipitates in this mixture does not prevent a precise determination of the radioactivity, as long as a 30 min. period has been allowed for spontaneous sedimentation before counting.

The oligosaccharides present in the liver extracts or formed during the incubation period were analysed by paper chromatography after deproteinization by trichloroacetic acid or by the barium–zinc mixture. The extract was deionized by shaking with Amberlite MB_3 ion-exchanger and then concentrated under vacuum. Ethyl acetate–pyridine–water (2:1:2; top layer; Fishman & Sie, 1958) was mostly used as solvent. The sugars were located either by colour reaction with alkaline silver nitrate or, when radioactive, by exposure of the dry paper to X-ray film. The radioactive spots were then cut out, dipped into the scintillating solution and counted in a Packard Tricarb scintillation spectrometer.

Human tissues

Biopsy material was obtained, stored and homogenized as previously described (Hers, 1959). Autopsy material was frozen as soon as possible.

Samples of various tissues were obtained from five cases of generalized glycogenosis. Cases 1 to 4 presented the muscular weakness and the cardiomegaly which are typical of Pompe's disease (for a description of the disease, see Di Sant'Agnese, Andersen & Mason, 1950). Case 5 had very serious muscular weakness but no cardiomegaly. In the five cases, phosphorylase, amylo-(1→6)-glucosidase and glucose 6-phosphatase were measured in tissue extracts without any important abnormality having been found. Glycogen structure, as determined by degradation with phosphorylase or β-amylase or by iodine coloration, was normal.

Case 1. *Male.* First symptoms at the age of 5 weeks, death at the age of 6 months. Various tissues were obtained at autopsy a few hours after death. The glycogen content was 13·5% in liver, 11% in skeletal muscle and 7·2% in heart muscle. The parents of the patient were relatives and a baby girl of the same family died at the age of 4 months from heart disease. Two other children were normal. (Dr G. Rosenboom, Leiden.)

Case 2. *Male.* Characteristic symptoms complicated by cleft palate; death at the age of 4·5 months. Heart muscle, obtained 10 hr. after death, contained 6% of glycogen. The child was born from an incestuous union between brother and sister. (Professor P. Monnet, Lyon.)

Case 3. *Female.* Characteristic symptoms were noticed at 5 months of age. Liver and muscle tissues obtained by biopsy contained respectively 12 and 10% of glycogen. The child died at the age of 10 months. Another child of the same family died at the age of 10 months with muscular

hypotonia. Two other children were normal. (Professor R. François, Lyon.)

Case 4. *Female.* Characteristic symptoms were noticed at the age of 5 months. Death was at the age of 8 months. The muscle, obtained 1 hr. later, contained 10% of glycogen. Another child of the same family was normal. (Dr M. Gautier, Paris.)

Case 5. *Female.* Muscular weakness at 3 months of age but no cardiomegaly. Liver and muscle tissues obtained by biopsy contained respectively 7 and 14% of glycogen. The child died at the age of 19 months. One other child of the same family died in similar circumstances. Four other children were normal. (Professor S. Van Creveld, Amsterdam.)

RESULTS

Hydrolysis of maltose and glycogen by human tissue. The influence of pH on the formation of glucose from maltose or glycogen by a human-liver extract is shown in Fig. 1. The curves are similar to those obtained with the lysosomal rat-liver α-glucosidase (Lejeune, Thinès-Sempoux & Hers, 1963). The activity was found to be entirely in soluble form, but, taking into consideration that the tissues were frozen before homogenization, this does not preclude a lysosomal origin for human acid maltase. This solubility and the low activity at pH 7 indicate that human liver does not contain a neutral, microsome-bound maltase similar to the one that has been found in rat liver (Lejeune *et al.* 1963). Isomaltose, α-methylglucose, cellobiose and sucrose were not hydrolysed at an appreciable rate by human-liver extracts. The enzyme was inhibited by glucose (Hers, 1961) and by turanose. This latter property is characteristic of the lysosomal α-glucosidase (Lejeune *et al.* 1963).

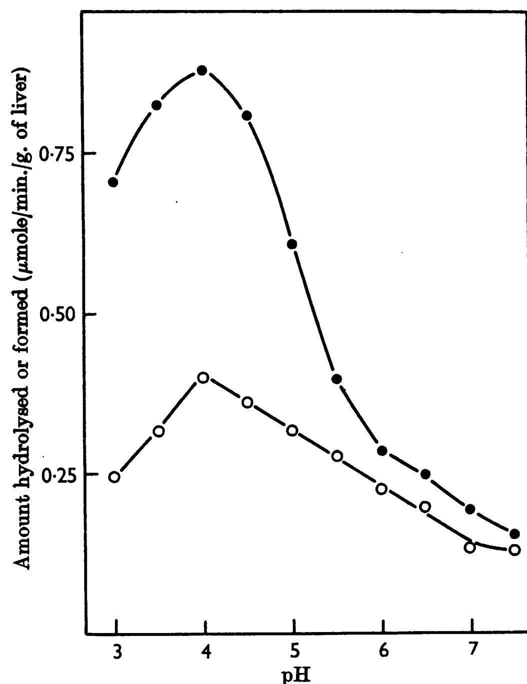

Fig. 1. Influence of pH on the hydrolysis of maltose and glycogen by human-liver extract. The liver was obtained by biopsy from a case of glycogen-storage disease characterized by a low activity of liver phosphorylase. The amount of extract corresponding to 0·5 mg. of liver was incubated for 4 hr. as described under Materials and Methods. The activity is expressed as μmole of maltose hydrolysed or μmole of glucose formed from glycogen in 1 min./g. of liver. Substrates: ●, maltose; ○, glycogen.

Fig. 2 shows the influence of pH on the hydrolysis of maltose and glycogen by human heart. The activity per g. of tissue is approximately one-third of that in the liver but the relative activity on the two substrates is similar.

Acid maltase is also present in human skeletal muscles. Its activity at pH 4 is of the order of 0·05 μmole of maltose hydrolysed/min./g. of muscle.

Transglucosylation. The formation of maltotriose and higher oligosaccharides from maltose under the action of liver maltase has been repeatedly described (Giri, Nagabhushanam, Nigam & Belavadi, 1955; Stetten, 1959). This type of transglucosyl-

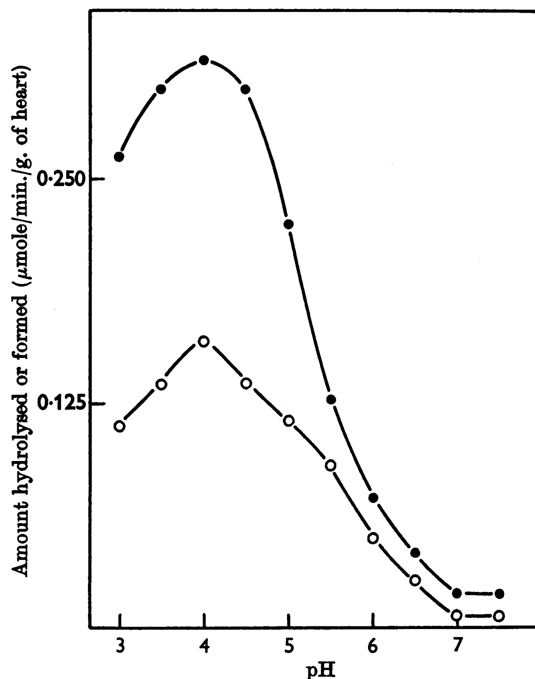

Fig. 2. Influence of pH on the hydrolysis of maltose and glycogen by extract of a normal human heart. The tissue sample was obtained at autopsy 24 hr. after death. Other conditions were as in Fig. 1. Substrates: ●, maltose; ○, glycogen.

ation has not been observed with human liver: maltotriose was not detected by paper chromatography amongst the products of the reaction on maltose or glycogen. Further, the incubation of maltose or glycogen with [^{14}C]glucose did not lead to the formation of a detectable amount of radioactive maltose; nor did the same experiment performed with [^{14}C]maltose yield radioactive maltotriose.

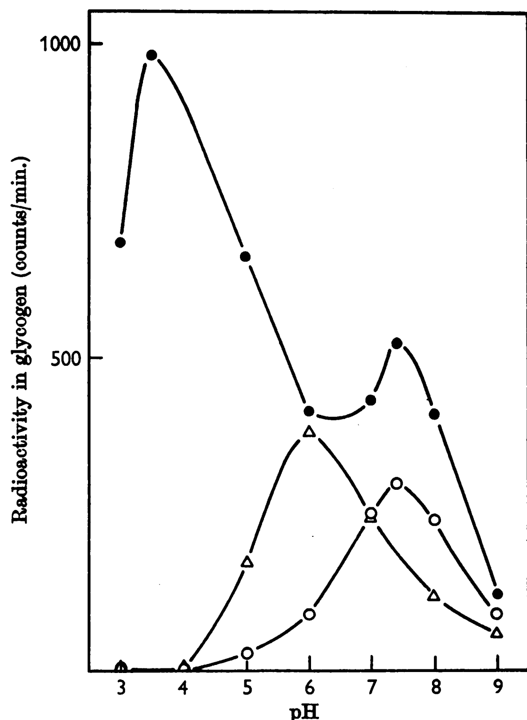

Fig. 3. Influence of pH on the incorporation of [^{14}C]-maltose and [^{14}C]glucose into glycogen by human-liver extract. Liver homogenate (1%; 0·1 ml.) was incubated for 4 hr. as described under Materials and Methods, except that in one case (Δ) [^{14}C]glucose was used as substrate instead of radioactive maltose. In all cases, the radioactivity of the substrate was 780 000 counts/min. ●, Same liver as in Fig. 1; ○ and Δ, liver of Case 1.

In contrast with these negative results, the incorporation of ^{14}C from [U-^{14}C]maltose into glycogen was easily measured (Fig. 3). That this labelling occurs by transglucosylation is shown by the fact that the ^{14}C atom of maltose specifically labelled on its reducing glucose moiety was not incorporated. The pH–activity curve of this transglucosylation is similar to that of the hydrolysis, with the exception that a second peak of activity was observed at neutral pH. The reaction was inhibited by turanose at pH 4 as well as at pH 7.

Free glucose is similarly incorporated into glycogen under the action of amylo-(1→6)-glucosidase (Hers, 1959). The pH–activity curve of this reaction is very different from that of the transglucosylation (Fig. 3) and therefore the two phenomena are probably not related to each other.

Human heart and skeletal muscles also incorporated [^{14}C]maltose into glycogen at pH 4.

Absence of acid maltase in Pompe's disease. The maltase activity of several human livers is recorded in Table 1. The livers of children with Pompe's disease hydrolysed neither maltose nor glycogen at pH 4 and showed a barely detectable activity at pH 7. Nor did they incorporate [^{14}C]-maltose into glycogen at pH 4, although they catalysed this reaction at neutral pH (Fig. 3). They did not inhibit the maltase activity of another liver extract when they were mixed together. One can therefore conclude that these livers do not contain the acid α-glucosidase. It also appears that transglucosylation at neutral pH must be attributed to another enzyme, which has little hydrolytic activity.

Homogenates of cardiac tissue from Cases 1 and 2 did not hydrolyse maltose or glycogen at pH 4 and did not incorporate [^{14}C]maltose into glycogen. The same negative results were obtained with skeletal muscles of Cases 1, 3, 4 and 5.

Table 1. *Hydrolysis of maltose and glycogen by homogenates of human liver*

Activity is expressed in μmole of maltose hydrolysed or in μmole of glucose formed from glycogen/g. of liver/min.

	Maltose as substrate		Glycogen as substrate	
	pH 4	pH 7	pH 4	pH 7
H.A. (male), 18 months: glycogenosis with absence of glucose 6-phosphatase; biopsy	0·60	0·08	0·25	0·07
N.G. (female), 3 years: generalized limit dextrinosis; biopsy	0·31	0·04	0·13	0·02
L.C. (female), 12 years: glycogenosis with low activity of liver phosphorylase; biopsy	0·75	0·25	0·30	0·09
M.H. (female), 7 months: fructose intolerance; autopsy	0·80	0·15	0·27	0·02
X.H. (male), 2 years: hepatomegaly of unknown origin; biopsy	0·64	0·10	0·24	0·07
Children with Pompe's disease:				
Case 1	0	0·09	0·004	0·016
Case 4	0	0·03	0	0·016
Case 5	0	0·09	0·018	0·028

Presence of oligosaccharides in human liver. The presence of maltose, maltotriose, maltotetraose and higher oligosaccharides in rat liver has been described by Fishman & Sie (1958). The same oligosaccharides were detected by paper chromatography in the livers of children affected by glycogenosis. The amount of this material present in the livers of children with Pompe's disease was of the same order of magnitude as in the other forms of glycogenosis.

DISCUSSION

The specificity of human acid maltase allows us to classify this enzyme, like several other animal maltases, in the group of the α-(1→4)-glucosidases for which the two appellations are currently used (for a review, see Larner, 1960). As will be shown in the following paper (Lejeune *et al.* 1963), rat-liver acid maltase is bound to lysosomes. A preliminary experiment performed with fresh human liver (N. Lejeune, unpublished work) has shown that, during fractionation by differential centrifuging, the distribution of acid maltase parallels that of acid phosphatase, which is currently used as a reference enzyme for lysosomes (de Duve, 1959*a*). It seems therefore very probable that human acid maltase is also bound to lysosomes.

The data presented in this paper show a clear correlation between the absence of acid maltase in liver and heart and skeletal muscles and the large deposition of glycogen that characterizes Pompe's disease. The absence of cardiomegaly in Case 5 of our series confirms that the form of glycogen-storage disease that clinically resembles amyotonia congenita is identical with Pompe's disease. Other authors have reached the same conclusion on the basis of a clinical and morphological study (see Friedman & Ash, 1958). Enzymic defects are usually attributed to the presence of a rare recessive gene in its homozygote combination and it seems very probable that Pompe's disease is similarly transmitted as a recessive character. It is therefore reasonable to establish a cause and effect relationship between the two phenomena; in our opinion, the most probable explanation is that the enzymic defect is responsible for the glycogen storage.

The mechanism by which the absence of an α-glucosidase can be responsible for a very severe glycogenosis is not clear. One could first assume that the enzyme plays a role in the phosphorolytic pathway of glycogen breakdown in liver and muscles. Walker & Whelan (1960) have published some evidence in favour of the participation of a 'transglucosylase' in the phosphorylase–amylo-(1→6)-glucosidase pathway of glycogen catabolism. As acid α-glucosidase catalyses transglucosylation on glycogen, it could be the enzyme postulated by Walker & Whelan (1960); its absence would then have the same consequence as the absence of phosphorylase in McArdle disease and of amylo-(1→6)-glucosidase in limit dextrinosis.

Several facts oppose this simple interpretation. Firstly, it has been shown (Verhue & Hers, 1961) that the transglucosylase hypothesis is not a necessary explanation for the observations of Walker & Whelan. On the other hand, the clinical manifestations of Pompe's disease are very different from those of McArdle disease and of limit dextrinosis; the glycogen concentration in muscles is also much higher in Pompe's disease than in the two other affections. Finally, the structure of glycogen is normal in Pompe's disease and would be abnormal in a deficiency of transglucosylase (Manners & Wright, 1961).

One might also assume that acid maltase plays a role in another mechanism of glycogen degradation. The possible physiological meaning of an amylase–oligoglucosidase pathway has been investigated by Rutter and co-workers (Rutter & Brosemer, 1961; Brosemer & Rutter, 1961; Rutter, Arnold, Brosemer & Miller, 1961), who came to a negative conclusion. The fact that there was no important modification in the concentration of liver oligosaccharides in Pompe's disease suggests that acid maltase is not involved in the metabolism of these compounds. The lysosomal localization of the glucosidase must, however, be taken into consideration. The role of lysosomes in the physiological renewal of tissues has been repeatedly postulated by de Duve (1959*a*, *b*) and additional experimental evidence for this has been given by Ashford & Porter (1962). It is postulated that the physiological breakdown of tissues occurs by digestion of small and limited areas of the cytoplasm under the action of the hydrolytic enzymes included in the lysosomes. In this process the role of the newly described glucosidase would be to destroy the glycogen. In its absence, i.e. in Pompe's disease, the polysaccharide would accumulate in vacuoles in which phosphorylase and other glycogenolytic enzymes would have been destroyed by the lysosomal hydrolases. The structure of this glycogen would be normal. Its progressive accumulation does not preclude the existence of other glycogen located in the cytoplasm and normally available for degradation by phosphorylase.

The above interpretation is in agreement with the clinical manifestations of Pompe's disease. It is indeed remarkable that, with the exception of the glycogen deposition, the patients show little disturbance of carbohydrate metabolism: their blood-sugar concentration is normal, they do not excrete ketone bodies and they have a normal hyperglycaemic response to adrenaline (Di Sant'Agnese

et al. 1950). On the other hand, the first symptoms are noticed only a few months after birth, although there is little doubt that the absence of maltase is congenital. It therefore appears that the pathological manifestations are not due to the enzymic defect itself but rather to the progressive glycogen deposition, which causes the disruption of the muscular fibres. This is in agreement with the morphological aspect of the tissues, which contain large vacuoles of glycogen and a small amount of normal cytoplasm.

If the above interpretation is confirmed, it can be expected that other deposition diseases might be explained on the basis of the absence of other lysosomal enzymes.

SUMMARY

1. Human liver and heart and skeletal muscles contain an enzyme that hydrolyses maltose and glycogen into glucose and which catalyses transglucosylation from maltose to glycogen.

2. This α-(1→4)-glucosidase is absent from the tissues of children affected by Pompe's disease (cardiomegalic form of glycogen-storage disease).

3. The mechanism by which the absence of maltase can cause glycogen storage is discussed.

This work has been supported by the Fonds de la Recherche Scientifique Médicale and by the U.S. Public Health Service (research grant A-4053).

REFERENCES

Ashford, T. P. & Porter, K. R. (1962). *J. Cell Biol.* **12**, 198.
Brosemer, R. W. & Rutter, W. J. (1961). *J. biol. Chem.* **236**, 1253.
Cori, G. T. (1957). *Mod. Probl. Pediat.* **3**, 344.
Dahlqvist, A. (1961). *Biochem. J.* **80**, 547.
de Duve, C. (1959*a*). In *Subcellular Particles*, p. 128. Ed. by Hayashi, T. New York: Ronald Press Co.
de Duve, C. (1959*b*). *Exp. Cell Res.* suppl. 7, 169.
Di Sant'Agnese, P. A., Andersen, D. H. & Mason, H. H. (1950). *Pediatrics*, **6**, 607.
Edelman, J. & Keys, A. J. (1961). *Biochem. J.* **79**, 12 P.
Fishman, W. H. & Sie, H. G. (1958). *J. Amer. chem. Soc.* **80**, 121.
Friedman, S. & Ash, R. (1958). *J. Pediat.* **52**, 635.
Giri, K. V., Nagabhushanam, A., Nigam, V. N. & Belavadi, B. (1955). *Science*, **121**, 898.
Hers, H. G. (1959). *Rev. int. Hépat.* **9**, 35.
Hers, H. G. (1961). *Chem. Weekbl.* **57**, 437.
Huggett, A. St G. & Nixon, D. A. (1957). *Biochem. J.* **66**, 12 P.
Larner, J. (1960). In *The Enzymes*, vol. 4, p. 369. Ed. by Boyer, P. D., Lardy, H. & Myrbäck, K. New York: Academic Press Inc.
Lejeune, N., Thinès-Sempoux, D. & Hers, H. G. (1963). *Biochem. J.* **86**, 16.
Manners, D. J. & Wright, A. (1961). *Biochem. J.* **79**, 18 P.
Rutter, W. J., Arnold, M., Brosemer, R. W. & Miller, J. A. (1961). *J. biol. Chem.* **236**, 1259.
Rutter, W. J. & Brosemer, R. W. (1961). *J. biol. Chem.* **236**, 1247.
Somogyi, M. (1934). *J. biol. Chem.* **104**, 245.
Stetten, M. R. (1959). *J. Amer. chem. Soc.* **81**, 1437.
Verhue, W. & Hers, H. G. (1961). *Arch. int. Physiol.* **69**, 757.
Walker, G. J. & Whelan, W. J. (1960). *Biochem. J.* **76**, 264.
Weichselbaum, T. E. & Somogyi, M. (1941). *J. biol. Chem.* **140**, 5.
White, J. W. & Subers, M. H. (1961). *Analyt. Biochem.* **2**, 380.

Biochem. J. (1963) **86**, 16

Tissue Fractionation Studies

16. INTRACELLULAR DISTRIBUTION AND PROPERTIES OF α-GLUCOSIDASES IN RAT LIVER*

BY NICOLE LEJEUNE, DENISE THINÈS-SEMPOUX AND H. G. HERS
Laboratory of Physiological Chemistry, University of Louvain, Belgium

(*Received* 16 *July* 1962)

The recent discovery that a α-(1→4)-glucosidase (or maltase) is lacking in the liver and heart and skeletal muscles of children affected by generalized glycogen-storage disease (Hers, 1961, 1963) has focused our attention on the study of this enzyme in animal tissues. The presence of maltase activity in liver tissue has been previously reported by several workers. The enzyme was detected by its ability either to liberate glucose from maltose or glycogen (Glock, 1936; Torres & Olavarria, 1961; Rosenfeld & Popova, 1962) or to catalyse transglucosylation (Whitby, 1954), or by both properties (Giri, Nagabhushanam, Nigam & Belavadi, 1955; Stetten, 1959). However, the published data

* Part 15: Sellinger, Beaufay, Jacques, Doyen & de Duve (1960).