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Translocation of Glycosylphosphatidylinositol-Anchored Proteins from Plasma Membrane Microdomains to Lipid Droplets in Rat Adipocytes Is Induced by Palmitate, H_2O_2 and the Sulfonylurea Drug, Glimepiride

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Running Title: GPI-protein translocation to lipid droplets

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Abbreviations: ADA, adenosine deaminase; AMPCP, adenosine 5'-[α,β-methylene]di-phosphate; Br-cAMPS, Sp-8-bromo-adenosine 3',5'-cyclic monophosphorothioate; (c)AMP, (3',5'-cyclic) adenosine monophosphate; ER, endoplasmic reticulum; FA, fatty acids; 5'-FSBA, 5'-*p*-fluorosulphonylbenzoyladenosine; Gce1, GPI-anchored cAMP-binding ectoprotein; GLUT4, glucose transporter isoform 4; GO, glucose oxidase; GPI, glycosylphosphatidylinositol; (G)PI-PLC, (G)PI-specific phospholipase C; GPI-protein, GPI-anchored membrane protein; hc/lcDIGs, high/low cholesterol-containing detergent-insoluble glycolipid-containing membrane rafts; HSL, hormone-sensitive lipase; IR, insulin receptor; LD, lipid droplets; m-ß-CD, methyl-ß-cyclodextrin; non-DIGs, plasma membrane areas lacking DIGs; 5'-Nuc, nucleotidase; PDE, phosphodiesterase; PI3'K, phosphatidylinositol-3 kinase; SDS-PAGE, sodium dodecylsulfate polyacrylamide gel electrophoresis

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ABSTRACT

Inhibition of lipolysis by palmitate, H_2O_2 and the antidiabetic sulfonylurea drug, glimepiride, in rat adipocytes has previously been shown to rely on the concerted degradation of cAMP by the glycosylphosphatidylinositol (GPI)-anchored phosphodiesterase Gce1 and 5'-nucleotidase CD73, which both gain access to the lipid droplets (LD). The present report demonstrates the translocation of Gce1 and CD73, harbouring the intact GPI anchor, from detergent-insoluble glycolipid-enriched plasma membrane domains (DIGs) to the LD in response to palmitate, H_2O_2 and glimepiride by analysis of their steady state distribution using photoaffinity labeling and activity determination as well as of their redistribution after pulse or equilibrium metabolic labeling. Surprisingly, palmitate, H_2O_2 and glimepiride induced the activation of the GPI-specific phospholipase C (GPI-PLC) at DIGs of rat adipocytes leading to anchor-less Gce1 and CD73. Inhibition of the GPI-PLC or the presence of non-hydrolyzable substrate analogues of Gce1 and CD73 interfered with the palmitate-, H_2O_2- and glimepiride-induced (i) lipolytic cleavage of Gce1 and CD73, (ii) translocation of their GPI-anchored versions from DIGs to LD, (iii) upregulation of cAMP degradation, and (iv) inhibition of lipolysis. These data suggest a novel insulin-independent anti-lipolytic mechanism in rat adipocytes which relies on the palmitate-, H_2O_2- and glimepiride-induced and GPI-PLC-dependent translocation of (c)AMP-degrading GPI-anchored proteins from the adipocyte plasma membrane to LD. The findings may shed new light on the biogenesis and degradation of LD in response to physiological and pharmacological stimuli.

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Introduction

Detergent-insoluble glycolipid-enriched membrane microdomains (DIGs), also called lipid rafts, are thought to act as platforms for the compartmentalization of various cellular processes, such as membrane transport, protein sorting and signal transduction. They have been detected in most eukaryotic cell types on basis of their insolubility in cold, non-ionic detergents, such as Triton X-100 and low buoyant density upon sucrose gradient centriguation (Brown and Rose, 1992; Rietveld and Simons, 1998). This characteristics of DIGs is due to the significant enrichment of cholesterol, sphingomyelin and (glyco)sphingolipids which are organized in the liquid-ordered state. In addition, proteins containing the stomatin/ prohibitin/flotillin/HflK (SPFH) domain and glycosylphosphatidylinositol-anchored proteins (GPI-proteins) are permanently or transiently concentrated at the cytoplasmic and exoplasmic leaflets, respectively, of the DIGs plasma membrane. It is assumed that the close packing of the saturated acyl chains of the (glyco)sphingolipids and glycosylphosphatidylinositol (GPI) anchors leads to the targeting of GPI-proteins to DIGs (Hanzal-Bayer and Hancock, 2007; Rajendran and Simons, 2005). Importantly, structural and compositional heterogeneity of DIGs has been inferred from several studies showing that different GPI-proteins are located in distinct populations of DIGs in primary rat and human adipocytes (Müller et al., 2002 and 2005; Öst et al., 2005; Örtegren et al., 2006). On basis of buoyant density and cholesterol content, at least two subclasses of DIGs have been discriminated, lcDIGs (of low cholesterol content and high buoyant density) and hcDIGs (of high cholesterol content and low buoyant density) with the GPI-proteins, Gce1 and CD73, being considerably enriched with hcDIGs *vs*. lcDIGs in untreated rat adipocytes (Müller et al., 2005). Strikingly, expression and targeting to DIGs of the 21-25-kDa cytoplasmic membrane coat protein, caveolin, is thought to induce small flask-shaped invaginations in the plasma membrane, so-called caveolae, which are expressed at high level in adipocytes (Anderson 1998; Parton et al., 2006). Thus, both DIGs and caveolae are dynamic structures, the protein composition and function of which may change with time and in response to certain endogenous or exogenous stimuli (Parton and Richards, 2003).

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Recently, evidence is increasing that in 3T3-L1 adipocytes and other cell lines caveolin and stomatin, formerly regarded to be confined exclusively to caveolae/DIGs, may also reside in LD under certain metabolic conditions, e.g. exposure to high levels of oleic acid (Fujimoto et al., 2001; Martin and Parton, 2005; Umlauf et al., 2004; Robenek et al. 2005). Most recently, certain GPI-protein family members, which hitherto are thought to reside exclusively at plasma membrane DIGs in mammalian cells, have been found to be associated with LD of rat adipocytes under certain metabolic conditions. The GPI-anchored 3',5'-cyclic adenosine monophosphate (cAMP)-binding ectoprotein and phosphodiesterase (PDE), Gce1, as well as 5'-adenosine monophosphate (AMP)-binding ectoprotein and 5'-nucleotidase (5'-Nuc), CD73, have been recovered with LD of rat adipocytes in response to lipolysis inhibition by palmitate, H_2O_2 and glimepiride (Müller et al., 2008b). In contrast, in the basal state.both Gce1 and CD73 behave as typical cell surface ectoproteins (Klip et al., 1988; Müller et al., 1993 and 1994a). Moreover, purified Gce1 harboring the intact GPI anchor was shown to interact with isolated adipocyte LD and to exchange between distinct LD *in vitro*, which strongly suggested that a subset of GPI-proteins can act as resident LD-associated proteins. Together these findings raised the possibility that in adipocytes DIGs and LD operate as dynamic organelles redistributing subsets of their typical constituent proteins, such as caveolin and certain GPI-proteins, rather than represent static structures.

In the present study the translocation of Gce1 and CD73 in response to physiological conditions (high levels of FA and H_2O_2) or pharmacological stimuli (glimepiride) from plasma membrane DIGs to LD was demonstrated in primary rat adipocytes using several biochemical approaches and its role in metabolic signaling was investigated. The findings may have implications for our current understanding of GPI-protein function and trafficking as well as LD biogenesis and lipolysis regulation.

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Materials and Methods

Materials. [^{3}H]cAMP was purchased from Amersham-Buchler (Braunschweig, Germany). GPI2350, GPI2349 and ß-amidotaurocholate were made available by the pharma synthesis department of Sanofi-Aventis Pharma (Frankfurt, Germany); wortmannin, triacsin C, brefeldin A and anti-glucose transport isoform-4 (GLUT4) antibodies were delivered by Calbiochem (Bad Soden, Germany), cAMP, AMP, Sp-8-bromo-adenosine 3'-5'-cyclic monophosphorothioate (Br-cAMPS); adenosine 5'-[α,β-methylene]diphosphate (AMPCP), 5'-Nuc (*Crotalus atrox*) and PDE (bovine brain) were bought from Sigma (Deisenhofen, Germany); cholesterol oxidase and "complete" protease inhibitor mix were obtained from Roche Molecular Biochemicals (Mannheim, Germany); anti-IR antibodies were delivered by Upstate Biotechnology (Dundee, UK); anti-α-flotillin-1 (reggie-2) monoclonal antibodies were purchased from BD Biosciences; recombinant GPI-PLC (*Trypanosoma brucei*) and anti-cross-reactive determinant (CRD) antibodies were obtained from Oxford Glycosystems (Oxford, UK); anti-caveolin-1 (rabbit) and anti-pp59^{Lyn} (clone 32) antibodies were purchased from Transduction Laboratories (Lexington, USA). The sources for all other materials were described previously (Müller et al., 1993; 1994b; 2001; 2002; 2005; 2008a, 2008b).

Metabolic labeling of rat adipocytes with [^{14}C]inositol. The incubation was performed as described previously (Müller et al., 2007b) but for 5 min for short-term pulse labeling or 60 min for long-term equilibrium labeling) in the presence of the various agents and/or inhibitors as indicated. For initiation of the chase, the cells were washed twice by flotation with 10 ml each of labeling medium containing 0.5 mM glucose and 10 mM *myo*-inositol and then suspended in 20 ml of the same medium (zero time point). After incubation (37°C, gentle shaking) for increasing periods of time in the presence of various agents and/or inhibitors as indicated, the adipocytes were separated from the medium by

flotation and washed with labeling medium (15°C).

Preparation of microsomes, plasma membranes, hc/lcDIGs and non-DIGs. For the preparation of plasma membranes, washed rat adipocytes ($3.5x10^8$ cells) were homogenized in 10 ml of lysis buffer (25 mM Tris/HCl, pH 7.4, 0.5 mM EDTA, 0.25 mM EGTA, 0.25 M sucrose, 50 mM NaF, 5 mM sodium pyrophosphate, 25 mM glycerol-3-phosphate, 10 µM okadaic acid and 1 mM sodium orthovanadate containing "complete" protease inhibitor mix) using a motor-driven Teflon-in-glass homogenizer (10 strokes with a loosely fitting pestle) at 22°C (Müller et al., 1994c). The defatted infranatant obtained after centrifugation (1,500x*g*, 5 min) was centrifuged (12,000x*g*, 15 min). Microsomes were collected from the supernatant by centrifugation (100,000x*g*, 1 h) and then suspended in TEPP-buffer (10 mM Tris/HCl, pH 7.4, 2 mM EDTA containing phosphatase [50 mM NaF, 5 mM sodium pyrophosphate, 10 µM okadaic acid, 1 mM sodium orthovanadate] and protease inhibitor mixes; see above) at 2-3 mg protein/ml. The pellet of the 12,000-*g* spin was suspended in 10 ml of lysis buffer, layered on top of a 5-ml cushion of 38 % (w/v) sucrose, 25 mM Tris/HCl (pH 7.4), 1 mM EDTA and then centrifuged (110,000x*g*, 1 h). Total plasma membranes were removed at the interface between the two layers by suction (0.5 ml), after 5-fold dilution collected by centrifugation (45,000x*g,* 30 min) and finally resuspended in TEPP-buffer at 0.5-1 mg protein/ml.

For preparation of DIGs, the pelleted plasma membranes (200-400 µg protein) were suspended in 800 µl of 25 mM MES/KOH (pH 6.0), 1 % TX-100, 150 mM NaCl, 35 % sucrose, 5 mM EDTA, 20 mM NaF and protease inhibitor mix by 10 strokes with a pistill fitting to 1.5-ml microcentrifuge tubes and then incubated (1 h, on ice). Two 200-µl cushions of the same medium containing 22 % and 5 % sucrose, respectively, were laid over in sequential fashion. After centrifugation (26,000x*g*, 30 min, 4°C, table-top rotor, Beckman), the light-scattering opalescent bands of flocculent material at the 5- to 22-% and 22- to 35-% sucrose interfaces were collected as hcDIGs and lcDIGs, respectively,

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using a 19-gauge needle and a syringe (~ 200 µl per fraction), then diluted with 800 µl of 25 mM MES/KOH (pH 6.0), 150 mM NaCl, 5 mM EDTA, 20 mM NaF and protease inhibitor mix and finally centrifuged (48,000x*g*, 15 min, 4°C). Density of the fractions was determined by measuring the refractive index. For preparation of plasma membrane areas lacking DIGs (non-DIGs), the TX-110-soluble proteins from the layer below the 35-% sucrose interface (~ 600 µl) were removed and then precipitated under native conditions. The collected DIGs and non-DIGs were suspended in TEPP-buffer at 0.1-0.5 mg protein/ml. hcDIGs, lcDIGs and non-DIGs were characterized by determination of relevant markers as described previously (Müller et al., 2002 and 2005) with typical enrichment (hc/lcDIGs) and deprivement (non-DIGs) of caveolin-1 (8.5- to 11.6-fold / 3.7- to 7.5-fold, and 0.3- to 0.6-fold), caveolin-2 (5.2- to 6.5-fold / 3.1-to 4.7-fold, and 0.1- to 0.2-fold) and cholesterol (3.0- to 3.5-fold corresponding to 0.81$\pm$0.12 nmol/µg protein / 1.9- to 2.5-fold corresponding to 0.55$\pm$0.10 nmol/µg protein and 0.5- to 0.8-fold corresponding to 0.13$\pm$0.05 nmol/µg protein) compared to total plasma membranes.

Protein extraction from DIGs. DIGs in 50 mM HEPES/KOH (pH 7.4), 150 mM NaCl, 1 % TX-100, 5 mM $MgCl_2$, 0.1 mM EDTA and protease inhibitor mix (0.1-0.3 mg protein/ml) were incubated (1 h, 4°C, several cycles of vortexing) with 60 mM octyl glucoside and 0.4 % ß-amidotaurocholate (Müller et al., 1994b). After centrifugation (100,000x*g*, 30 min, 4°C), the supernatant proteins were used for precipitation under native conditions.

TAG synthesis by DIGs. DIGs (100-150 µg protein) were incubated with 200 µM [^{3}H]glycerol-3-phosphate (5 µCi) in 500 µl of LD buffer (500 µM oleoyl-CoA, 100 µM oleic acid, 200 µM CoA, 2 mM ADP, 10 mM creatine phosphate, 0.2 U/ml creatine kinase, 50 mM Tris/HCl ,pH 7.4, 10 mM $MgCl_2$, 0.5 mM DTT, 140 mM KCl, 250 mM sucrose, 0.5 % BSA). After brief sonication (bath sonifier) and incubation (30 min, 37°C), the reactions were terminated by the addition of 5 ml of toluene-based scintillation cocktail (Quickscint

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501, Zinsser). After incubation (12 h, 25°C), the radioactivity recovered in the organic phase was determined by liquid scintillation counting. Blank values of incubations lacking protein were subtracted in each case to correct for unspecific partitioning of [^{3}H]glycerol-3-phosphate.

LD formation by DIGs. DIGs (200-250 µg protein) were incubated (1 h, 37°C) with cytosol prepared from basal rat adipocytes (100-150 µg of protein) in 0.75 ml of LD buffer containing protease inhibitor mix as described for the measurement of TAG synthesis. Thereafter, the samples were adjusted to 40 % sucrose, and 1.5-ml samples were sequentially overlaid with 3 ml of 50 mM Tris/HCl (pH 7.5), 25 % sucrose, 10 mM EDTA and finally with 1 ml of 50 mM Tris/HCl (pH 7.5), 10 mM EDTA. After centrifugation (160,000x*g*, 18 h, 4°C, SW55Ti rotor, Beckman), the gradient was divided into five fractions with mean densities [g/ml] of 1.051 (1.5 ml), 1.092 (1 ml), 1.118 (1 ml), 1.149 (1 ml) and 1,192 (1 ml).

Determination of enzyme activities. PDE activity was assayed as described previously (Hansen et al., 1982) with modifications. Briefly, precipitated protein samples (10-20 µg protein) were dissolved in 300 µl of 50 mM HEPES/KOH (pH 7.4), 0.1 mM EGTA, 8 mM $MgCl_2$, 0.1 mg/ml BSA and then incubated (10 min, 30°C) with [^{3}H]cAMP (10 nCi, 0.1 µM) in the absence or presence of isobutylmethylxanthine (100 µM) or isoform-specific inhibitors as indicated. Under these conditions no more than 20 % of the substrate was hydrolyzed. 5'-Nuc (*Crotalus atrox* venom, 0.5 mU) was added and the incubation continued (30 min, 30°C) for complete dephosphorylation of 5'-AMP to adenosine. Adenosine was separated from residual cAMP by passage over DEAE-Sephadex A-25 columns and then determined by liquid scintillation counting. The activity of the different PDE isoforms was calculated as the difference between the absence and presence of a specific inhibitor (0.5 µM cilostamide for PDE3, 5 µM rolipram for PDE4). PDE activities were proportional to time and the protein amount used. 5'-Nuc was assayed as described

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(Avruch and Wallach, 1971) with modifications (Müller et al., 1993). Briefly, precipitated protein samples (20-50 µg protein) were dissolved in 100 µl of 100 mM Tris/HCl (pH 7.4), 20 mM $MgCl_2$ and then incubated (30 min, 37°C) with [^{3}H]AMP (150 nCi, 100 µM). After termination of the reaction by the addition of $ZnSO_4$ (250 mM final conc.), unhydrolyzed AMP was removed by precipitation with 250 µl of 0.3 M $Ba(OH)_2$ and subsequent centrifugation (10,000x*g*, 2 min). The supernatant was determined for radiolabeled adenosine by liquid scintillation counting (5 ml of Zinsser cocktail 361).

Miscellaneous. Published procedures were used for the preparation (Müller et al., 2003) and incubation of rat adipocytes with insulin, glimepiride, glucose oxidase (GO) and palmitate bound to BSA (Müller et al., 2008a), preparation of LD and cytosol (Müller et al., 2008a and 2008b), preparation of methyl-ß-cyclodextrin (m-ß-CD)-cholesterol inclusion complexes and cholesterol depletion of adipocytes (Müller et al., 2002), photoaffinity labeling with 8-N_3-[^{32}P]cAMP (Müller et al., 1994a) or [^{14}C]5'-*p*-fluorosulphonylbenzoyladenosine (5'-FSBA; ref. Stochaj and Mannherz, 1990), protein extraction from LD and protein precipitation, affinity purification of Gce1 and CD73 by adsorption to cAMP/AMP-Sepharose, determination of cAMP-to-adenosine conversion and determination of cholesterol using cholesterol oxidase (Müller et al., 2008a and 2008b), incubation with phosphatidylinositol-specific phospholipase C (PLC; ref. Müller et al., 1994a), TX-114 partitioning (Bordier, 1981), determination of lipolysis by measurement of glycerol and FA release (Müller et al., 2003), determination of hormone-sensitive lipase (HSL) translocation (Müller et al., 2008a), sodium dodecylsulfate polyacrylamide gel electrophoresis (SDS-PAGE; 4-12 % Bis-Tris precast gel, pH 6.4, MES/SDS running buffer) under reducing conditions, immunoblotting using chemiluminescent detection (Müller et al., 2001), determination of protein using the BCA method (Pierce) with BSA as calibration standard, calculation of EC_{50}-values and construction of figures from phosphor/lumiimages (Müller et al., 2005). Differences between the experimental groups

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were determined using analysis of variance (ANOVA) with statistical significance set at *P* values of < 0.05.

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Results

Effect of insulin, palmitate, glimepiride and H_2O_2 on the intracellular distribution of Gce1 and CD73 in rat adipocytes. Previously, the GPI-proteins, Gce1 and CD73, had been localized at DIGs of the plasma membrane of adipocytes (Klip et al., 1988; Müller et al., 1993; 1994a; 1994c). However, subsequently they have been identified also at LD acting as a cAMP-degrading PDE (Gce1) and AMP-degrading 5'-Nuc (CD73) on basis of a variety of biochemical evidences, such as photoaffinity and metabolic labeling, affinity purification and depletion, immunoreactivity and enzymatic activity, as well as inhibition of their activities upon interference with their LD expression (Müller et al., 2008b). Therefore, the possibility was studied that DIGs operate as storage compartment for Gce1 and CD73 for their delivery to LD during inhibition of lipolysis by treatment of isolated rat adipocytes with palmitate, glimepiride and GO (for the generation of H_2O_2) as has been reported previously (Müller et al., 2008a). The isoproterenol-, adenosine deaminase- and forskolin-induced release of glycerol and FA into the incubation medium of adipocytes is known to be reduced with varying maximal potencies and IC_{50}-values by insulin (80-90 %, 0.05-0.08 nM), palmitate (45-55 %, 0.4-0.5 mM), glimepiride (55-65 %, 0.8-1.4 µM) and GO (70-80 %, 2-4 mU/ml)(Müller et al., 2008a).

To obtain a first hint for involvement of DIGs, they were disrupted by cholesterol depletion using m-ß-CD under conditions, which do not affect cell viability (Müller et al., 2002), prior to treatment of the adipocytes with palmitate, glimepiride and GO. Subsequently, LD were prepared and assayed for the expression of Gce1 and CD73 by determination of the conversion of cAMP to adenosine through their concerted PDE (Gce1) and 5'-Nuc (CD73) activities (Table 1). The glimepiride-, palmitate- and GO-induced cAMP-to-adenosine conversion was diminished by 60-85 % with LD from cholesterol-depleted adipocytes compared to untreated cells. The isoproterenol-induced

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lipolysis measured in parallel was found to be reduced in untreated adipocytes by 50-70 % in response to glimepiride, palmitate and GO compared to control cells, but to resist significant suppression in cholesterol-depleted cells. Treatment of the adipocytes with stoichiometric amounts of m-ß-CD and m-ß-CD-cholesterol inclusion complexes, which does not lead to net transfer of cholesterol to or from DIGs (Müller et al., 2002), failed to significantly compromise the upregulated cAMP-to-adenosine conversion as well as the inhibited lipolysis (Table 1). These findings strongly suggest that the observed effects are caused by the specific disruption of DIGs in course of cholesterol depletion rather than by the presence of m-ß-CD *per se*. Taken together, the abrogation of the palmitate-, glimepiride- and H_2O_2-induced upregulation of the PDE and 5'-Nuc activities at LD as well as lipolysis inhibition in adipocytes lacking DIGs provided first evidence for a role of these structures as source or storage site for the GPI-proteins, Gce1 and CD73, prior to their translocation to the LD.

For direct demonstration of the regulated translocation of Gce1 and CD73 from hcDIGs to LD, these structures were prepared from palmitate-, glimepiride- and GO-treated rat adipocytes and then subjected to photoaffinity labeling of Gce1 with 8-N_3-[^{32}P]cAMP and CD73 with [^{14}C]5'-FSBA. Control experiments on basis of quantitative [^{3}H]cAMP- and [^{3}H]AMP-binding filtration assays and an assumed binding stoichiometry of one nucleotide per protein molecule had revealed that photoaffinity labeling of both proteins is not quantitative with different efficacies for isolated DIGs (Gce1: 0.7-1.5 %; CD73: 2.5-3.5 %) and LD (Gce1: 5-8 %; CD73: 9-13 %). But importantly the efficacies had turned out to be of low variance between different labelings of the same DIGs or LD preparations (less than 10 %) or labelings of different preparations from the same cells (less than 20 %) and to be linear within the range of total amounts of DIGs and LD protein routinely used. Thus, photoaffinity labeling of isolated DIGs and LD can be used to reliably follow the relative distribution and translocation of Gce1 and CD73 between these compartments.

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The phosphorimages of the SDS-PAGE for the above experiment revealed significant concentration-dependent decreases in the amount of photoaffinity-labeled Gce1 and CD73 recovered with hcDIGs (Fig. 1a) in response to palmitate (by 72 and 59 %, respectively, at 2 mM), glimepiride (by 77 and 56 %, respectively, at 20 µM) and GO (by 82 and 69 %, respectively, at 100 mU/ml). These decreases were paralleled by the palmitate-/glimepiride-/GO-induced increases in the amounts of LD-associated Gce1 (by 224/281/384 %) and CD73 (98/169/329 %)(Fig. 1b). The specificity of the photoaffinity labeling reactions was demonstrated by the almost complete quenching of labeling of Gce1 and CD73 by excess of cAMP and AMP, respectively. For a given stimulus the incremental increases at LD and decreases at hcDIGs of the Gce1 and CD73 protein amounts and of the PDE and 5'-Nuc activities as well as the corresponding EC_{50}-values were very well correlated (Fig. 1c). These data indicated that palmitate, glimepiride and GO action modify the steady-state distribution of Gce1 and CD73 between hcDIGs and LD of rat adipocytes leading to their enrichment at LD and deprivement at hcDIGs.

In order to follow the translocation process of Gce1 and CD73 from hcDIGs to LD, pulse-chase experiments were performed with stimulated adipocytes after metabolic labeling of their GPI anchors with [^{14}C]inositol. The retention of the inositol residue within the phosphoinositolglycan moiety of the GPI anchor of both intact and lipolytically cleaved GPI-proteins in combination with the low metabolism of inositol into other carbohydrates in rat adipocytes during the pulse-chase periods used has been demonstrated in previous studies (Müller et al., 1993) and enables monitoring of the intracellular trafficking of GPI-proteins in general. After incubation of rat adipocytes with *myo*-[^{14}C]inositol for 5 min (pulse labeling; Fig. 2a and c) or 60 min (equilibrium labeling; Fig. 2b and c) followed by the addition of excess of unlabeled *myo*-inositol in the presence of palmitate, GO or glimepiride for increasing periods of time, Gce1 and CD73 were affinity-purified from the isolated hcDIGs and LD by adsorption to cAMP- and AMP-Sepharose, respectively, and

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then analyzed by SDS-PAGE. Phosphorimaging (Fig. 2a) and quantitative evaluation (Fig. 2c) revealed that in pulse-labeled basal adipocytes the amounts of [^{14}C]inositol-labeled Gce1 and CD73 at hcDIGs increased during the initial 10 to 60 min of chase and subsequently declined til the end of the chase. In the presence of palmitate, GO and glimepiride during the chase period the peak and final levels of Gce1 and CD73 at hcDIGs were significantly lower than in the basal state. In contrast, the continuous increases in [^{14}C]inositol-labeled Gce1 and CD73 at LD observed to up to 120 min of chase were significantly higher with stimulated than basal adipocytes (Fig. 2a and c). In adipocytes labeled at equilibrium, the amounts of [^{14}C]inositol-labeled Gce1 and CD73 at hcDIGs decreased continuously during the chase period and more rapidly in the presence of palmitate, GO and glimepiride (15-60 min half life times) compared to basal cells (90-120 min). In contrast, the amounts of [^{14}C]inositol-labeled Gce1 and CD73 at LD increased in the presence of palmitate, GO and glimepiride during the chase to up to 90-120 min and thereafter declined til the end of the chase (Fig. 2b and c). In basal adipocytes [^{14}C]inositol-labeled Gce1 and CD73 at LD remained constant til 120 min and then slightly declined. Taken together, the (lower) increases during pulse labeling and the (more rapid) losses during equilibrium labeling of Gce1 and CD73 at hcDIGs in (stimulated *vs*. basal) adipocytes were accompanied by (more pronounced) increases of Gce1 and CD73 at LD in (stimulated *vs*. basal) adipocytes during both pulse and equilibrium labelings. These relationships are compatible with the translocation of Gce1 and CD73 from hcDIGs to LD in rat adipocytes which is significantly upregulated in response to palmitate, glimepiride and GO action. The rankings of the potencies for translocation, cAMP-to-adenosine conversion by LD and inhibition of lipolysis are identical (GO > glimepiride > palmitate).

Recent investigations showed that Gce1 and CD73 are apparently redistributed from hcDIGs to lcDIGs upon challenge of adipocytes with glimepiride (Müller et al., 2001). To test whether Gce1 and CD73 move *via* lcDIGs during their translocation from hcDIGs to

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LD, hcDIGs, lcDIGs and LD were prepared from palmitate-, glimepiride and GO-treated rat adipocytes and subsequently analyzed for the presence of Gce1 and CD73 by photoaffinity labeling, the typical DIGs-associated proteins, caveolin-1 and flotillin-1 (reggie-2), and the typical LD-associated proteins, HSL and perilipin-A, by immunoblotting, cholesterol by enzymatic measurement and TAG-synthesizing enzymes by determination of TAG synthesis as glycerol-3-phosphate incorporation into TAG (Fig. 3). As expected, in the basal state Gce1 and CD73 (Fig. 3a) as well as cholesterol (Fig. 3d) were significantly enriched at hcDIGs *vs*. lcDIGs, whereas the opposite was true for perilipin-A (Fig. 3b), flotillin-1 (Fig. 3c) and TAG-synthesizing enzymes (Fig. 3d). Caveolin-1 was distributed about equally between hcDIGs and lcDIGs (Fig. 3c). LD harboured the highest amounts of HSL, perilipin-A, flotillin-1 and cholesterol, but only low levels of Gce1, CD73, caveolin-1 and TAG-synthesizing enzymes (Fig. 3c and d). Microsomes contained minute amounts of perilipin-A and HSL (data not shown), caveolin-1 and flotillin-1 (Fig. 3c), which is in agreement with its identification in endosomes and the trans-Golgi network in adipocytes (Langhorst et al., 2005). A trend for elevated amounts of perilipin-A, caveolin-1 and flotillin-1 at lcDIGs upon challenge with palmitate, glimepiride and GO was observed which, however, did not result in detectable changes in the abundance of perilipin-A and caveolin-1 at hcDIGs and LD and of the relative distribution of flotillin-1 as well as cholesterol and TAG-synthesizing enzymes between hcDIGs, lcDIGs and LD (Fig. 3b, c, d). This demonstrated maintenance of the subcompartmentalization of the adipocyte plasma membrane as well as of the structure of LD in adipocytes in course of suppressed lipolysis. Importantly, all three stimuli (GO > glimepiride > palmitate) induced slight but significant increases in the amounts of Gce1 and CD73 at lcDIGs which were paralleled by pronounced increases at LD and decreases at hcDIGs (Fig. 3a). These relationships are compatible with the translocation of the GPI-proteins from hcDIGs to LD *via* lcDIGs. Thus, in contrast ot the storage compartment hcDIGs, lcDIGs may act as an intermediary or

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transient compartment for GPI-proteins which would corroborate the previously recognized heterogeneity of DIGs at rat adipocyte plasma membranes on basis of differences in their protein composition (see Introduction). However, direct and simultaneous translocation of GPI-proteins from hcDIGs to LD and lcDIGs can not be excluded at present.

The specificity of the translocation of Gce1 and CD73 from hcDIGs to LD in rat adipocytes was addressed by immunoblotting for the typical marker proteins, caveolin-1 as structural protein anchored at the inner leaflet of plasma membrane caveolae, $p59^{Lyn}$ as the dually acylated non-receptor tyrosine kinase anchored at the inner leaflet of plasma membrane hcDIGs (Müller et al., 2001), GLUT4 and IR as transmembrane proteins of plasma membrane non-DIGs and HSL and perilipin-A as LD-associated proteins. The chemiluminescent images (Fig. 4) revealed that the stimulation of lipolysis by isoproterenol and adenosine deaminase (ADA), which leads to the translocation of HSL to and perilipin-A from LD (see also refs. Müller et al., 2003; Londos et al., 2005) as well as the inhibition of the isoproterenol/ADA-induced lipolysis by palmitate, glimepiride or GO, which blocks HSL and perilipin-A translocation, did not significantly affect the relative distribution of perilipin-A, HSL, caveolin-1 and IR between the hcDIGs and LD. In agreement with previous studies (Müller et al., 2005), glimepiride and to a lesser degree palmitate decreased and increased the amounts of $p59^{Lyn}$ and GLUT4, respectively, at hcDIGs (but not LD) compared to control and GO treatment, which is thought to mediate the IR-independent insulin-mimetic signaling of glimepiride *via* activated $p59^{Lyn}$ to glucose transport in rat adipocytes. Taken together, these findings argue for the specificity of the palmitate-, glimepiride- and GO-induced translocation of Gce1 and CD73 from hcDIGs to LD.

To gain first insights into the molecular mechanism underlying the stimulus-dependent translocation of GPI-proteins to LD, rat adipocytes with defective DIGs/caveolae, TAG synthesis or vesicular trafficking were prepared by treatment with m-ß-CD for depletion of

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plasma membrane cholesterol, triacsin C for inhibition of fatty acyl-CoA synthase or brefeldin A for blockade of the ER-to-Golgi transport and then challenged with palmitate, glimepiride or GO. Phosphorimaging of the photoaffinity-labeled Gce1 recovered with the LD revealed that m-ß-CD, but not brefeldin A, significantly diminished the challenge-dependent amounts of LD-associated Gce1 (Fig. 5). Remarkably, triacsin C significantly reduced upregulation of Gce1 at LD in palmitate-/GO- but not glimepiride-treated adipocytes. This suggests that translocation of GPI-proteins from hcDIGs to LD does not depend on vesicular trafficking but requires intact DIGs/caveolae irrespective of the anti-lipolytic agent employed. The differential and critical role of fatty acyl-CoA synthase may rely on the production of TAG for LD biogenesis which could depend on the acylation of either activated free FA in palmitate-/GO-treated adipocytes or *de novo* synthesized FA in glimepiride-treated adipocytes. Previous studies demonstrated stimulation of *de novo* FA synthesis by glimepiride in adipocytes (Müller et al., 2005).

For a more detailed understanding of the translocation reaction, a cell-free system was introduced for the formation of LD by hcDIGs *in vitro* and the concomitant translocation of GPI-proteins from hcDIGs to LD. For this, hcDIGs derived from [^{14}C]inositol-labeled control or palmitate-, glimepiride- and GO-treated adipocytes were incubated with cytosol, FA, an ATP-regenerating system and [^{3}H]glycerol-3-phosphate and then separated from the putatively formed LD by sucrose gradient centrifugation. Fractions of different buoyant density were analyzed for the presence of radiolabeled Gce1 and CD73 by affinity purification and subsequent phosphorimaging and of LD marker proteins by immunoblotting and for TAG synthesis (by assaying glycerol-3-phosphate incorporation into toluene-extractable lipids (Fig. 6). A considerable portion of the newly synthesized radiolabeled TAG was recovered with the top fraction ($d \leq 1.059$ g/ml) which apparently contained LD according to their content of caveolin-1 and perilipin-A/B. The amount of TAG was significantly higher in palmitate-, glimepiride- and GO-treated adipocytes than in

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basal cells and reached the level observed with the bottom fraction (d = 1.175 g/ml) which apparently corresponded to hcDIGs. TAG synthesis by hcDIGs as well as the distribution of caveolin-1 and perilipin-A/B between the top (LD) and bottom (hcDIGs) fractions was, however, not significantly affected by suppressed lipolysis (Fig. 6 and data not shown). In contrast, [^{14}C]inositol-labeled Gce1 and CD73 were predominantly recovered with the LD or hcDIGs using hcDIGs from palmitate-, glimepiride- and GO-treated or basal adipocytes, respectively (Fig. 6). Together, the distributions of marker proteins and TAG synthesis capability argue that hcDIGs (bottom fraction) and LD (top fraction) are efficiently separated from one another by three gradient fractions of intermediate density (d = 1.105, 1.119 and 1.148). Incubation of the cell-free system in the absence of cytosol, glycerol-3-phosphate or oleoyl-CoA completely abrogated the agent-dependent increases in TAG synthesis and Gce1 amount at LD (data not shown). These findings suggest that in rat adipocytes LD equipped with typical LD-associated proteins, such as caveolin and perilipin, the GPI-proteins, Gce1 and CD73, and TAG-synthesizing enzymes are formed by hcDIGs. This mechanism depends on cytosolic factor(s) and ongoing TAG synthesis, is activated by palmitate, glimepiride and GO action and can be reconstituted in a cell-free system.

Role of the GPI anchor cleavage in the translocation of Gce1 and CD73 to LD. In basal adipocytes Gce1 and CD73 are anchored at hcDIGs *via* covalently linked GPI anchors. These are accessible to cleavage by a plasma membrane GPI-PLC known to be activated by glimepiride (Müller et al., 1993; 1994c; Movahedi and Hooper, 1997). This raised the question whether the amphiphilic or hydrophilic versions harbouring the intact or cleaved GPI anchor (with the phosphoinositolglycan moiety left), respectively, are translocated from hcDIGs to LD. For this, LD proteins extracted from [^{14}C]inositol-labeled and palmitate-, GO- or glimepiride-treated adipocytes were incubated in the absence or presence of bacterial PI-PLC. Following their partitioning between aqueous and TX-114 phases, Gce1 was detected by affinity purification, SDS-PAGE and phosphorimaging. In

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palmitate-, GO- or glimepiride-treated adipocytes the amounts of amphiphilic Gce1 recovered with the TX-114 phase were 2- to 7-fold higher than in basal cells (Fig. 7). Only low levels of hydrophilic Gce1 were detectable in the aqueous phase in both treated and basal adipocytes. This was confirmed by immunoprecipitation of hydrophilic Gce1 with anti-CRD antibodies, which react with lipolytically cleaved GPI-proteins, only (Müller et al., 1994c; Zamze et al., 1988). The specificity of the anti-CRD antibodies for the terminal cyclic-1,2-phosphoinositol epitope as generated by bacterial PI-PLC action was demonstrated by inclusion of excess of cyclic-1,2-phosphoinositol which drastically reduced the amount of immunoprecipitated Gce1 (data not shown). Moreover, amphiphilic rather than hydrophilic CD73 was recovered with LD from glimepiride-treated adipocytes (data not shown).

LD expression of Gce1 carrying an intact GPI anchor was confirmed by treatment of the LD proteins with bacterial PI-PLC, which led to conversion of the [^{14}C]inositol-labeled amphiphilic Gce1 into its hydrophilic counterpart as revealed by TX-114 partitioning and subsequent immunoprecipitation with anti-CRD antibodies (Fig. 7). The generation of hydrophilic Gce1 was abrogated in the presence of the (G)PI-PLC-specific inhibitor, GPI-2350. Taken together, Gce1 and CD73 harbouring the intact GPI anchor rather than their anchor-less versions are associated with and translocated to LD in response to palmitate, glimepiride and GO action in rat adipocytes. This is in agreement with the requirement of the intact GPI anchor for the successful reconstitution of Gce1 into LD *in vitro* (Müller et al., 2008b).

Role of the activation of the GPI-PLC for the translocation of Gce1 and CD73 to LD. The GPI anchor of Gce1 and CD73 has recently been demonstrated to be cleaved by the activated GPI-PLC in primary and cultured adipocytes in response to glimepiride (Müller et al., 1993; 1994c). Here this finding was extended to palmitate and GO action. For this,Gce1 and CD73 were subjected to TX-114 partitioning after their affinity

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purification from total plasma membranes of [^{14}C]inositol-labeled and then palmitate-, GO- or glimepiride-treated adipocytes (Fig. 8). As revealed by the phosphorimages, the levels of [^{14}C]inositol-labeled hydrophilic Gce1 and CD73 increased significantly with increasing concentrations of palmitate, glimepiride and GO. The generation of hydrophilic Gce1 and CD73 was completely blocked by the GPI-PLC inhibitor GPI-2350. These findings and the apparent retention of the (radiolabeled) inositol residue by hydrophilic Gce1 and CD73 (most likely within the phosphoinositolglycan moiety at the carboxy-terminus of the polypeptide portion)(Fig. 8) strongly argue for lipolytic cleavage of their GPI anchors, most likely by the GPI-PLC. The EC_{50}-values of palmitate, glimepiride and GO as well as their relative potencies (GO > glimepiride > palmitate) for stimulation of the GPI-PLC (Fig. 8) are well correlated to those for the translocation of Gce1 and CD73 proteins as well as PDE and 5'-Nuc activities from hcDIGs to LD (Fig. 1). This raised the question about the putative role of the GPI-PLC in GPI-protein translocation.

For studying this, hcDIGs and LD were prepared from rat adipocytes which had been treated with palmitate, glimepiride and GO in the absence or presence of GPI-2350 and then analyzed for the presence of amphiphilic or hydrophilic Gce1 by photoaffinity labeling and subsequent TX-114 partitioning. As expected, the phosphorimages demonstrated palmitate-, glimepiride- and GO-induced increases and decreases in amphiphilic Gce1 at LD and hcDIGs, respectively, as well as significant increases in hydrophilic Gce1 at hcDIGs. The apparent retention of the anchor-less version of Gce1 at hcDIGs rather than its translocation to LD is in agreement with above findings. Importantly, addition of GPI-2350 abrogated the agent-dependent translocation of amphiphilic Gce1 to LD and completely eliminated hydrophilic Gce1 from hcDIGs. In contrast, an inactive version of GPI-2350, GPI-2349 (Müller et al., 2005), was completely ineffective (data not shown) arguing for efficient blockade of the GPI-PLC by GPI-2350. This demonstrates involvement of the GPI-PLC in the palmitate-, glimepiride- and GO-induced lipolytic cleavage of GPI-

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proteins and the translocation of their anchor-harboring versions from hcDIGs to LD. The low amount of Gce1 cleaved by the GPI-PLC in untreated adipocytes was apparently not sufficient for triggering detectable translocation of its anchor-containing counterpart (Fig. 9).

Since Gce1 and CD73 bind and degrade cAMP and AMP, respectively, occupancy of their substrate binding sites could modulate their translocation from hcDIGs to LD. This was tested by incubation of isolated rat adipocytes with excess of cAMP or AMP or their non-hydrolyzable analogues, SP-8-Br-cAMPS or AMPCP, prior to challenge with palmitate, glimepiride or GO. LD and hcDIGs were prepared and then assayed for the presence of Gce1 and CD73 by photoaffinity labeling and TX-114 partitioning of the extracted proteins. The phosphorimages (Fig. 10a) demonstrated that excess of SP-8-Br-cAMPS or AMPCP or, most effectively, a combination thereof significantly reduced, whereas excess of cAMP or AMP increased the amounts of amphiphilic and hydrophilic Gce1 and CD73 at LD and hcDIGs, respectively, in palmitate-, glimepiride- and GO-treated adipocytes. ATP or adenosine did not affect the agent-dependent lipolytic cleavage and translocation of Gce1 and CD73 (data not shown). High concentrations of SP-8-Br-cAMPS, AMPCP, cAMP and AMP did not affect the GPI-PLC activity of isolated rat adipocyte hcDIGs when measured *in vitro* with bovine brain acetylcholinesterase as the GPI-protein substrate arguing against direct inhibition of the GPI-PLC by (c)AMP analogues (data not shown). Measurement of the cAMP-to-adenosine conversion by isolated LD (Fig. 10b) revealed that exogenously added cAMP and AMP significantly enhanced and SP-8-Br-cAMPs and AMPCP diminished the palmitate-, glimepiride- and GO-induced upregulation of the cAMP-degrading activity at LD. Again, ATP and adenosine were ineffective (data not shown). These findings demonstrate that occupancy of the GPI-proteins, Gce1 and CD73, with non-hydrolyzable substrate analogues and the authentic substrates impairs and favors, respectively, their agent-induced translocation from hcDIGs to LD in rat adipocytes.

Remarkably, SP-8-Br-cAMPS alone impaired the redistribution of CD73 and *vice versa*

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AMPCP alone the redistribution of Gce1 (Fig. 10a). These findings argue for interference of nucleotide binding to and/or inhibition of Gce1 or CD73 with a common translocation apparatus which may be shared by other GPI-proteins, too, and rely on their aggregation/complex formation. Alternatively, on basis of the limited membrane permeability of the (c)AMP analogues used, control of the translocation by the (c)AMP-dependent protein kinases can not be completely dismissed..

Role of the GPI-PLC and translocation of Gce1 and CD73 to LD for inhibition of lipolysis by palmitate, glimepiride and H_2O_2. The role of the stimulation of the GPI-PLC and GPI-protein translocation by palmitate, glimepiride and GO action for their anti-lipolytic activity in rat adipocytes was studied by inhibition of the GPI-PLC with GPI-2350 and activation or inhibition of the Gce1/CD73 translocation with excess of cAMP/AMP or SP-8-Br-cAMPS/AMPCP, respectively. Analysis of the glycerol and FA release (Fig. 11) and the amount of LD-associated HSL (Fig. 12) revealed that inhibition of the GPI-PLC and GPI-protein translocation does not affect basal and isoproterenol-induced lipolysis *per se* (data not shown). However, GPI-2350 (but not GPI-2349), SP-8-Br-cAMPS and AMPCP completely abrogated the inhibition of the isoproterenol-stimulated lipolysis (Fig. 11) as well as translocation of HSL to LD (Fig. 12) in response to palmitate, glimepiride and GO action, but not insulin. In contrast, exogenous cAMP and AMP alone or in combination with identical concentrations of SP-8-Br-cAMPS and AMPCP did not compromise lipolysis inhibition by either agent. Thus, the molecular mechanism for the anti-lipolytic activity of palmitate, glimepiride and GO action in rat adipocytes apparently relies on activation of the GPI-PLC and the translocation of Gce1 and CD73 and thereby differs from that engaged by insulin.

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Discussion

The following experimental evidence reported in this study strongly argues for the regulated translocation of the GPI-proteins, Gce1 and CD73, which in a concerted action convert cAMP into adenosine (Müller et al., 2008b), from DIGs to LD in primary rat adipocytes: (i) Disruption of plasma membrane DIGs upon cholesterol depletion from intact adipocytes abrogates palmitate-, glimepiride- and H_2O_2-triggered conversion of cAMP to adenosine by isolated LD (Table 1) and the upregulation of Gce1 protein expression at LD (Fig. 5). (ii) The steady-state distributions of the Gce1 and CD73 proteins as well as of their intrinsic PDE and 5'-Nuc activites are shifted from hcDIGs, their predominant localization in the basal state, to LD upon challenge of the adipocytes with palmitate, glimepiride and H_2O_2 (Figs. 1 and 3). (iii) Pulse and equilibrium labeling of the GPI anchors of Gce1 and CD73 with the anchor constituent, inositol, is compatible with a precursor-product relationship between the GPI-proteins recovered with hcDIGs and LD in both basal and palmitate-, gliempiride- and H_2O_2-treated adipocytes. However, in the treated adipocytes less pronounced increases and shorter chase times for Gce1 and CD73 at hcDIGs during pulse and equilibrium labeling, respectively, and more pronounced increases at LD during both pulse and equilibrium labeling were observed (Fig. 2). (iv) The translocation from hcDIGs to LD is specific for Gce1 and CD73 since the distribution of typical marker proteins for DIGs, caveolae and LD, such as caveolin, perilipin, HSL and TAG-synthesizing enzymes, is not affected by palmitate, glimepiride and H_2O_2 (Fig. 3b and c, Fig. 4). (v) The translocation reaction can be reconstituted in a cell-free system consisting of hcDIGs, cytosolic factors, ATP and precursors of TAG synthesis (Fig. 6).

Role of the GPI anchor (cleavage) for the translocation of Gce1 and CD73. The following findings suggest that GPI-anchored rather than lipolytically cleaved Gce1 and CD73 are translocated from hcDIGs to LD. (i) Gce1 does not get rid of its GPI anchor

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during translocation to LD as it retains its amphiphilic nature and displays the anti-CRD epitope upon cleavage by the PI-PLC, which are both characteristic for modification by the intact GPI structure (Fig. 7). (ii) Gce1p from yeast harboring the intact rather than the lipolytically cleaved GPI anchor associates with LD *in vitro* and confers PDE activity onto LD (Müller et al., 2008b). Thus, GPI anchorage appears to ensure stable association of Gce1 and CD73 with LD.

Surprisingly, albeit Gce1 and CD73 with intact GPI anchor are translocated to LD, only, GPI-PLC action seems to be required for their palmitate-, glimepiride- and H_2O_2-induced translocation based on the following findings: (i) Palmitate, glimepiride and H_2O_2 induce GPI anchor cleavage of Gce1 and CD73 by the GPI-PLC located at the plasma membrane of rat adipocytes (Fig. 8). (ii) Gce1 with cleaved GPI anchor generated in response to these agents accumulates at the hcDIGs rather than at the LD (Fig. 9). (iii) Inhibition of the GPI-PLC leads to accumulation of Gce1 harbouring the intact GPI anchor at hcDIGs (Fig. 9). (iv) Impairment of the palmitate-, glimepiride- or H_2O_2-induced generation of Gce1 and CD73 with cleaved GPI anchor at hcDIGs by non-hydrolyzable (c)AMP analogues is correlated well to reduced appearance of their anchor-containing versions (Fig. 10a) and their intrinsic cAMP-to-adenosine conversion activity (Fig. 10b) at LD. Taken together, it is concluded that challenge of rat adipocytes with palmitate, glimepiride and H_2O_2 causes (i) cleavage of the GPI anchors of Gce1 and CD73 by the activated GPI-PLC, (ii) retention at hcDIGs of Gce1 and CD73 with cleaved GPI anchor, presumably upon interaction of the generated phosphoinositolglycan moiety with a recently discovered receptor at hcDIGs (Müller et al., 2002c), and (iii) translocation of Gce1 and CD73 with intact GPI anchor from hcDIGs to LD.

Mechanism of GPI-protein translocation to LD*.* The findings of the regulated translocation of the GPI-proteins, Gce1 and CD73, from plasma membrane hcDIGs to cytosolic LD raises the intriguing question about the molecular mechanism involved. Three

models can be envisaged which differ predominantly in the sites of TAG synthesis and LD formation: (i) translocation of Gce1 and CD73 to the ER by vesicular trafficking and subsequently to LD as they are formed at and released from the ER, (ii) translocation alone or accompanied by FA molecules, which have been taken up at DIGs, to pre-existing cytosolic LD and (iii) incorporation into peripheral LD as these are formed at and released from DIGs followed by fusion central LD.

Compatible with the currently widely accepted model for LD biogenesis involving vesicular budding of LD from TAG-surrounding ER membrane leaflets (Wolins et al., 2006) and the appearance at LD of transient ER proteins, such as the caveolins (Robenek et al., 2005a and 2005b) and the GPI-proteins, Gce1 and CD73, as reported here are the recent findings of the presence of ribosomes, ER-like membranes and many ER-specific membrane and luminal proteins at the LD of U937 human monocytes (Wan et al., 2007). However, brefeldin A, which blocks vesicular trafficking of proteins from the ER to the Golgi-apparatus, also in adipocytes, does not impair the palmitate-, glimepiride- and H_2O_2-triggered translocation of Gce1 and CD73 from hcDIGs to LD (Fig. 5). Moreover, endocytic movement of Gce1 and CD73 to the ER would result in luminal orientation of their protein moieties as well as insertion of their GPI anchors into the luminal ER membrane leaflet. This topology is incompatible with budding of the LD together with the GPI-proteins incorporated into their phospholipid monolayer shell from the cytoplasmic ER membrane leaflet. Taken together, vesicular trafficking between the plasma membrane and the ER and subsequent budding of LD from the ER do not seem to be involved in the translocation of Gce1 and CD73 to LD in response to palmitate, glimepiride or H_2O_2.

Regarding non-vesicular mechanisms for the direct translocation of GPI-proteins from hcDIGs to pre-existing cytosolic LD, it may be of relevance that PAT family protein members, such as perilipin, which are typical LD-associated proteins, have recently been identified as integral components of the plasma membrane (Robenek et al., 2005a).

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Moreover, typical DIGs-associated proteins, such as caveolin and stomatin, have previously been recovered with LD (Robenek et al., 2005b, Umlauf et al., 2004), hinting to the existence of (transient) contacts or interactions between plasma membrane DIGs and LD. Thus, adipocyte LD may recruit their PAT proteins and caveolin-1 by direct interaction with specialized DIGs of the plasma membrane. This “imprinting” mechanism may be facilitated by the short distance (~ 0.5 µm) between the adipocyte plasma membrane and the cytosolic LD separated by a thin film of cytoplasm, only. Alternatively, the existence of a translocation channel between caveolae/DIGs and LD may be envisaged. In insulin-stimulated adipocytes, fluorescent FA have been demonstrated to accumulate in caveolin-containing large (> 1 µm) fluorescent bulbs at the plasma membrane and subsequently to penetrate and dissolve into the large cytosolic LD of the cell (Öst et al., 2005; Örtegren et al., 2006). It is therefore conceivable that FA molecules are transferred from their site of uptake at plasma membrane caveolae/DIGs in concert with a subset of GPI-proteins in micellar structures *via* the translocation channel to the sites of their incorporation into and storage as TAG, the cytosolic LD. This mechanism would lead to a direct flow of FA from the caveolae/DIGs to the LD, as was indeed inferred from fluorescence microscopy data (Örtegen et al., 2006), which may be accompanied by the brefeldin A-insensitive cotranslocation of Gce1 and CD73 from DIGs to LD.

An alternative vesicular trafficking-independent mechanism of GPI-protein translocation from DIGs to specialized peripheral LD on basis of their direct formation at and release from DIGs has recently been supported by the identification of a subclass of high-buoyant density and apparently closed plasma membrane-associated caveolae in primary rat adipocytes (Öst et al., 2005). These are capable of synthesizing TAG and assembling (a subclass of) LD as tiny dispersed structures near the cell periphery (Wolins et al., 2005). The relationship of these high-buoyant density caveolae to the lcDIGs prepared in this study on basis of detergent insolubility, low cholesterol content and high buoyant density

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and identified as site for the accumulation of Gce1 and CD73 similar to, albeit with lower efficacy than LD (Fig. 3a and 3b), remains to be clarified. (lc)DIGs operating as site for the formation of GPI-protein-harboring LD are compatible with the findings described here using a cell-free system: (i) Incubation of isolated caveolin-containing hcDIGs with cytosol, ATP and components required for TAG synthesis leads to formation of typical LD (as judged from buoyant density, accumulation of TAG, presence of caveolin-1 and perilipin-A/B) which harbor Gce1 (Fig. 6). (ii) *In vitro* GPI-proteins undergo exchange between distinct LD or GPI-protein-harboring LD manage to fuse with each other in a cytosol- and ATP-dependent process (Müller et al., 2008b). It is tempting to speculate that peripheral LD formed at DIGs undergo fusion with the ER-derived central LD during LD maturation accompanied by sequential translocation of a subset of GPI-proteins from (hc)DIGs to (lc)DIGs-derived LD to ER-derived LD. In conclusion, evidence available so far favors translocation of GPI-proteins from hcDIGs to LD involving the formation of peripheral LD at DIGs of the adipocyte plasma membrane.

TAG synthesis and LD formation by spezialized plasma membrane DIGs may be of advantage for adipocytes since they are faced with a massive influx of potentially lethal FA. Owing to their pronounced detergent resistance, the caveolin-containing DIGs/caveolae are adapted to cope with the detergent properties of FA by promoting the *de novo* synthesis of TAG from FA and glycerol-3-phosphate in the plasma membrane of primary adipocytes. Compatible with this physiological role of adipocyte DIGs are the findings that (i) caveolin-1, a major component of hcDIGs, has been shown to bind FA (Trigatti et al., 1999), (ii) overexpression of caveolin-1 in HEK293 cells enhances the transmembrane flux of FA (Meshulam et al., 2006), (iii) uptake of FA by the adipocytes seems to be regulated at the level of its conversion into TAG, at least at high concentrations (Mashek and Coleman, 2006). Thus, TAG synthesis and LD formation at hcDIGs/caveolae of the adipocyte plasma membrane could ensure rapid and efficient sequestration of FA, at least

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under certain physiological (excess of FA or reactive oxygen species) or pharmacological conditions (administration of glimepiride). Upregulation of the translocation of the cAMP-to-adenosine conversion machinery consisting of the PDE, Gce1, and the 5'-Nuc, CD73, from hcDIGs to the LD under these conditions may facilitate the formation of LD and improve their resistance against cAMP-dependent lipolytic attack involving protein kinase A-activated lipases, such as HSL (Müller et al., 2008a). It is tempting to speculate that the transfer of Gce1 and CD73 from hcDIGs-derived peripheral LD to ER-derived central LD in course of their subsequent fusion may guarantee the coordination of LD biogenesis between both sites in case of excessive burden of the adipocytes with FA or reactive oxygen species. Studies are in progress to elucidate the primary molecular mechanism(s) of GPI-PLC activation and GPI-protein translocation putatively shared by H_2O_2, palmitate and glimepiride. They may provide novel target(s) for the therapy of metabolic diseases, such as type II diabetes and hyperlipidemia, which are thought to rely on unrestrained lipolysis and impaired LD formation in adipocytes (Unger, 2002).

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LEGENDS TO FIGURES

Fig. 1. Effect of palmitate, glimepiride and GO action on the steady state distribution of Gce1 and CD73 proteins as well as PDE and 5'-Nuc activities between hcDIGs and LD. Isolated rat adipocytes were incubated (60 min, 37°C) in the absence (basal) or presence of increasing concentrations of palmitate, glimepiride or GO as indicated and then used for the preparation of hcDIGs and LD. Proteins were extracted from the hcDIGs (a and c) and LD (b and c) and then precipitated under native conditions. Portions of the solubilized proteins were photoaffinity-labeled with N_3-[^{32}P]cAMP or [^{14}C]5'-FSBA in the absence or presence of 10 mM unlabeled cAMP or AMP for the detection of Gce1 or CD73, respectively, then precipitated under denaturing conditions and following solubilization separated by SDS-PAGE. The phosphorimages of a typical experiment are shown repeated two times with similar results. Other portions of the solubilized proteins were assayed for PDE and 5'-Nuc activities (c). Quantitative evaluations (means $\pm$ SD, n = 4 independent adipocyte preparations and activity determinations) are given. The activities recovered with LD and hcDIGs are set at 1 (fold stimulation) and 100 % (activity recovered), respectively, for each treatment.

Fig. 2. Effect of palmitate, glimepiride and GO action on the translocation of Gce1 and CD73 from hcDIGs to LD. Isolated rat adipocytes were metabolically labeled with *myo*-[^{14}C]inositol for 5 min (pulse labeling, a) or 60 min (equilibrium labeling, b) in the presence of isoproterenol (1 µM). After addition of excess of unlabeled *myo*-inositol (zero time points), the incubation was continued for increasing periods of time (chase) in the absence (basal) or presence of palmitate (1 mM), glimepiride (10 µM) or GO (100 mU/ml). hcDIGs and LD were prepared from the washed adipocytes and then used for extraction and precipitation of the proteins under native conditions. The dissolved protein samples were

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analyzed for the presence of Gce1 and CD73 by affinity purification and subsequent SDS-PAGE analysis of the eluted and precipitated (under denaturing conditions) proteins. The phosphorimages of a typical experiment are shown (for Gce1 only, a and b). Quantitative evaluations (means ± SD, *n* = 3 adipocyte preparations and metabolic labelings) are given (for CD73 only, c). The amounts of ^{14}C-labeled CD73 recovered with LD and hcDIGs from basal adipocytes at the zero time points are set at 100 %.

Fig. 3. Effect of palmitate, glimepiride and GO action on the steady-state distribution of Gce1, CD73, HSL, caveolin and perilipin between hcDIGs, lcDIGs and LD. Isolated rat adipocytes were incubated (60 min, 37°C) in the absence (basal) or presence of palmitate (1 mM), glimepiride (10 µM) or GO (100 mU/ml) and then used for the preparation of microsomes, hcDIGs, lcDIGs and LD. (a) From portions, proteins were extracted and precipitated under native conditions, and after solubilization photoaffinity-labeled with N_3-[^{32}P]cAMP or [^{14}C]5'-FSBA for the detection of Gce1 and CD73, respectively. The proteins were precipitated under denaturating conditions and then analyzed by SDS-PAGE. Quantitative evaluations of the phosphorimages (means ± SD, n = 3 independent experiments, amounts of Gce1 and CD73 at hcDIGs in the basal state set at 100) are shown. (b and c) From other portions of the hcDIGs, lcDIGs, LD and microsomes (as indicated), proteins were extracted and precipitated under denaturating conditions and then analyzed for the presence of HSL, perilipin-A, caveolin-1 (b) and flotillin-1 (c) by immunoblotting. Chemiluminescent images from a representative experiment repeated once are shown. (d) Other portions of the hcDIGs, lcDIGs and LD were analyzed for cholesterol and TAG synthesis. Quantitative evaluations (means ± SD, *n* = 3 independent adipocyte preparations and cholesterol/TAG synthesis measurements) are given. The amounts of cholesterol and TAG synthesis measured with hcDIGs from untreated adipocytes were set at 1. * indicate significant difference ($p < 0.05$) compared to the

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corresponding fraction from untreated adipocytes. • indicate significant difference (P < 0.05) compared to hcDIGs from the correspondingly treated adipocytes.

Fig. 4. Effect of isoproterenol, ADA, palmitate, glimepiride and GO on the localization of typical marker proteins for LD and hcDIGs. Isolated rat adipocytes were incubated (60 min, 37°C) in the absence or presence of palmitate (1 mM), glimepiride (10 µM) or GO (100 mU/ml) prior to the addition of isoproterenol (final conc. 1 µM), ADA (1 U/ml) or buffer alone (basal). After further incubation (20 min), LD and hcDIGs were prepared from the adipocytes and then used for the extraction and precipitation under denaturating conditions. The solubilized proteins were finally analyzed for the presence of perilipin-A, HSL, caveolin-1, $p59^{Lyn}$, GLUT4 and IR by immunoblotting. Chemiluminescent images from a representative experiment repeated twice are shown.

Fig. 5. Effect of cholesterol depletion, inhibition of TAG synthesis and blockade of ER-to-Golgi transport on the steady-state distribution of Gce1. Isolated rat adipocytes were incubated (5 min, 37°C) in the absence or presence of m-ß-CD (3.8 mM), triacsin C (20 µM) or brefeldin A (5 µg/ml) prior to treatment with palmitate (final conc. 1 mM), glimepiride (10 µM) or GO (100 mU/ml) as indicated. After further incubation (60 min, 37°C), LD were prepared from the adipocytes and used for the extraction and precipitation of proteins under native conditions. The solubilized proteins were photoaffinity-labeled with 8-N_3-[^{32}P]cAMP for the detection of Gce1, then precipitated under denaturing conditions and finally separated by SDS-PAGE. Phosphorimages of a typical experiment are shown. Quantitative evaluations (means $\pm$ SD, n = 3 independent adipocyte preparations and treatments) are given. Bold numbers indicate significant difference (P < 0.05) compared to stimulated adipocytes in the absence of m-ß-CD, triacsin C or brefeldin A set at 100.

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Fig. 6. Translocation of Gce1 and CD73 from hcDIGs to LD in a cell-free system. Isolated rat adipocytes were metabolically labeled (60 min) with *myo*-[^{14}C]inositol and then incubated (4 h, 37°C) in the absence (basal) or presence of palmitate (1 mM), glimepiride (10 µM) or GO (100 mU/ml). Thereafter, hcDIGs were prepared from the adipocytes. Portions were incubated (60 min, 37°C) with cytosol, oleoyl-CoA, oleate, CoA, an ATP-regenerating system and [^{3}H]glycerol-3-phosphate as described in Materials and Methods and then subjected to sucrose gradient centrifugation. Portions (0.2 ml) of the five fractions obtained were analyzed for TAG synthesis. Other portions were pecipitated under denaturing (0.1 ml) or native (0.5 ml) conditions and then analyzed for the presence of caveolin-1 and perilipin-A/B by immunoblotting or of Gce1 and CD73 by affinity purification and subsequent SDS-PAGE. Chemiluminescent and phosphorimages of a representative experiment are shown. Quantitative evaluations (mean $\pm$ SD, n = 4 independent adipocyte preparations/incubations) of the amounts of Gce1, CD73, caveolin-1, perilipin-A/B and TAG synthesizing enzymes are given and set at 1000 for the bottom fraction (d = 1.175) for each incubation condition. Bold numbers / * indicate significant difference ($P < 0.05$) compared to the top fraction (d = 1.059) from control adipocytes.

Fig. 7. Effect of palmitate, glimepiride and GO action on the steady-state distribution of anchor-containing and anchor-less Gce1 at LD. Isolated rat adipocytes were metabolically labeled (60 min) with *myo*-[^{14}C]inositol and then incubated (60 min, 37°C) in the absence (basal) or presence of palmitate (1 mM), glimepiride (10 µM) or GO (100 mU/ml). Thereafter, LD were prepared from the adipocytes for the extraction and precipitation of proteins under native conditions. The solubilized proteins were treated without or with PI-PLC (*Bacillus cereus*) in the absence or presence of GPI-2350 (100 µM). After TX-114 partitioning, the proteins recovered from the aqueous (a) and TX-114 (d) phases were precipitated under native conditions. After solubilization of the proteins Gce1 was affinity-

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purified. Portions of the eluted Gce1 were analyzed by SDS-PAGE (total). Other portions were immunoprecipitated with anti-CRD antibodies prior to SDS-PAGE (Anti-CRD). The phosphorimages of a representative experiment are shown. Quantitative evaluations (mean ± SD, *n* = 4 independent adipocyte preparations/incubations) are given. The amounts of Gce1 not treated with PI-PLC and recovered with the TX-114 phase from LD of basal adipocytes were set at 100. Bold numbers indicate significant difference ($P < 0.05$) compared to the correspondingly treated Gce1 recovered from the corresponding phase of basal adipocytes.

Fig. 8. Effect of palmitate, glimepiride and GO action on the lipolytic cleavage Gce1 and CD73. Isolated rat adipocytes were metabolically labeled (60 min) with *myo*-[^{14}C]inositol and then incubated (5 min, 37°C) in the absence or presence of GPI-2350 (100 µM) prior to the addition of increasing concentrations of palmitate, glimepiride or GO. After further incubation (60 min, 37°C), plasma membranes were prepared from the adipocytes and subjected to TX-114 partitioning. Proteins recovered with the aqueous phase were precipitated under native conditions. Gce1 and CD73 were affinity-purified from the solubilized proteins and after elution analyzed by SDS-PAGE. Phosphorimages of a representative experiment are shown (for Gce1 only). Quantitative evaluations (means ± SD, *n* = 4 independent adipocyte preparations and metabolic labelings) are given (for CD73 only) with the amount of hydrophilic CD73 recovered with plasma membranes of untreated adipocytes set at 1. * indicate significant difference ($P < 0.05$) compared to the corresponding untreated adipocytes.

Fig. 9. Effect of inhibition of the GPI-PLC on the palmitate-, glimepiride- and GO-induced translocation of Gce1. Isolated rat adipocytes were incubated (5 min, 37°C) in the absence or presence of GPI-2350 (100 µM) prior to the addition of palmitate (final conc. 1 mM),

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glimepiride (10 µM), GO (100 mU/ml) or buffer. After further incubation (20 min, 37°C), hcDIGs and LD were prepared from the adipocytes for the extraction and precipitation of proteins under native conditions. Solubilized proteins were photoaffinity-labeled with 8-N_3-[^{32}P]cAMP, partitioned between aqueous (a) and TX-114 (d) phases, then precipitated under denaturating conditions and finally analyzed by SDS-PAGE. The phosphorimages of a representative experiment are shown. Quantitatve evaluations (means $\pm$ SD, n = 3 independent adipocyte preparations/incubations) are given with the amount of amphiphilic Gce1 recovered with the hcDIGs from untreated adipocytes in the absence of GPI-2350 set at 100. Bold numbers indicate significant difference ($P < 0.05$) compared to the aqueous phase of hcDIGs or detergent phase of LD, respectively, from untreated adipocytes.

Fig. 10. Effect of (c)AMP and analogues on the palmitate-, glimepiride- and GO-induced lipolytic cleavage and translocation of Gce1 and CD73. Isolated rat adipocytes were incubated (5 min, 37°C) with cAMP, AMP, Br-cAMPS and AMPCP, or combinations thereof (100 µM each) prior to the addition of palmitate (final conc. 1 mM), glimepiride (10 µM), GO (100 mU/ml) or buffer (basal) as indicated. After further incubation (60 min, 37°C), hcDIGs and LD were prepared from the adipocytes for the extraction and precipitation of proteins under under native conditions. Portions of the solubilized proteins were photoaffinity-labeled with 8-N_3-[^{32}P]cAMP or [^{14}C]5'-FSBA. After TX-114 partitioning, proteins recovered from the aqueous phases (hcDIGs only) and TX-114 phases (LD only) were precipitated under denaturing conditions and then analyzed by SDS-PAGE. Phosphorimages of a representative experiment are shown repeated once with similar results (a). Other portions of the solubilized proteins prepared from the LD were assayed for cAMP-to-adenosine conversion (b). Quantitative evaluations (means $\pm$ SD, n = 4 independent adipocyte preparations/incubations) are given with the cAMP-to-adenosine

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conversion by LD from basal adipocytes incubated in the absence of (c)AMP analogues was set at 1. * indicate significant difference ($P < 0.05$) compared to the correspondingly treated or basal adipocytes in the absence of the (c)AMP analogues.

Fig. 11. Effect of inhibition of the GPI-PLC and GPI-protein translocation on lipolysis inhibition by insulin, palmitate, glimepiride and GO. Isolated rat adipocytes were incubated (5 min, 37°C) in the absence or presence of GPI-2350 (100 µM), GPI 2349 (100 µM), Br-cAMPS, AMPCP, cAMP or AMP (100 µM each) prior to the addition of insulin (final conc. 5 nM), palmitate (1 mM), glimepiride (10 µM), GO (100 mU/ml) or buffer (basal). After further incubation (30 min), isoproterenol (final conc. 1 µM) or buffer was added. Following incubation (90 min), the medium was separated from the adipocytes and analyzed for glycerol and FA release (means ± SD, n = 5 independent adipocyte preparations/incubations) with the values obtained with basal adipocytes in the absence of isoproterenol/(c)AMP analogue/inhibitor set at 1. * indicate significant difference ($P < 0.05$) compared to the correspondingly treated isoproterenol-stimulated adipocytes in the absence of (c)AMP analogue or inhibitor.

Fig. 12. Effect of inhibition of the GPI-PLC and GPI-protein translocation on the inhibition of HSL translocation by insulin, palmitate, glimepiride and GO. Isolated rat adipocytes were incubated (5 min, 37°C) in the absence or presence of GPI-2350 (100 µM), AMPCP *plus* Br-cAMPS (100 µM each) prior to the addition of insulin (final conc. 5 nM), palmitate (1 mM), glimepiride (10 µM), GO (100 mU/ml) or buffer. After further incubation (30 min), isoproterenol (final conc. 1 µM) or buffer was added and the incubation continued (20 min). LD were prepared from the adipocytes and used for the extraction and precipitation of proteins under denaturing conditions. Thereafter the solubilized proteins were immunoblotted for HSL. Chemiluminescent images of a representative experiment are

shown. Quantitative evaluations (means ± SD, *n* = 3 independent adipocyte preparations/incubations) are given with the amount of HSL recovered with LD from isoproterenol-treated adipocytes in the absence of anti-lipolytic challenge/(c)AMP analogue/GPI-2350 set at 100. Bold numbers indicate significant difference ($P < 0.05$) compared to the correspondingly treated adipocytes in the absence of (c)AMP analogue/GPI-2350.

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	cAMP-to-Adenosine Conversion			**Isoproterenol-Induced Lipolysis**			
Treatment	glimepiride	palmitate	GO	control	glimepiride	palmitate	GO
-	100±17	100±12	100±14	100±6	39±4	51±3	29±2
m-ß-CD	**28±5**	**20±3**	**35±6**	87±3	**90±4**	**89±3**	**90±5**
m-ß-CD + cholesterol	85±9	92±10	105±17	91±5	36±2	45±3	26±3

TABLE 1

Effect of cholesterol depletion on the cAMP-to-adenosine conversion by LD and lipolysis. Isolated rat adipocytes were incubated (50 min, 37°C) in the absence or presence of 3.8 mM m-ß-CD or 1.9 mM m-ß-CD *plus* 1.9 mM m-ß-CD-cholesterol complex. Thereafter, the cells were incubated (37°C) with palmitate (1 mM, 120 min), glimepiride (10 µM, 60 min), GO (10 mU/ml, 20 min) or buffer alone (control). Portions of the adipocytes were separated from the medium for the preparation of LD which were then assayed for cAMP-to-adenosine conversion. Other portions of the adipocytes were incubated with isoproterenol (1 µM, 2 h, 37°C) and then separated from the medium for the analysis of the glycerol released. cAMP-to-adenosine conversion by LD prepared from untreated adipocytes was set at 100 % for each anti-lipolytic challenge. Isoproterenol-induced lipolysis of control adipocytes was set at 100 % (means ± SD, n = 3 independent adipocyte preparations/incubations). Bold numbers indicate significant difference ($P < 0.05$) compared to the untreated and correspondingly glimepiride-, palmitate- and GO-challenged adipocytes..

Fig. 1a

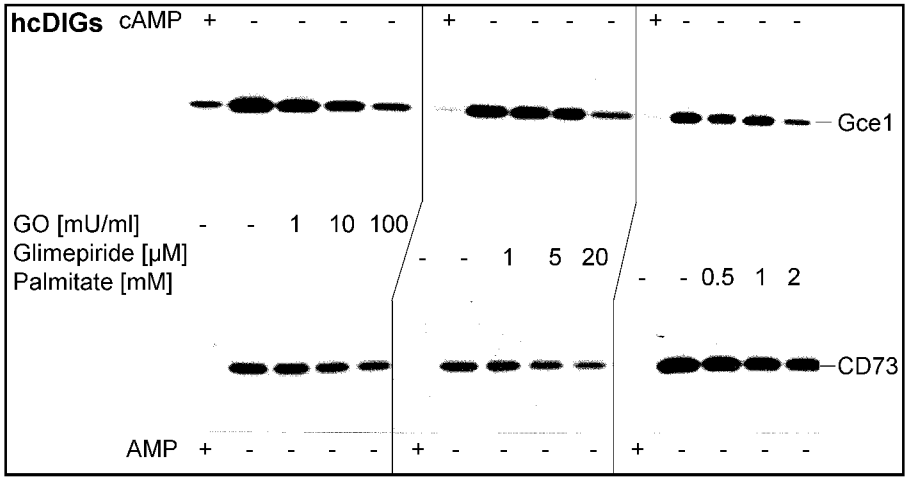
hcDIGs
cAMP + - - - - + - - - - + - - - -
Gce1
GO [mU/ml] - - 1 10 100
Glimepiride [µM] - - 1 5 20
Palmitate [mM] - - 0.5 1 2
CD73
AMP + - - - - + - - - - + - - - -

Fig. 1b

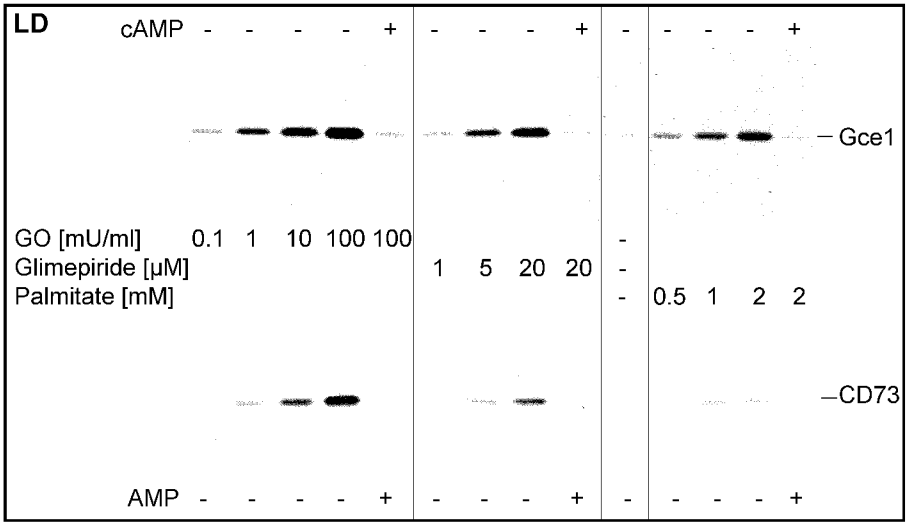
LD
cAMP - - - - + - - - + - - - - +
Gce1
GO [mU/ml] 0.1 1 10 100 100 -
Glimepiride [µM] 1 5 20 20 -
Palmitate [mM] - 0.5 1 2 2
CD73
AMP - - - - + - - - + - - - - +

Fig. 1c

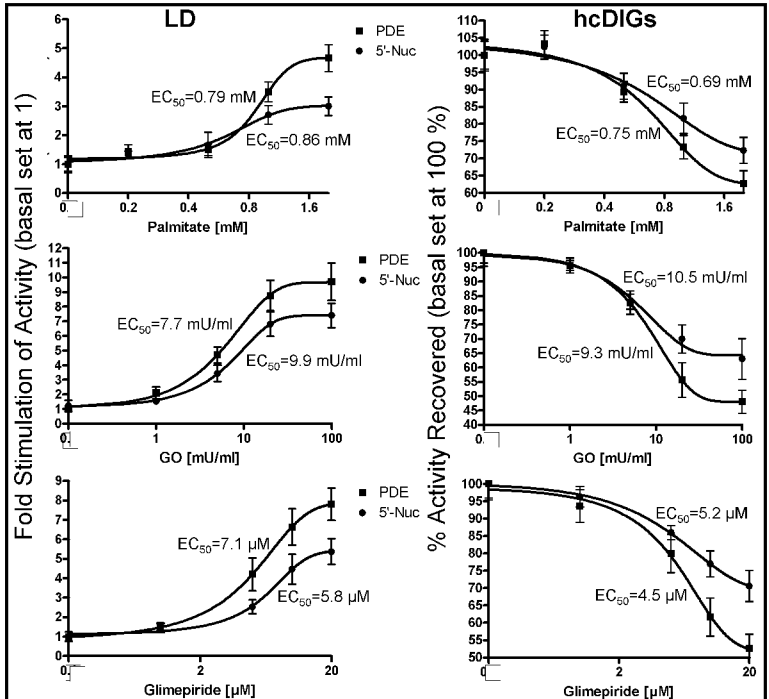
LD
hcDIGs
Fold Stimulation of Activity (basal set at 1)
% Activity Recovered (basal set at 100 %)
PDE
5'-Nuc
EC50=0.79 mM
EC50=0.86 mM
EC50=0.69 mM
EC50=0.75 mM
Palmitate [mM]
EC50=7.7 mU/ml
EC50=9.9 mU/ml
EC50=10.5 mU/ml
EC50=9.3 mU/ml
GO [mU/ml]
EC50=7.1 µM
EC50=5.8 µM
EC50=5.2 µM
EC50=4.5 µM
Glimepiride [µM]

Fig. 2a

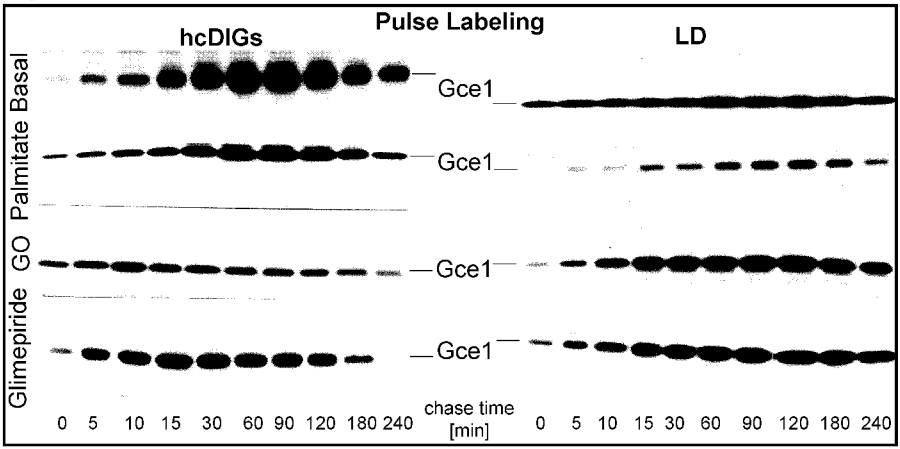
Pulse Labeling
hcDIGs
LD
Basal
Palmitate
GO
Glimepiride
Gce1
Gce1
Gce1
Gce1
0 5 10 15 30 60 90 120 180 240
chase time [min]
0 5 10 15 30 60 90 120 180 240

Fig. 2b

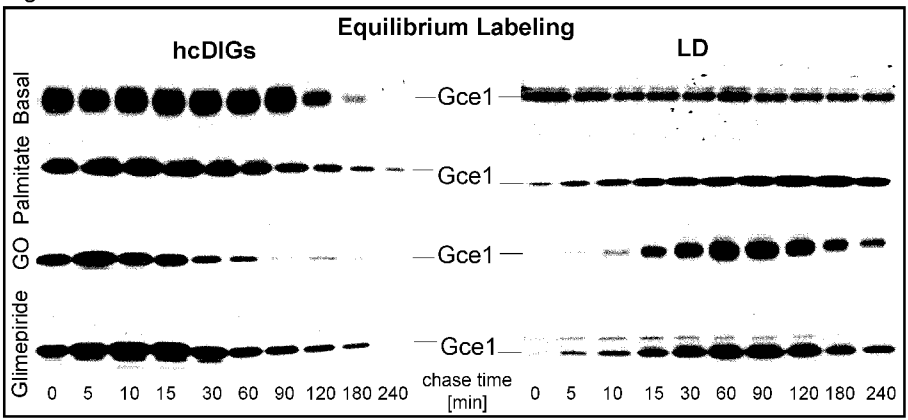
Equilibrium Labeling
hcDIGs
LD
Basal
Palmitate
GO
Glimepiride
Gce1
Gce1
Gce1
Gce1
0 5 10 15 30 60 90 120 180 240
chase time [min]
0 5 10 15 30 60 90 120 180 240

Fig. 2c

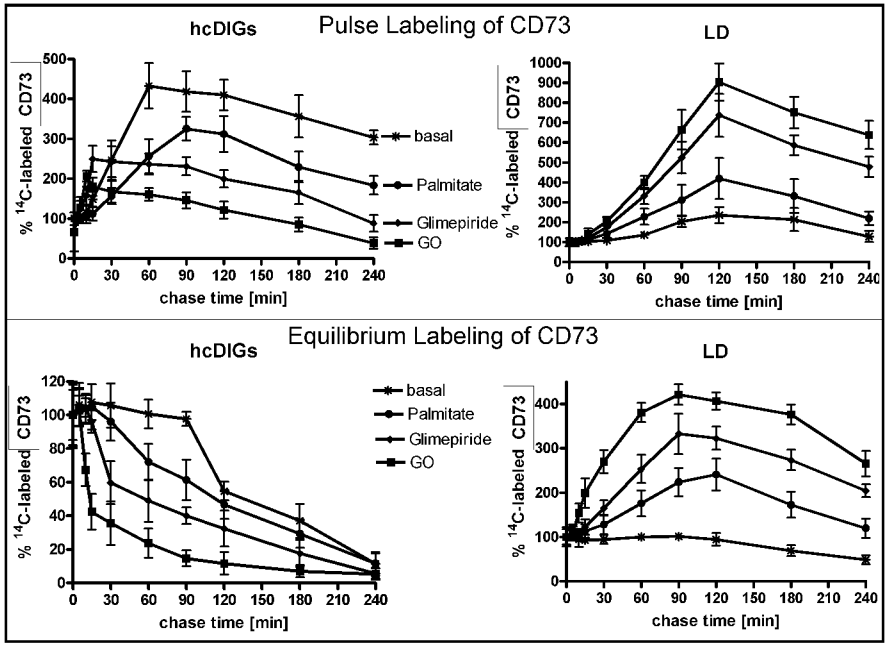
hcDIGs
Pulse Labeling of CD73
LD
% 14C-labeled CD73
chase time [min]
basal
Palmitate
Glimepiride
GO
Equilibrium Labeling of CD73
hcDIGs
LD
% 14C-labeled CD73
chase time [min]
basal
Palmitate
Glimepiride
GO

Fig. 3a

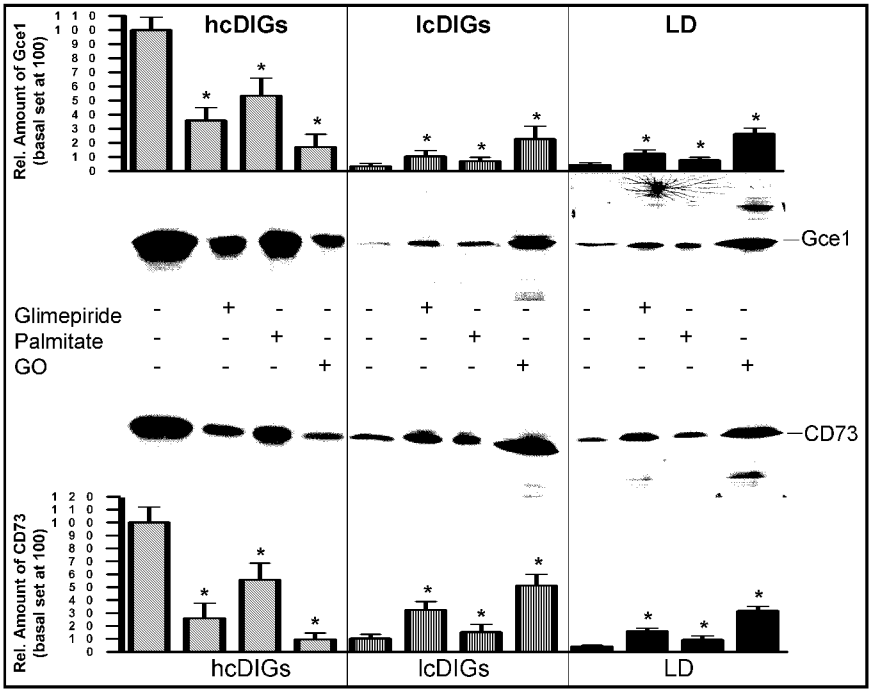
hcDIGs
lcDIGs
LD
Rel. Amount of Gce1 (basal set at 100)
Gce1
Glimepiride
Palmitate
GO
CD73
Rel. Amount of CD73 (basal set at 100)
hcDIGs
lcDIGs
LD

Fig. 3b

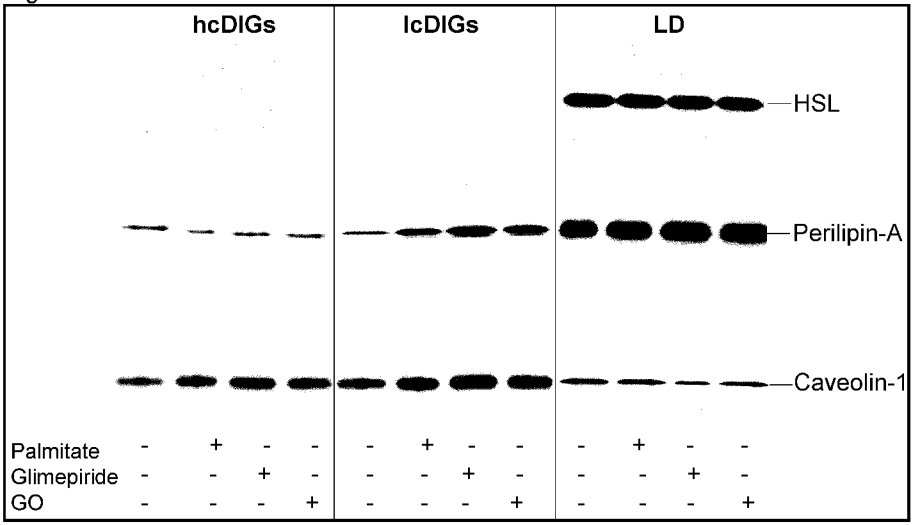
hcDIGs
lcDIGs
LD
HSL
Perilipin-A
Caveolin-1
Palmitate - + - - - + - - - + - -
Glimepiride - - + - - - + - - - + -
GO - - - + - - - + - - - +

Fig. 3c

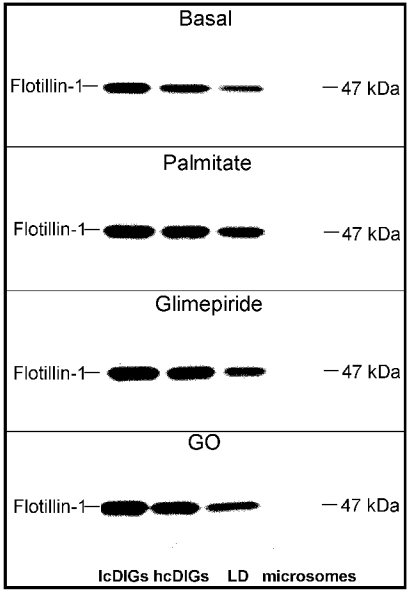
Basal
Flotillin-1
47 kDa
Palmitate
Flotillin-1
47 kDa
Glimepiride
Flotillin-1
47 kDa
GO
Flotillin-1
47 kDa
lcDIGs hcDIGs LD microsomes

Fig. 3d

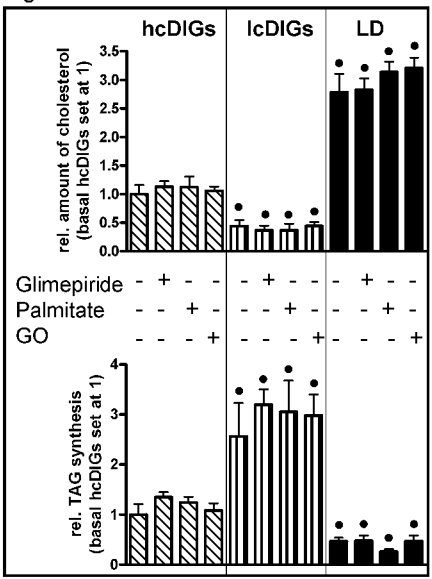
hcDIGs
lcDIGs
LD
rel. amount of cholesterol (basal hcDIGs set at 1)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Glimepiride - + - - - + - - - + - -
Palmitate - - + - - - + - - - + -
GO - - - + - - - + - - - +
rel. TAG synthesis (basal hcDIGs set at 1)
4
3
2
1
0

Fig. 4

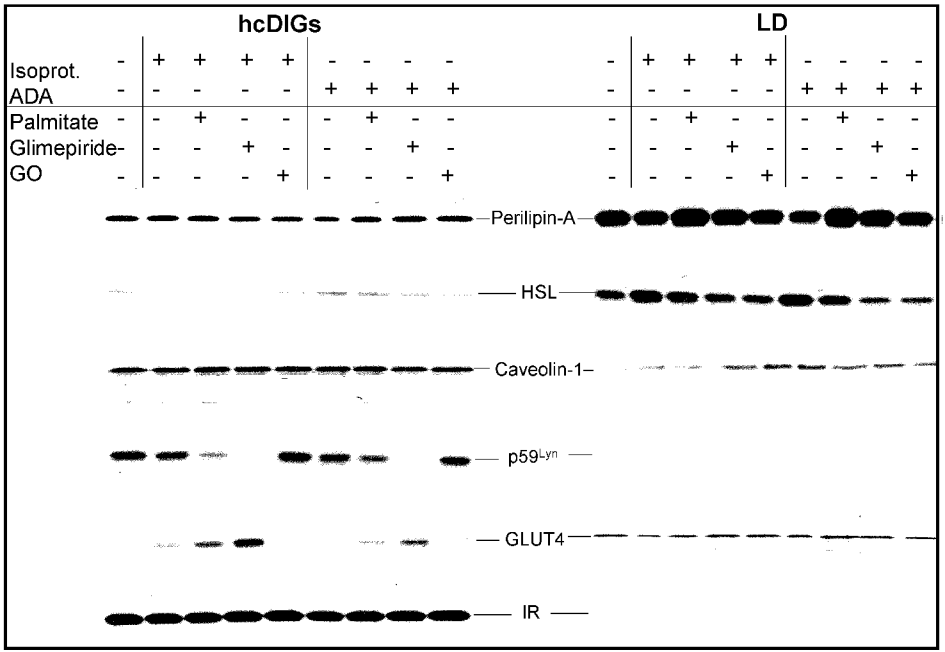
hcDIGs
LD
Isoprot.
ADA
Palmitate
Glimepiride-GO
Perilipin-A
HSL
Caveolin-1
p59Lyn
GLUT4
IR

Fig. 5

Glimepiride	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
GO	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	-
Palmitate	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	
m-ß-CD	-	-	-	+	-	-	-	-	+	-	-	-	-	+	-	
Triacsin C	-	-	+	-	-	-	-	+	-	-	-	-	+	-	-	
Brefeldin A	-	-	-	-	+	-	-	-	-	+	-	-	-	-	+	

15±6	100±18	109±21	**9±3**	81±11	**8±4**	100±13	**21±4**	**11±3**	119±23	**12±5**	100±19	**18±4**	**7±3**	94±15

Fig. 6

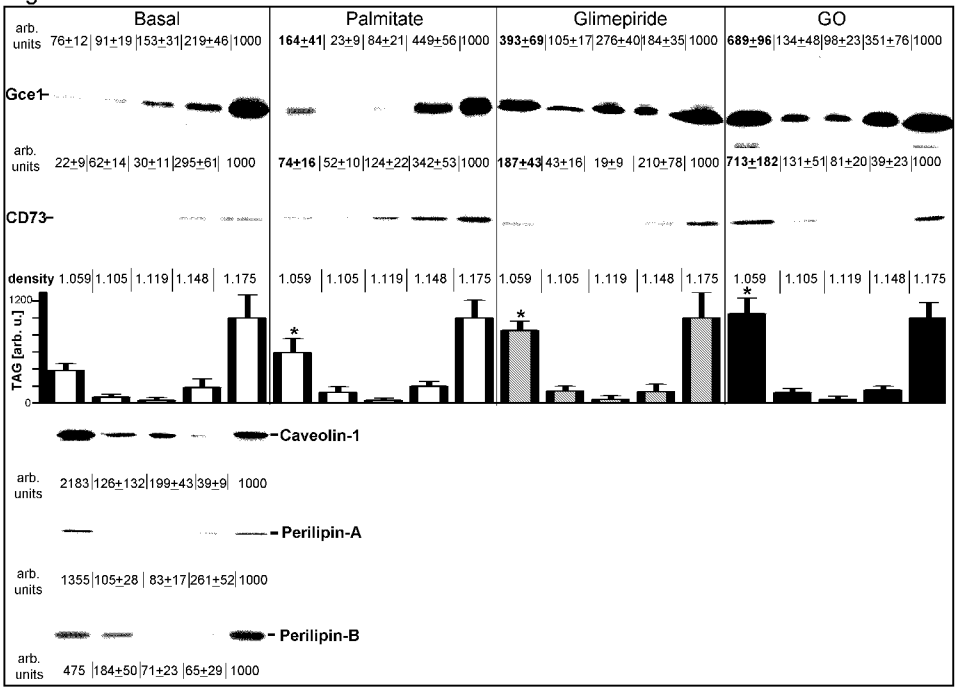
Basal
Palmitate
Glimepiride
GO
arb. units
76±12 | 91±19 | 153±31 | 219±46 | 1000
164±41 | 23±9 | 84±21 | 449±56 | 1000
393±69 | 105±17 | 276±40 | 184±35 | 1000
689±96 | 134±48 | 98±23 | 351±76 | 1000
Gce1–
arb. units
22±9 | 62±14 | 30±11 | 295±61 | 1000
74±16 | 52±10 | 124±22 | 342±53 | 1000
187±43 | 43±16 | 19±9 | 210±78 | 1000
713±182 | 131±51 | 81±20 | 39±23 | 1000
CD73–
density 1.059 | 1.105 | 1.119 | 1.148 | 1.175
1.059 | 1.105 | 1.119 | 1.148 | 1.175
1.059 | 1.105 | 1.119 | 1.148 | 1.175
1.059 | 1.105 | 1.119 | 1.148 | 1.175
TAG [arb. u.]
1200
0
*
*
*
Caveolin-1
arb. units
2183 | 126±132 | 199±43 | 39±9 | 1000
Perilipin-A
arb. units
1355 | 105±28 | 83±17 | 261±52 | 1000
Perilipin-B
arb. units
475 | 184±50 | 71±23 | 65±29 | 1000

Fig. 7

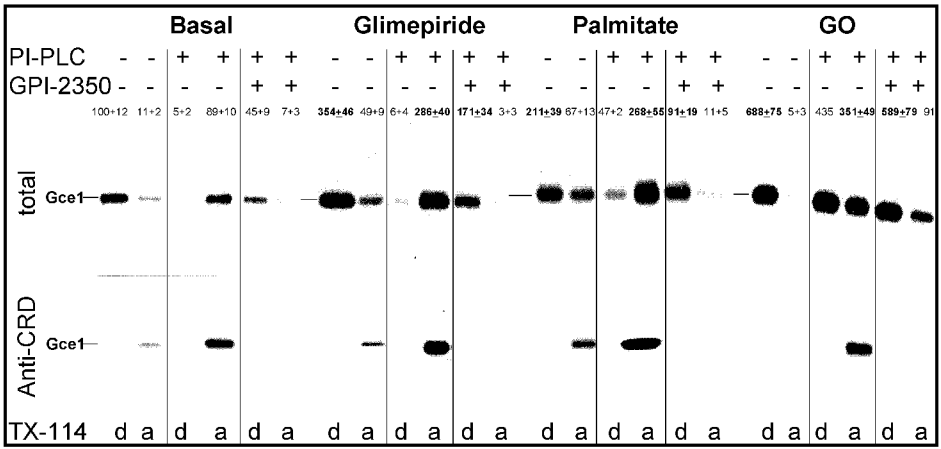
Basal
Glimepiride
Palmitate
GO
PI-PLC
GPI-2350
100+12 11+2 5+2 89+10 45+9 7+3 354±46 49+9 6+4 286±40 171±34 3+3 211±39 67+13 47+2 268±55 91±19 11+5 688±75 5+3 435 351±49 589±79 91
total
Gce1
Anti-CRD
Gce1
TX-114 d a d a d a d a d a d a d a d a d a d a d a

Fig. 8

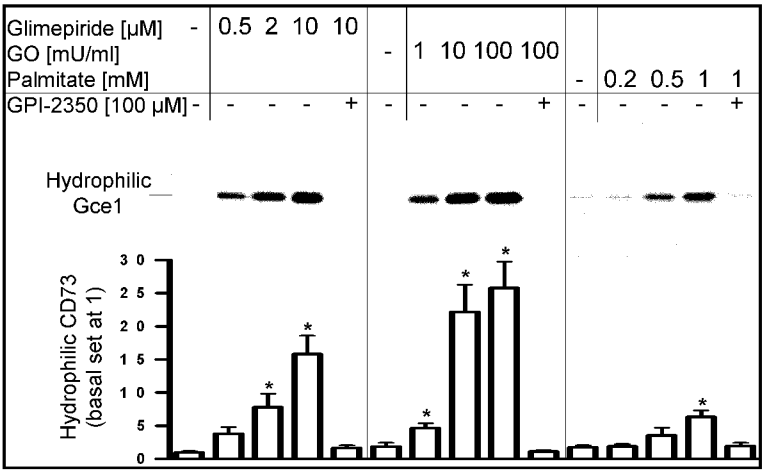
Glimepiride [µM] - 0.5 2 10 10 - 1 10 100 100 - 0.2 0.5 1 1
GO [mU/ml]
Palmitate [mM]
GPI-2350 [100 µM] - - - - + - - - - + - - - - +
Hydrophilic Gce1
Hydrophilic CD73 (basal set at 1)
0
5
10
15
20
25
30
*

Fig. 9

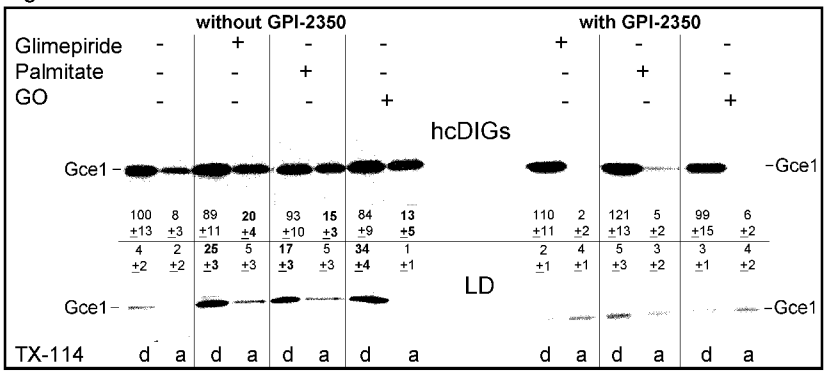
without GPI-2350
with GPI-2350
Glimepiride
Palmitate
GO
hcDIGs
Gce1
Gce1
LD
Gce1
Gce1
TX-114
d a d a d a d a d a d a d a
100 ±13
8 ±3
89 ±11
20 ±4
93 ±10
15 ±3
84 ±9
13 ±5
110 ±11
2 ±2
121 ±13
5 ±2
99 ±15
6 ±2
4 ±2
2 ±2
25 ±3
5 ±3
17 ±3
5 ±3
34 ±4
1 ±1
2 ±1
4 ±1
5 ±3
3 ±2
3 ±1
4 ±2

Fig. 10a

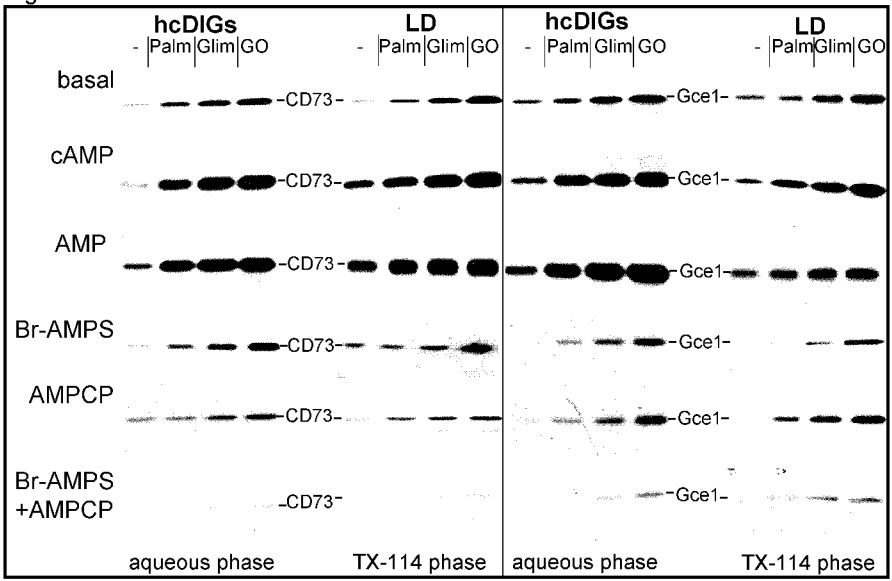
hcDIGs
LD
hcDIGs
LD
- Palm Glim GO
- Palm Glim GO
- Palm Glim GO
- Palm Glim GO
basal
cAMP
AMP
Br-AMPS
AMPCP
Br-AMPS +AMPCP
CD73
Gce1
aqueous phase
TX-114 phase
aqueous phase
TX-114 phase

Fig. 10b

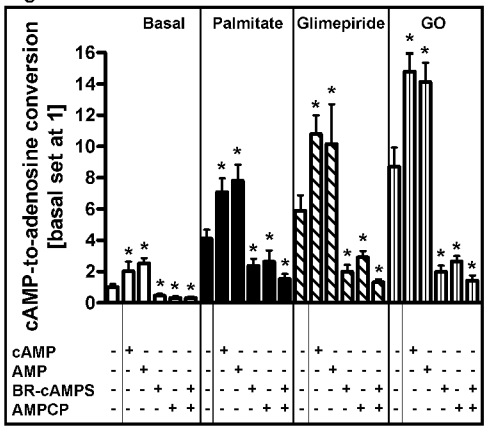
cAMP-to-adenosine conversion
[basal set at 1]
Basal
Palmitate
Glimepiride
GO
16
14
12
10
8
6
4
2
0
cAMP
AMP
BR-cAMPS
AMPCP

Fig. 11

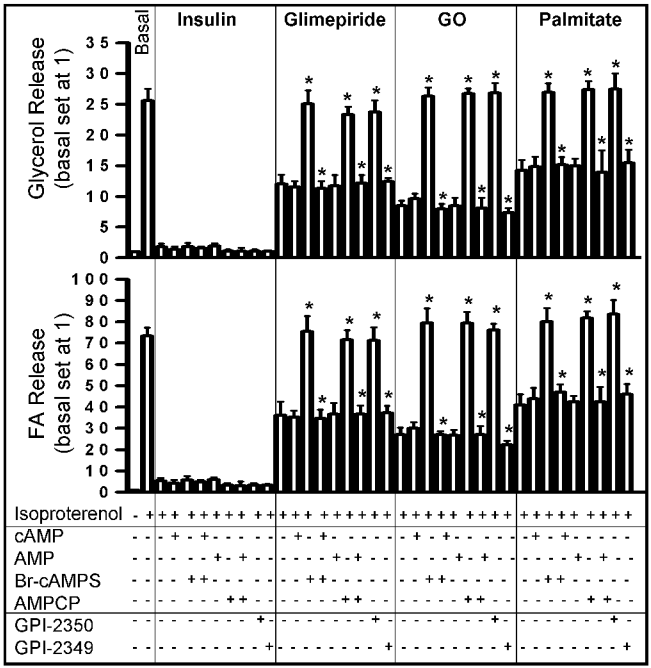
Basal
Insulin
Glimepiride
GO
Palmitate
Glycerol Release (basal set at 1)
FA Release (basal set at 1)
Isoproterenol
cAMP
AMP
Br-cAMPS
AMPCP
GPI-2350
GPI-2349

Fig. 12

Isoproterenol	-	+	+	+	+	+	+	+	+	+	+	+	+	+
Insulin	-	-	+	-	-	-	+	+	-	-	-	-	-	-
Palmitate	-	-	-	+	-	-	-	-	+	+	-	-	-	-
Glimepiride	-	-	-	-	+	-	-	-	-	-	+	+	-	-
GO	-	-	-	-	-	+	-	-	-	-	-	-	+	+
GPI-2350	-	-	-	-	-	-	+	-	+	-	+	-	+	-
AMPCP+ Br-cAMPS	-	-	-	-	-	-	-	+	-	+	-	+	-	+
HSL														
	15±7	100±9	21±5	49±6	39±6	25±5	17±3	35±6	105±8	99±9	102±10	96±8	101±9	93±7