

# Discovery of SCO-267, a First-in-class GPR40 Full Agonist, as a Promising Candidate for the Treatment of Type 2 Diabetes Mellitus, Obesity, and NASH

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*Naoyoshi Noguchi, Ph.D. on behalf of the GPR40 PJ Team  
Research Division, Drug Discovery Chemistry Laboratory  
SCOHA PHARMA, Inc.*

EFMC-ISMIC Virtual Event 2020

First Time Disclosures & Late Breaking News

📍 Online 📅 September 7-8, 2020



## 1. Introduction

## 2. Med. Chem. Campaign to Discover SCO-267

## 3. Pharmacological Efficacy of SCO-267

- Single Dosing and Repeated Dosing Effects in N-STZ-1.5 Rats (Diabetic Model)
- Repeated Dosing Effects in DIO-rats (Obese Model)
- Single Dosing and Repeated Dosing Effects in CDAHFD-fed Mice (NAFLD Model)

## 4. Summary

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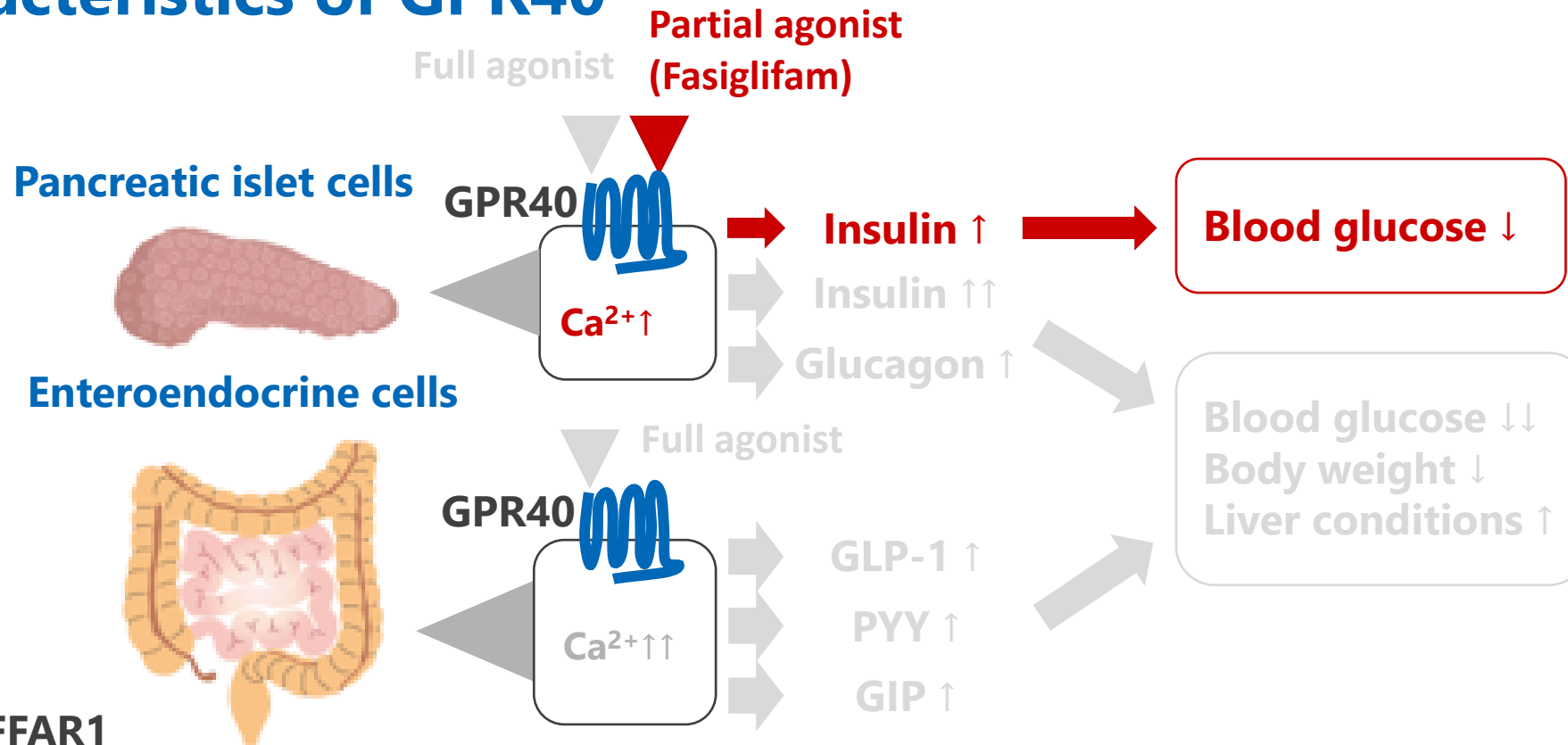
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# Characteristics of GPR40



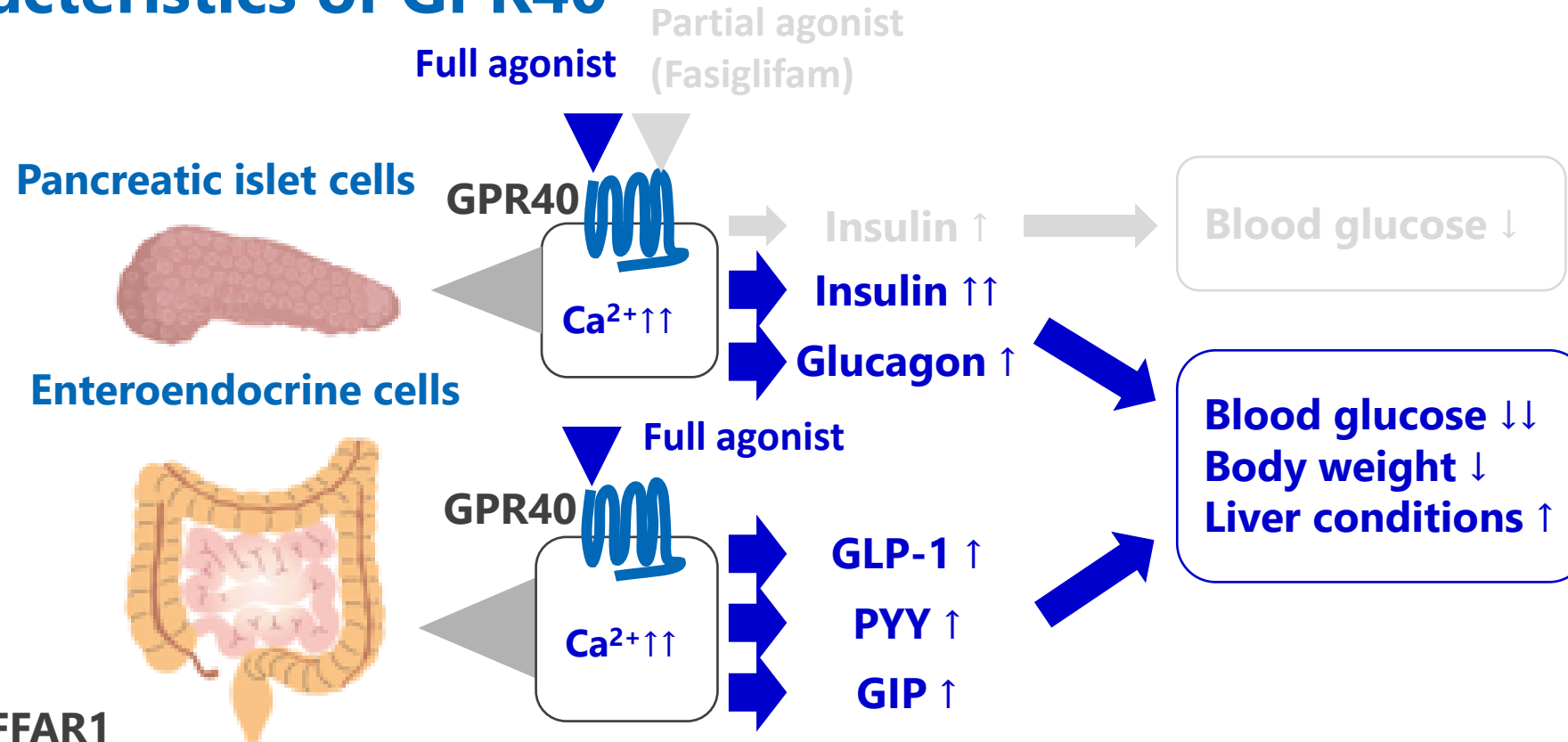
## ■ GPR40/FFAR1

- GPCR activated by endogenous ligands of medium-to-long chain fatty acids
- Expressed in pancreatic islet cells and enteroendocrine cells

## ■ Partial agonist - Fasiglifam

- Markedly improved glycemic control by increasing *insulin* secretion in patients with T2DM

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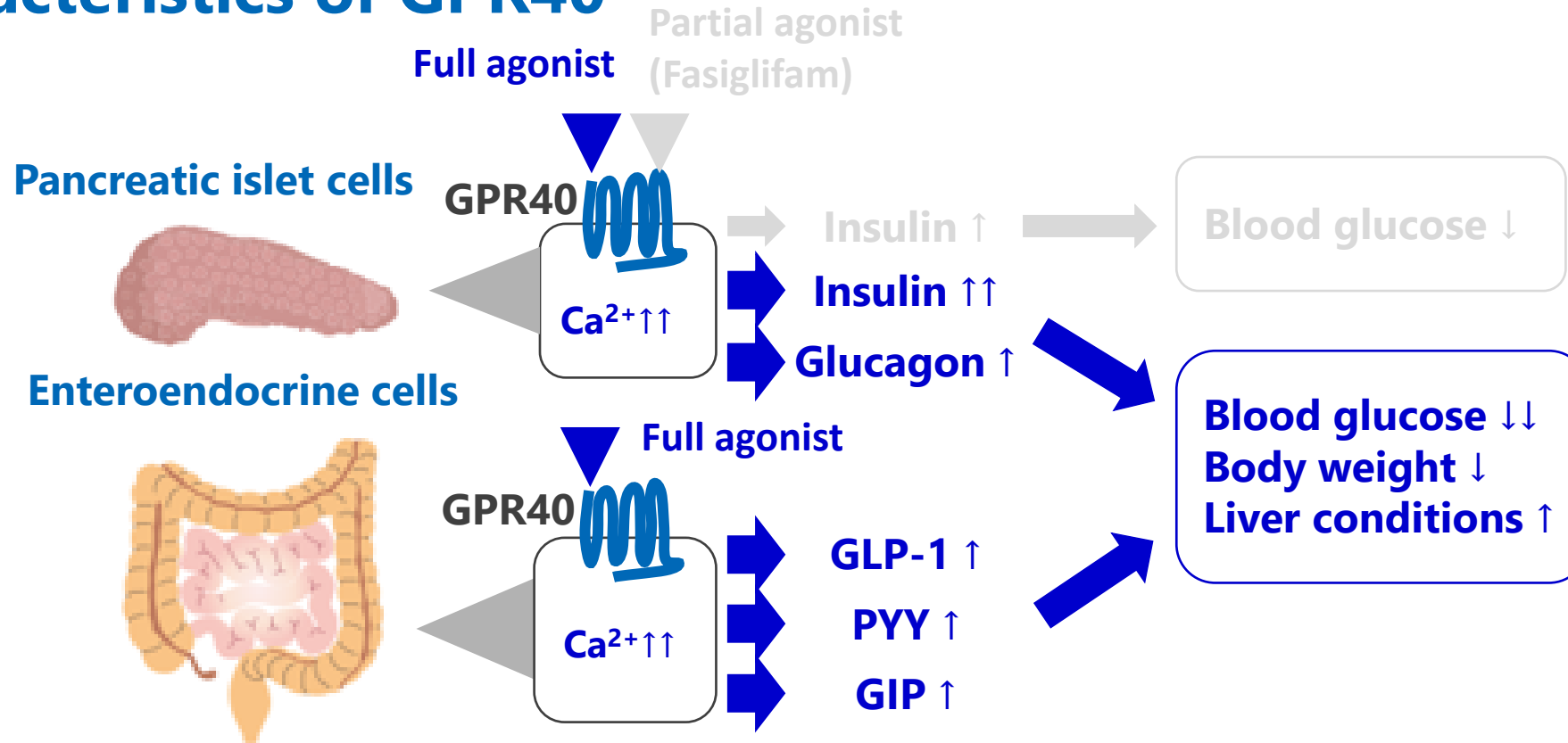
## ■ Partial agonist - Fasiglifam

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## ■ Full agonist

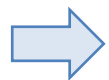
- Stimulates secretion of not only *insulin*, but also *GLP-1*, *GIP*, *PYY*, and *glucagon*

# Characteristics of GPR40



## ■ Full agonist

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**GPR40 full agonist is expected to be a new drug option for the treatment of *diabetes*, *obesity*, and *NAFLD/NASH***

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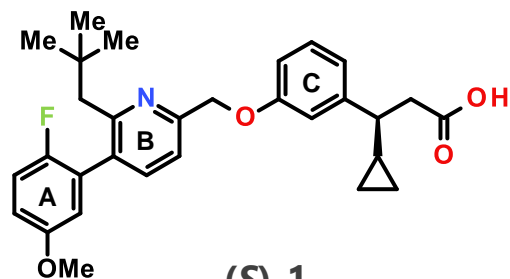
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# Exploration of New Lead Compound



(S)-1

hGPR40 EC<sub>50</sub>: 150 nM

clogP: 7.1

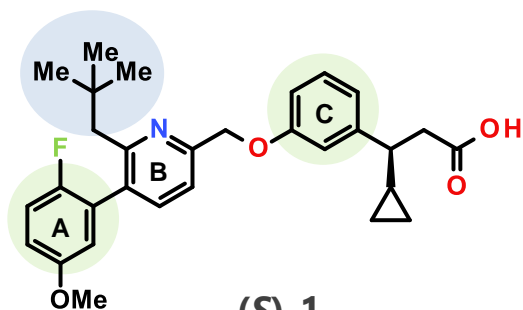
Previously reported GPR40 full agonist  
(WO2013122029)

## Challenges of compound (S)-1

- Aromaticity (negative impact on overall physicochemical properties, DMPK profiles...)
- Insufficient agonistic activity



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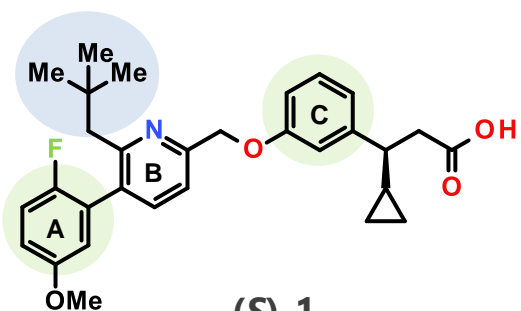
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## Initial SAR

- The hydrophobic substituent and the terminal aromatic rings (A and C) are essential for potent agonistic activity

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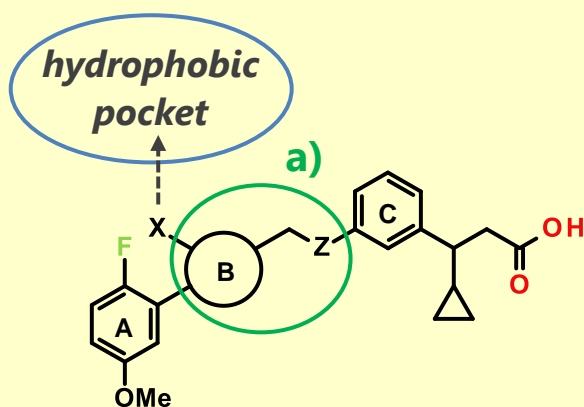
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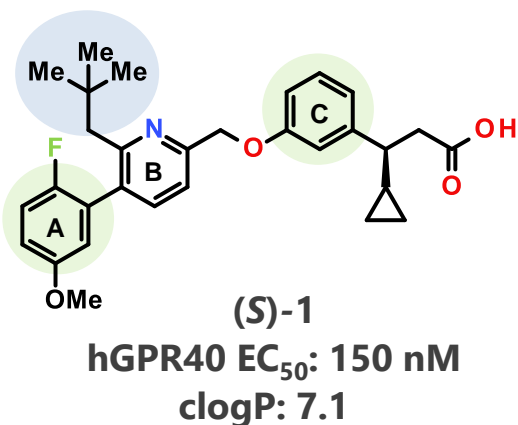
- The hydrophobic substituent and the terminal aromatic rings (A and C) are essential for potent agonistic activity

## Molecular design and hypothesis



- a. The central aromatic ring (B) of compound (S)-1 would serve as just a linker to keep the position and distance of terminal aromatic rings (A and C), therefore, would be replaced with a saturated ring system

# Exploration of New Lead Compound



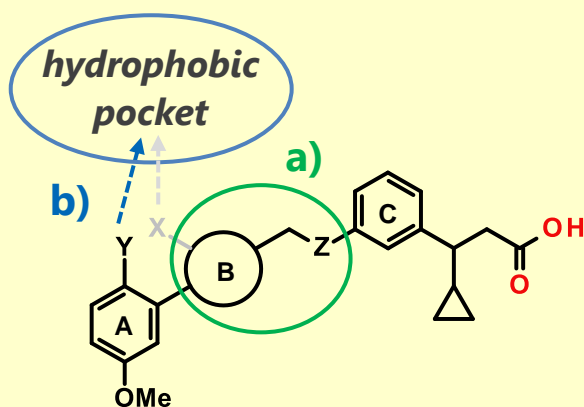
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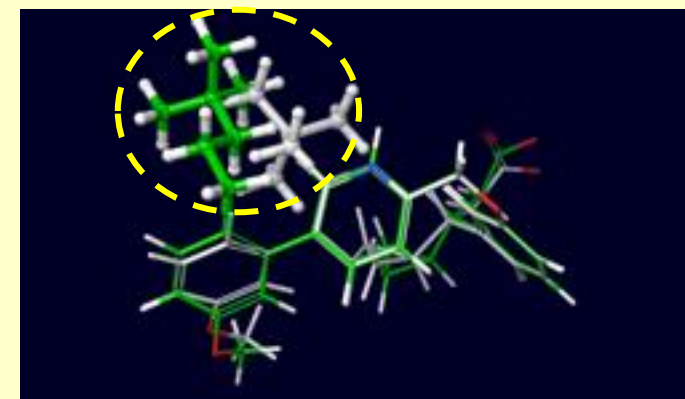
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- The hydrophobic substituent and the terminal aromatic rings (A and C) are essential for potent agonistic activity

## Molecular design and hypothesis

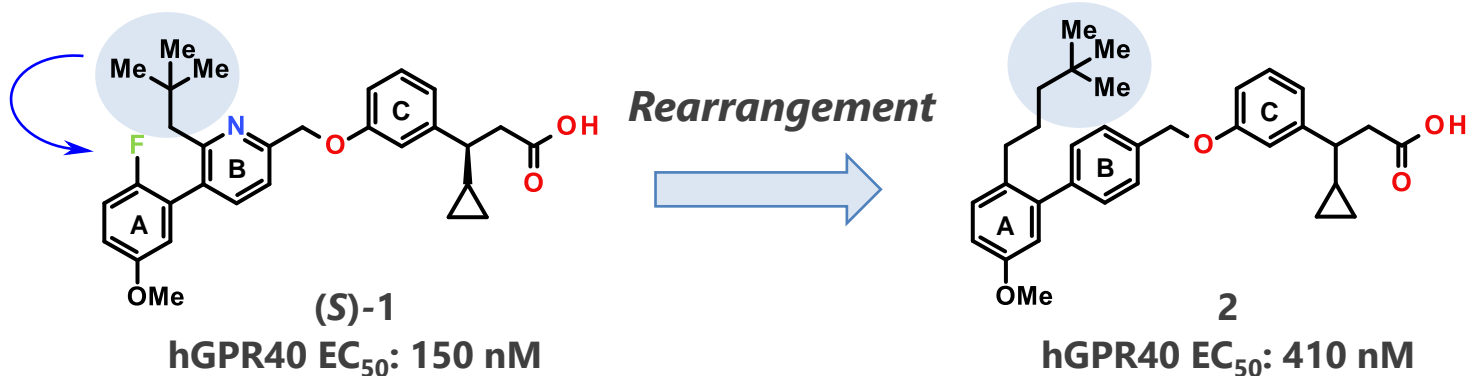


- The central aromatic ring (B) of compound (S)-1 would serve as just a linker to keep the position and distance of terminal aromatic rings (A and C), therefore, would be replaced with a saturated ring system
- Fluorine-substituted position of compound (S)-1 would easily access the presumed hydrophobic pocket that the neopentyl alkyl chain of compound (S)-1 occupies

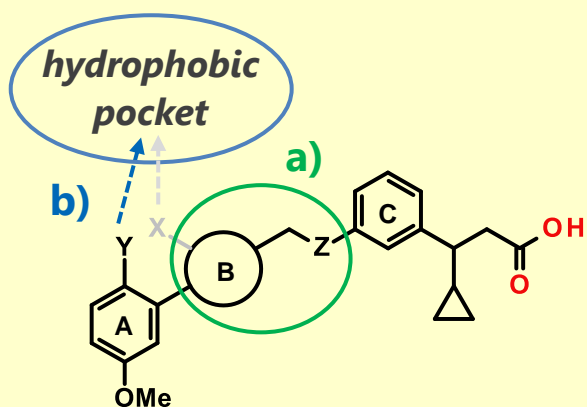


Flexible alignment of (S)-1 (gray) and designed compound (green) using Maestro.

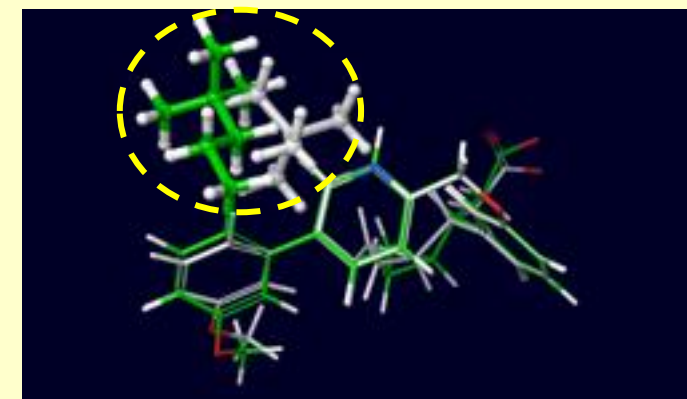
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## Molecular design and hypothesis



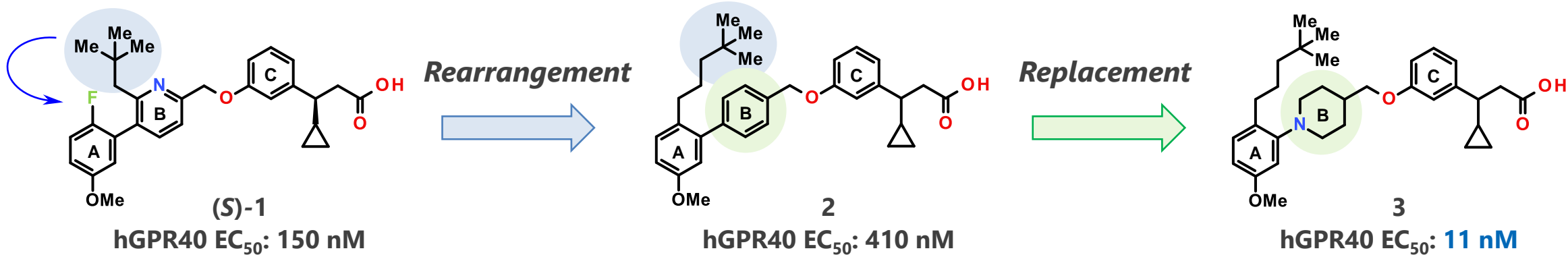
- The central aromatic ring (B) of compound **(S)-1** would serve as just a linker to keep the position and distance of terminal aromatic rings (A and C), therefore, would be replaced with a saturated ring system
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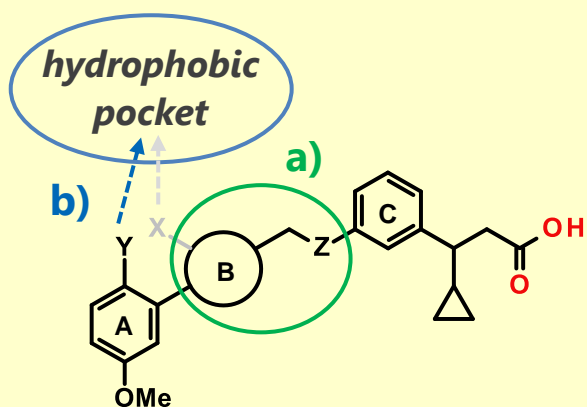
Flexible alignment of compounds **(S)-1** (gray) and **2** (green) using Maestro.

- **Rearrangement of the hydrophobic moiety on the central ring (B) to the terminal ring (A) retained agonistic activity**

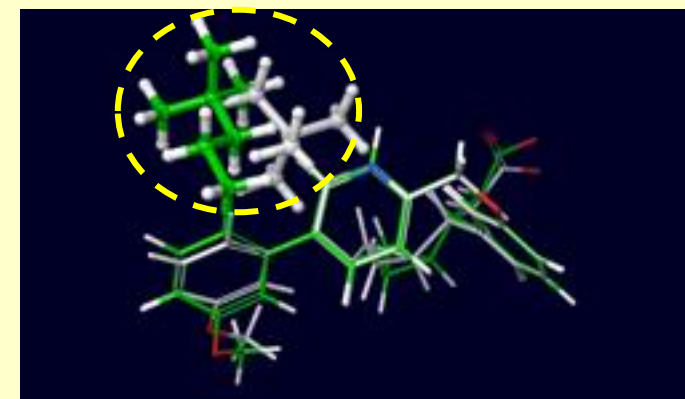
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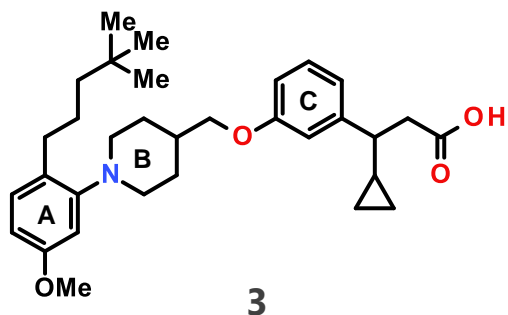
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- Fluorine-substituted position of compound **(S)-1** would easily access the presumed hydrophobic pocket that the neopentyl alkyl chain of compound **(S)-1** occupies



Flexible alignment of compounds **(S)-1** (gray) and **2** (green) using Maestro.

- **4-Methyl piperidine ether 3** was identified as a new lead compound which showed **potent agonistic activity**

# Effect of Substituent on the Benzene Ring A



3

hGPR40 EC<sub>50</sub>: 11 nM

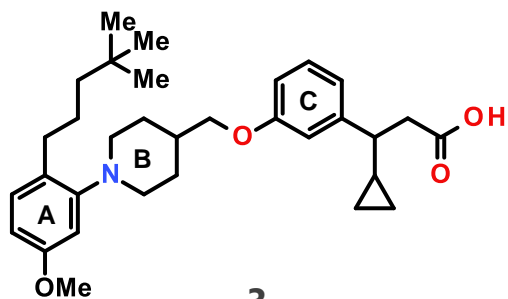
clogP: 8.4

Cell viability ATP at 30 μM: 0.1%

## Challenge of compound 3

- Highly lipophilic property

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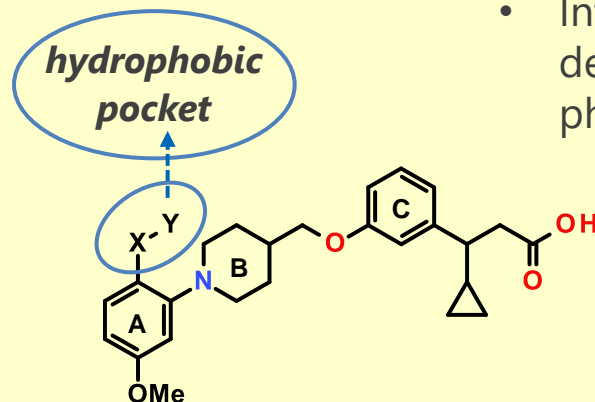
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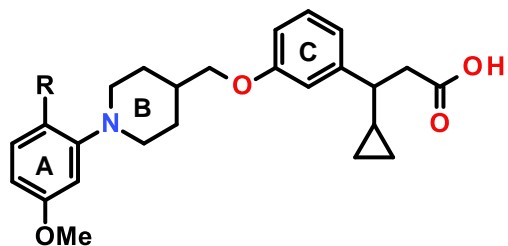
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## Molecular design



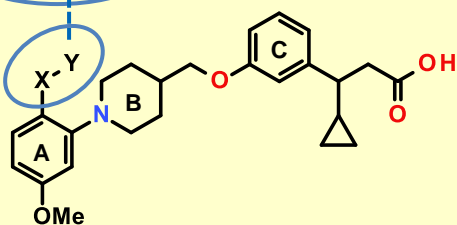
- Introduction of a polar linker (X and/or Y) to decrease the lipophilicity and to improve the physicochemical properties

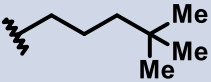
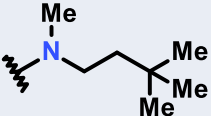
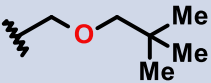
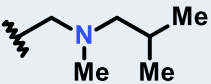
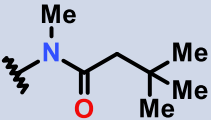
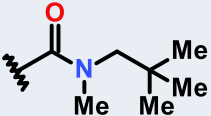
# Effect of Substituent on the Benzene Ring A



## Molecular design

hydrophobic pocket



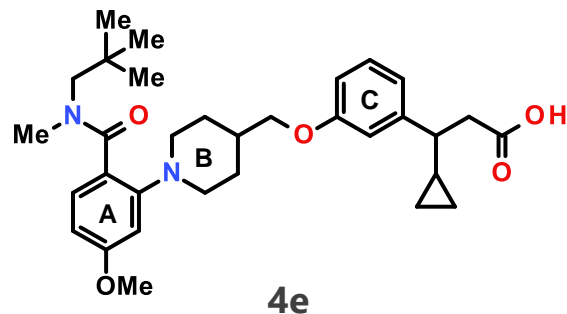
Compound	R	hEC <sub>50</sub> nM	E <sub>max</sub>	clogP	Cell viability ATP % at 30 μM
3		11	106%	8.4	0.1
4a		190	108%	7.6	0.1
4b		97	112%	6.5	0.1
4c		1000	110%	4.0	80.7
4d		2200	96%	5.8	76.4
4e		100	107%	5.6	82.2

- Introduction of amide moiety as a linker led to the improvement of druggability especially for lipophilicity and cell viability (set the target clogP value: <6.0)

\*All compounds are racemate unless otherwise noted



# Effect of Substituents on the Amide Group



4e

hGPR40 EC<sub>50</sub>: 100 nM

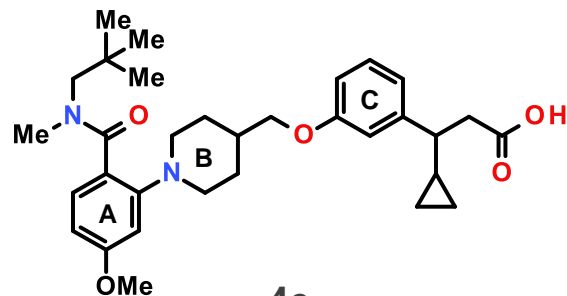
clogP: 5.6

Cell viability ATP at 30 μM: 82.2%

## Challenge of compound 4e

- Insufficient agonistic activity

# Effect of Substituents on the Amide Group



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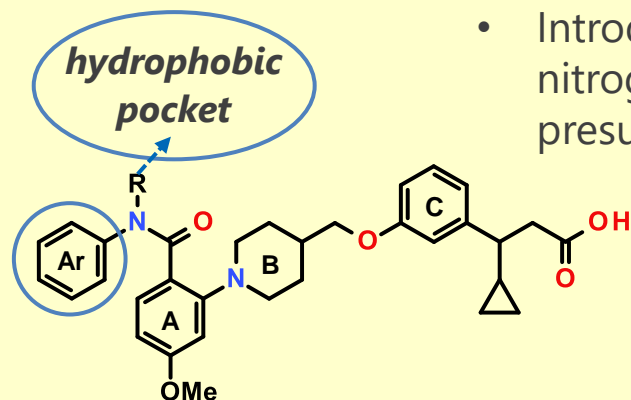
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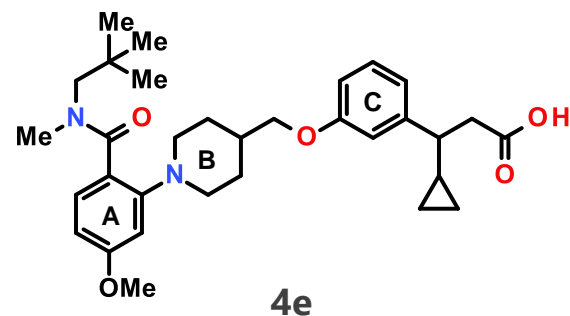
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## Molecular design



- Introduction of aromatic ring onto the amide nitrogen to restrict the *N*-alkyl moiety to the presumed hydrophobic pocket

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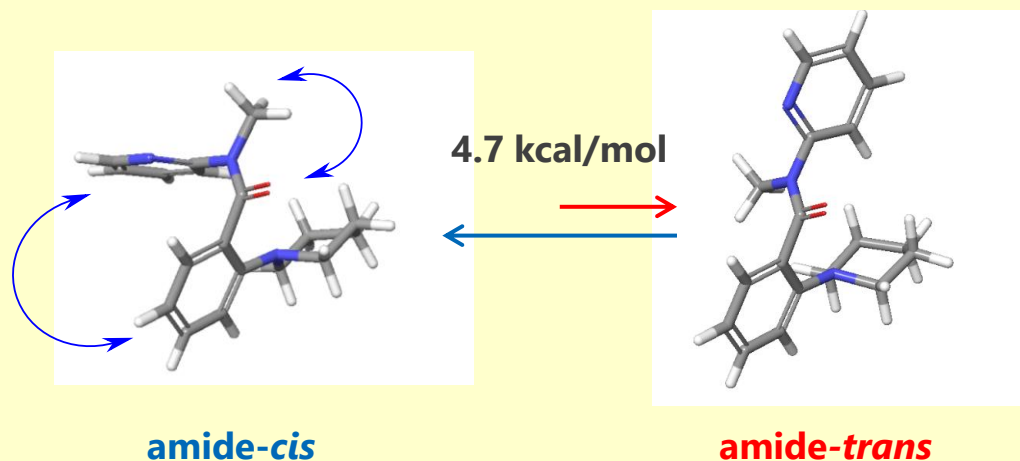
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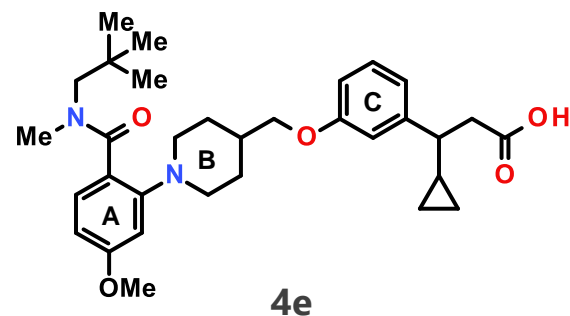
- Introduction of aromatic ring on the amide nitrogen to restrict the *N*-alkyl moiety to the presumed hydrophobic pocket

## Conformational preference of *N*-methylbenzanilide



The structure of *N*-methylbenzanilide derivatives place the aromatic ring in *cis* conformation to each other, and the methyl substituent on nitrogen is *cis* to the carbonyl group

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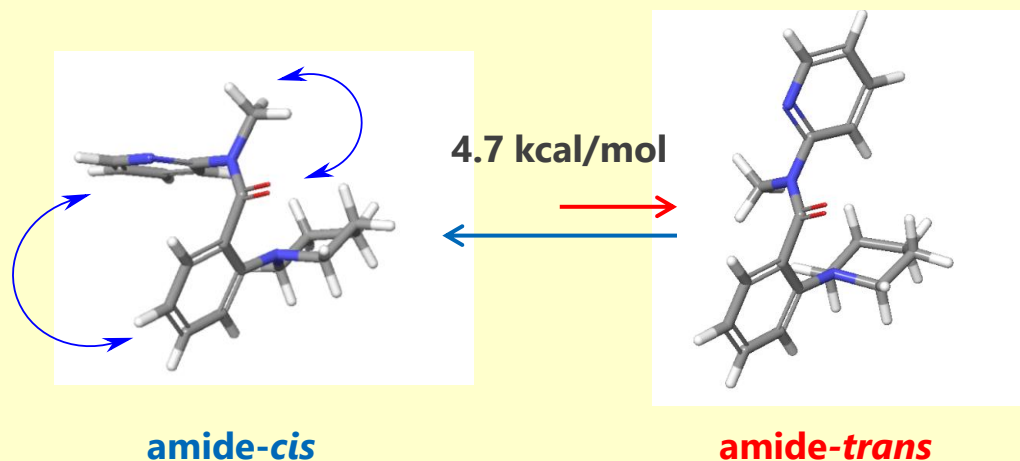
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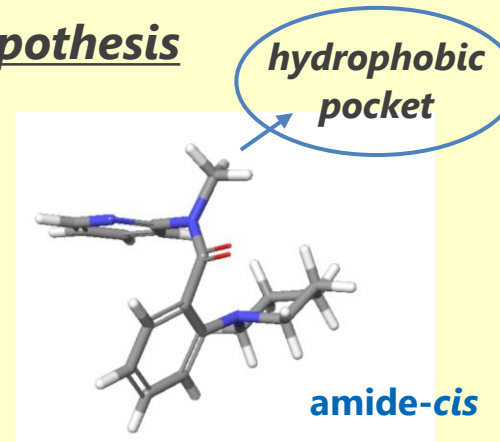
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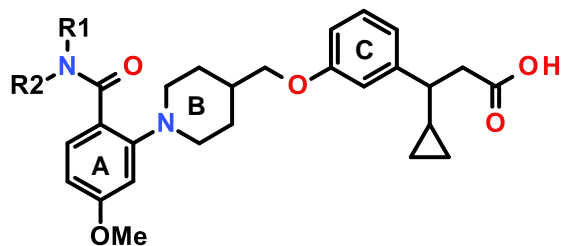


## Hypothesis



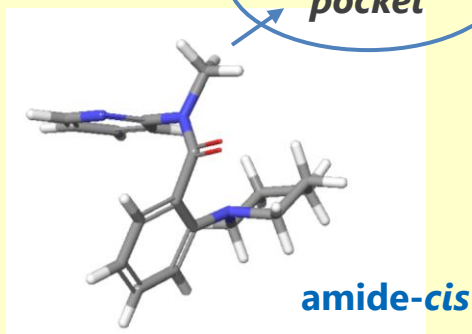
Incorporation of suitable lipophilic moiety onto the nitrogen group of the benzanilide moiety would enhance the agonistic activity

# Effect of Substituents on the Amide Group

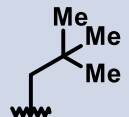
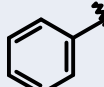
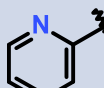


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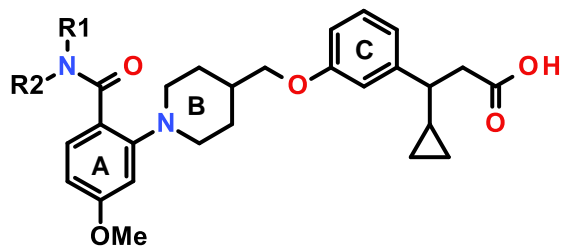
hydrophobic pocket



amide-cis

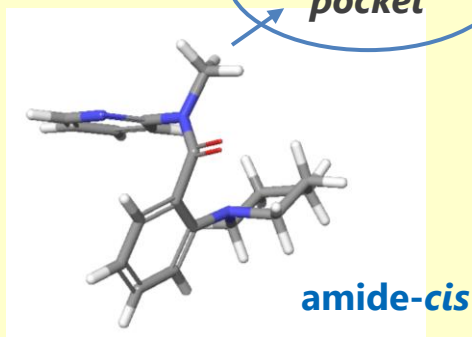
Compound	R <sup>1</sup>	R <sup>2</sup>	hEC <sub>50</sub> nM	E <sub>max</sub>	clogP
4e		Me	100	107%	5.6
4f	Me		140	101%	5.5
4g	Me		180	105%	4.0

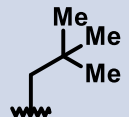
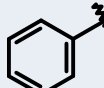
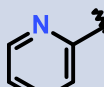
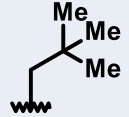
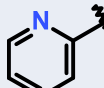
# Effect of Substituents on the Amide Group



## Hypothesis

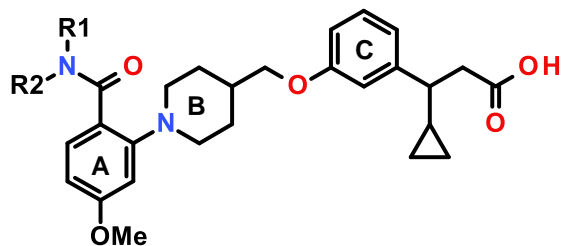
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4f	Me		140	101%	5.5
4g	Me		180	105%	4.0
4h			26	110%	5.9

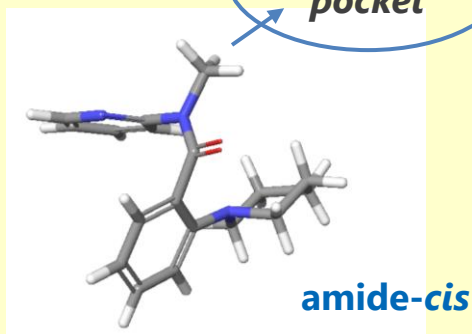
- Incorporation of aromatic ring and suitable lipophilic moiety dramatically impacted agonistic activity

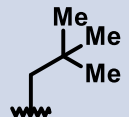
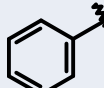
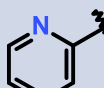
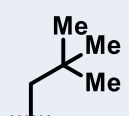
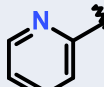
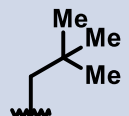
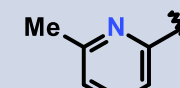
# Effect of Substituents on the Amide Group



## Hypothesis

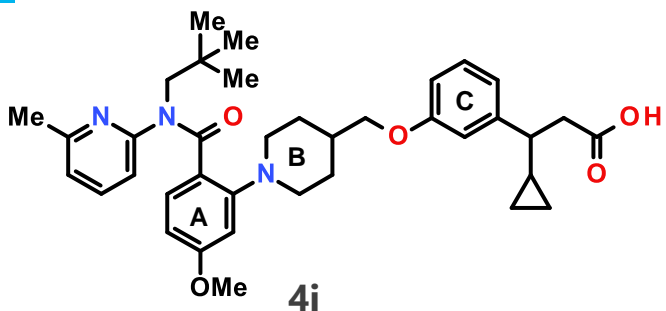
hydrophobic pocket



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4f	Me		140	101%	5.5
4g	Me		180	105%	4.0
4h			26	110%	5.9
4i			17	109%	6.4

- Incorporation of aromatic ring and suitable lipophilic moiety dramatically impacted agonistic activity
- Introduction of a "magic methyl" group onto the pyridine ring led to a discovery of 4i with a good balance between agonistic activity and lipophilicity

# Effect of Polar Aromatic Ring of Phenyl Propanoic Acid Moiety



4i

hGPR40 EC<sub>50</sub>: 17 nM

clogP: 6.4

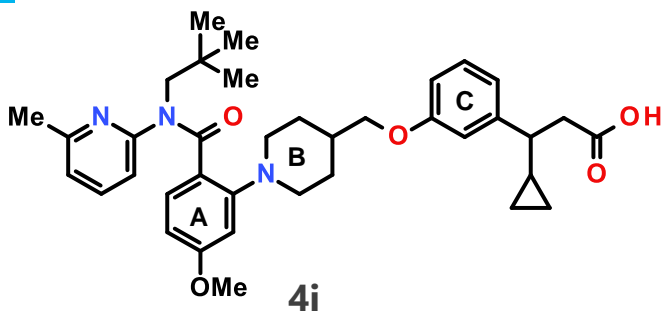
Cell viability ATP at 30 μM: 5.0%

## Challenge of compound 4i

- Slightly high lipophilicity (Target clogP value: <6.0)



# Effect of Polar Aromatic Ring of Phenyl Propanoic Acid Moiety



4i

hGPR40 EC<sub>50</sub>: 17 nM

clogP: 6.4

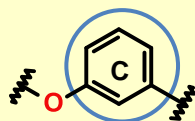
Cell viability ATP at 30 μM: 5.0%

## Challenge of compound 4i

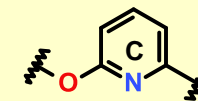
- Slightly high lipophilicity (Target clogP value: <6.0)

## Molecular design

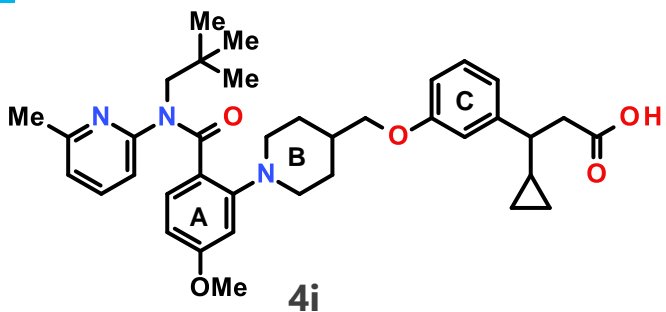
- Replacement of the benzene ring (C) with a 2-alkoxy pyridine ring to reduce the lipophilicity



Basic property is NOT tolerable for agonistic activity



# Effect of Polar Aromatic Ring of Phenyl Propanoic Acid Moiety



4i

hGPR40 EC<sub>50</sub>: **17 nM**

clogP: 6.4

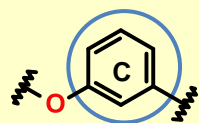
Cell viability ATP at 30 μM: 5.0%

## Challenge of compound 4i

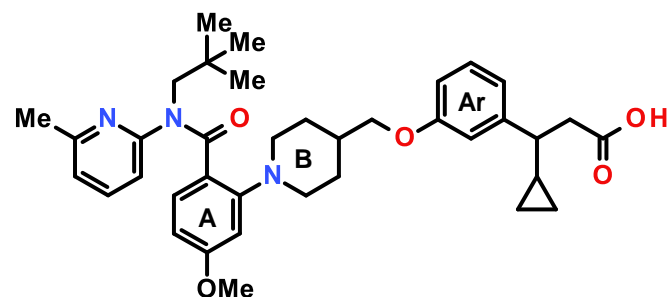
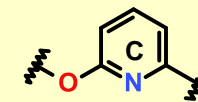
- Slightly high lipophilicity (Target clogP value: <6.0)

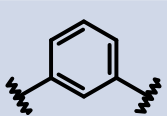
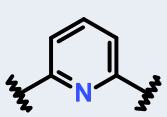
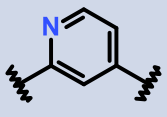
## Molecular design

- Replacement of the benzene ring (C) with a 2-alkoxy pyridine ring to reduce the lipophilicity



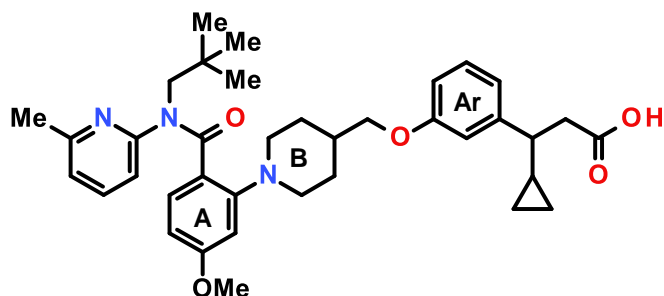
Basic property is NOT tolerable for agonistic activity

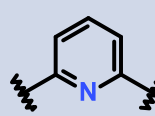
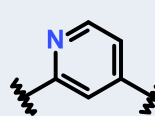


Compound	Ar	hEC <sub>50</sub> nM	E <sub>max</sub>	clogP
4i		17	109%	6.4
5a		39% at 10 μM	-	5.8
5b		17	112%	5.8

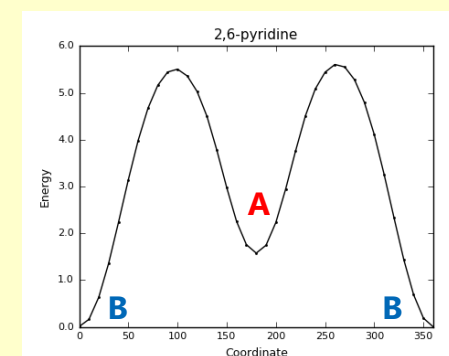
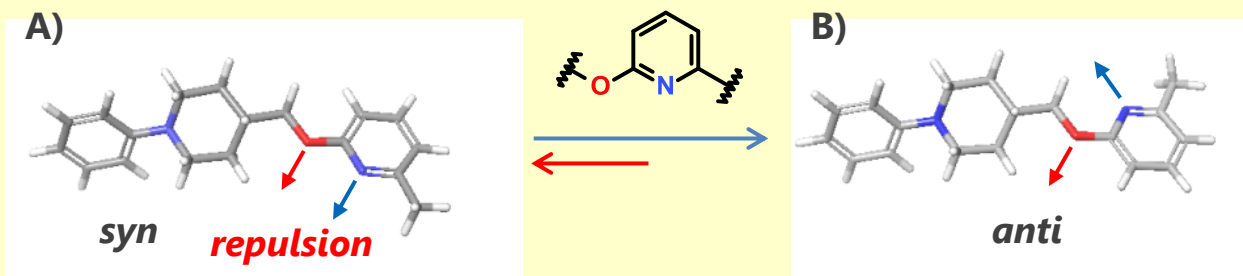
■ 2,4-Disubstituted pyridine derivative 5b retained agonistic activity with decreased lipophilicity

# Effect of Polar Aromatic Ring of Phenyl Propanoic Acid Moiety

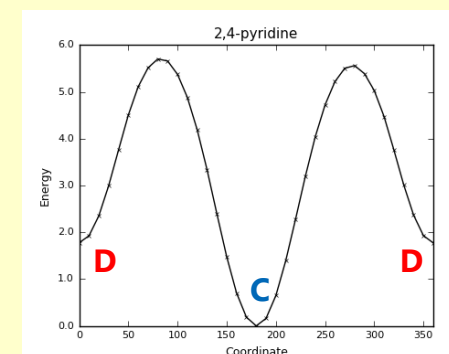
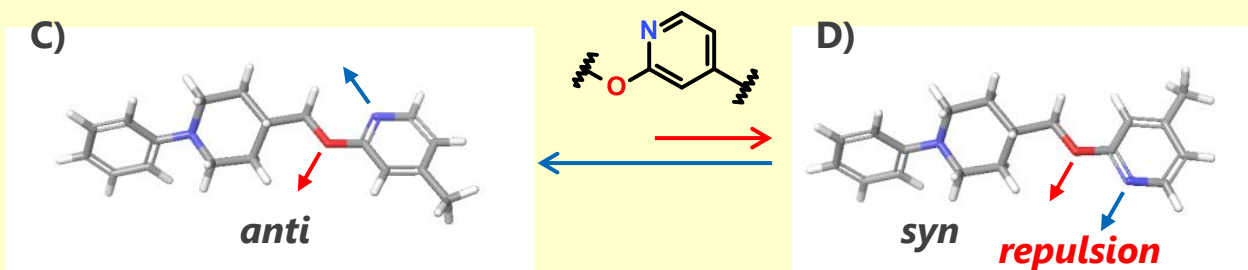


Compound	Ar	hEC <sub>50</sub> nM	E <sub>max</sub>	clogP
5a		39% at 10 μM	-	5.8
5b		17	112%	5.8

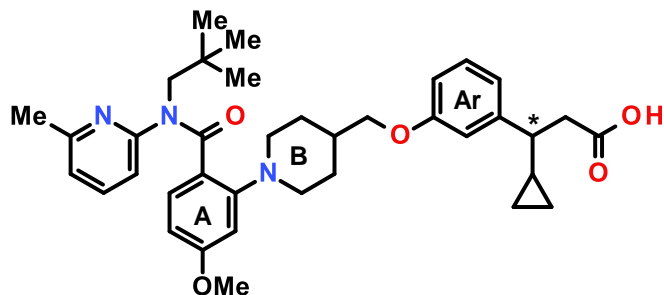
**2,6-disubstituted pyridine (5a): presumed active conformer A is less stable than B**

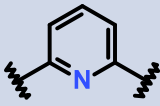
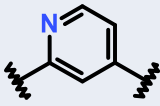
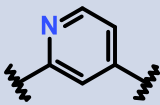
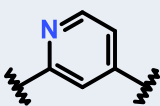


**2,4-disubstituted pyridine (5b): presumed active conformer C is more stable than D**



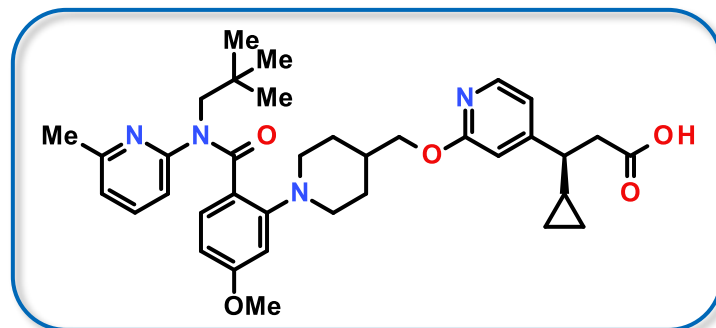
# Effect of Polar Aromatic Ring of Phenyl Propanoic Acid Moiety



Compound	Ar	hEC <sub>50</sub> nM	E <sub>max</sub>	clogP
5a		39% at 10 μM	-	5.8
5b		17	112%	5.8
(S)-5b SCO-267		12	108%	5.8
(R)-5b		84	109%	5.8

- (S)-5b was identified as an eutomer based on its agonistic activity
- (S)-5b (SCO-267) was selected for further evaluation

# Profiles of SCO-267



## ■ GPR40 agonistic activity

human GPR40 EC<sub>50</sub>: 12 nM

## ■ Pharmacokinetic profiles in rat/mouse

Good oral bioavailability

Compound	Species	F (%)	Intravenous (0.1 mg/kg)		Oral (1 mg/kg)		
			CL <sub>total</sub> (mL/h/kg)	V <sub>ss</sub> (mL/kg)	C <sub>max</sub> (ng/mL)	AUC <sub>0-8h</sub> (ng·h/mL)	MRT (h)
SCO-267	rat	16	1478	3094	19.9	126.6	4.1
	mouse	26	2584	1349	33.2	98.7	2.3

## ■ In vitro Tox assessment

Good cell viability profile (ATP: 92.1% at 30 μM), No risk of hERG inhibition and Ames test

## ■ In vivo Tox assessment

Wide safety margin (633- (male) to 776- (female) and 471- (male) to 421- (female) fold in the rat and dog 4-week studies, respectively), No concerns in the safety pharmacology studies

## 1. Introduction

## 2. Med. Chem. Campaign to Discover SCO-267

## 3. Pharmacological Efficacy of SCO-267

- Single Dosing and Repeated Dosing Effects in N-STZ-1.5 Rats (Diabetic Model)
- Repeated Dosing Effects in DIO-rats (Obese Model)
- Single Dosing and Repeated Dosing Effects in CDAHFD-fed Mice (NAFLD Model)

## 4. Summary

# Single Dosing Effects in N-STZ-1.5 Rats (Diabetic Model)

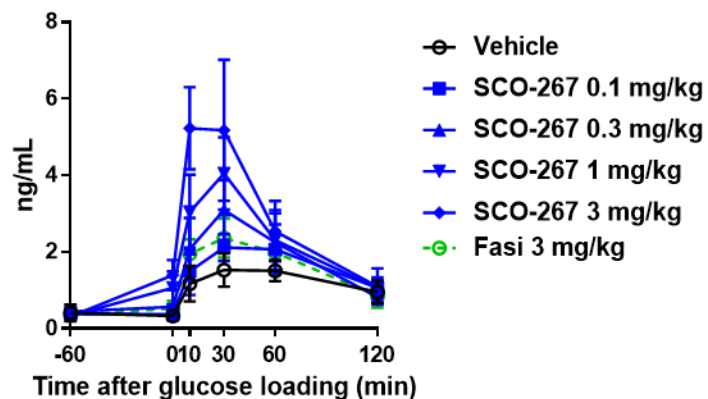
Male N-STZ-1.5 rats  
(25-week-old)  
Fasted

• Vehicle (*p.o.*) • SCO-267 (*p.o.*) • Fasiglifam (*p.o.*)

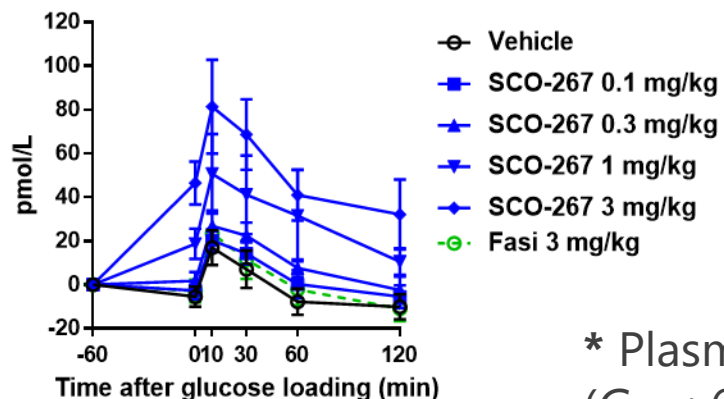
Single oral dosing → OGTT (1.5 g/kg) 1 h after drug dosing

\* $P < 0.025$  and # $P < 0.025$  vs. vehicle by one-tailed Williams' test and one-tailed Shirley-Williams test, respectively. Values are presented as mean  $\pm$  S.D. ( $n = 6$ ). Fasi, fasiglifam.

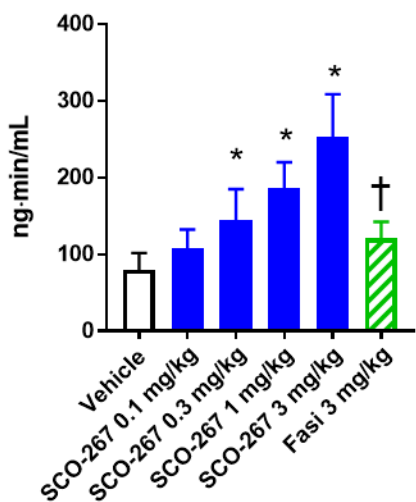
Plasma insulin



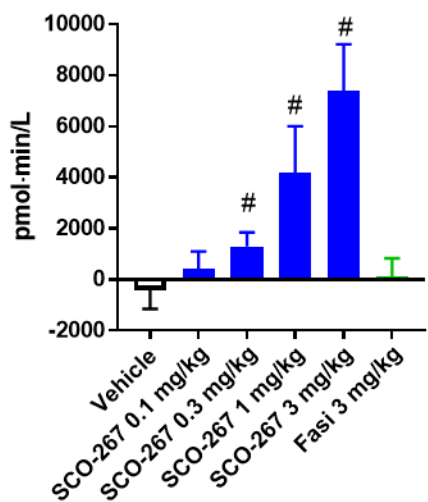
Plasma GLP-1 change



Plasma insulin AUC<sub>0-60min</sub>



Plasma GLP-1 change AUC<sub>-60-120 min</sub>



\* Plasma concentration of 3 mg/kg fasiglifam ( $C_{max}$ : 6170 ng/ml) in N-STZ-1.5 rats is similar levels with clinically effective exposure of 50 mg fasiglifam ( $C_{max}$ : 5300 ng/ml) in T2DM patients

■ **Single dosing of SCO-267 increased insulin and GLP-1 in N-STZ-1.5 rats in a dose-dependent manner**

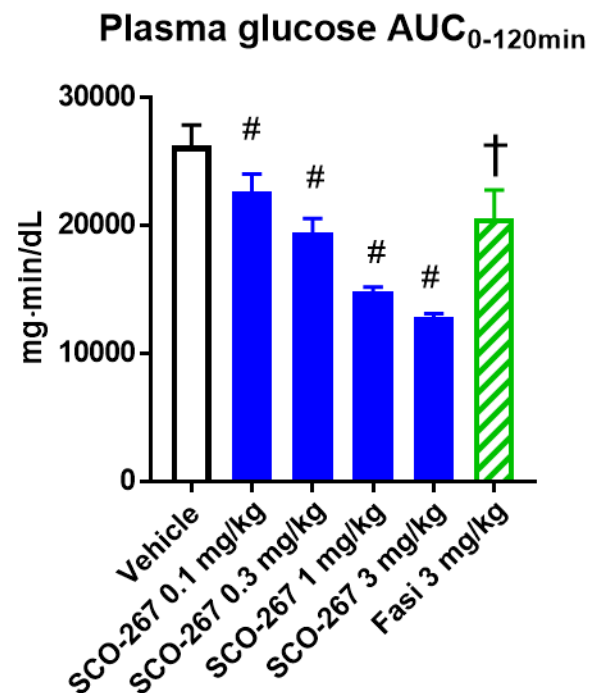
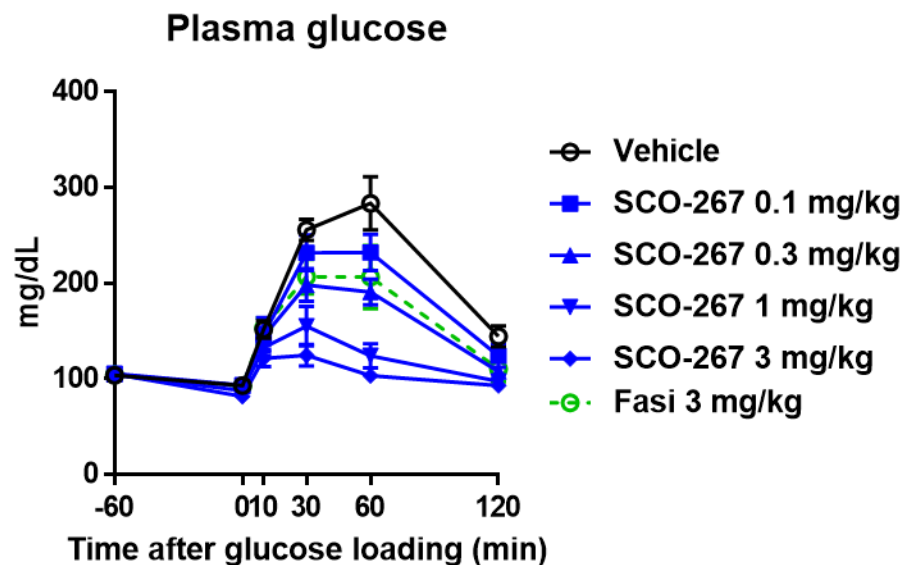
# Single Dosing Effects in N-STZ-1.5 Rats (Diabetic Model)

Male N-STZ-1.5 rats  
(25-week-old)  
Fasted

• Vehicle (p.o.) • SCO-267 (p.o.) • Fasiplifam (p.o.)

Single oral dosing → OGTT (1.5 g/kg) 1 h after drug dosing

\* $P < 0.025$  and # $P < 0.025$  vs. vehicle by one-tailed Williams' test and one-tailed Shirley-Williams test, respectively. Values are presented as mean  $\pm$  S.D. ( $n = 6$ ). Fasi, faspilifam.



- **0.3 mg/kg SCO-267 ( $C_{max}$ : 22.7 ng/ml) had a glucose-lowering efficacy comparable to that of 3 mg/kg faspilifam ( $C_{max}$ : 6170 ng/ml)**



# Repeated Dosing Effects in N-STZ-1.5 Rats (Diabetic Model)

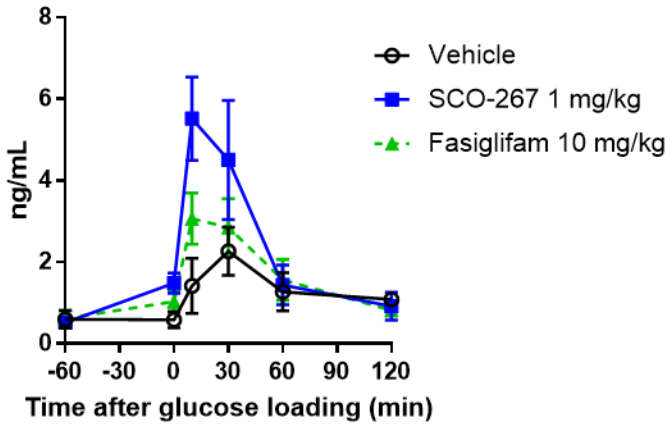
Male N-STZ-1.5 rats  
(27-week-old)

• Vehicle (*p.o.*) • SCO-267 (*p.o.*) • Fasiglifam (*p.o.*)

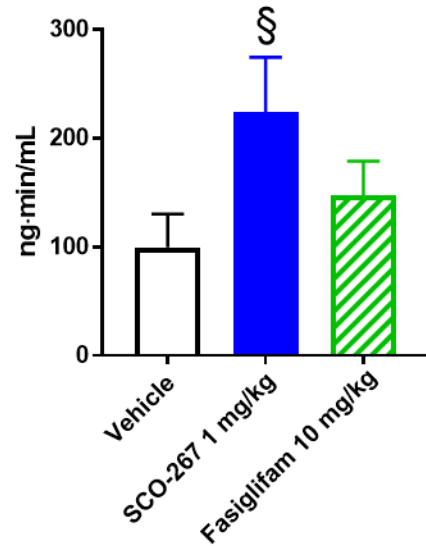
Once daily dosing for 2 weeks → OGTT (1.5 g/kg) 1 h  
after drug dosing

§ and ¶P<0.05 vs vehicle by Dunnett's test and Steel test, respectively.  
Values are presented as mean ± SD (n=6).

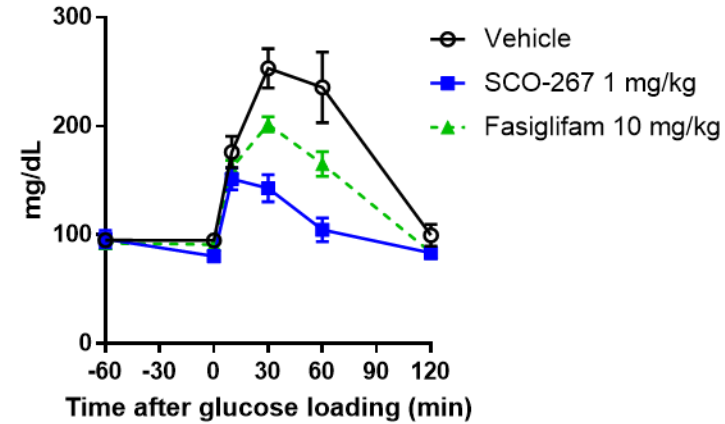
Plasma insulin



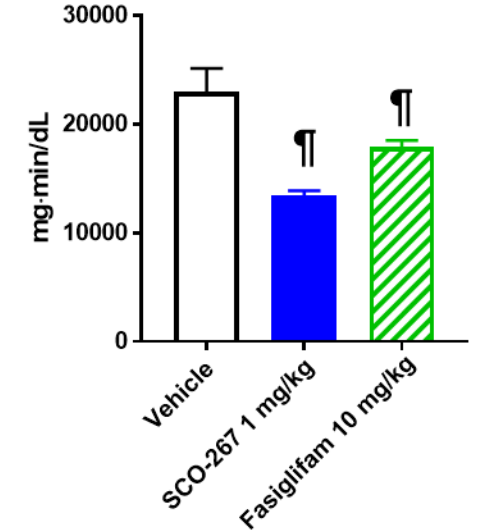
Plasma insulin AUC<sub>0-60min</sub>



Plasma glucose



Plasma glucose AUC<sub>0-120min</sub>



- 2 weeks of repeated dosing of SCO-267 resulted in sustained glucose lowering, and the efficacy was much better than that of fasiglifam
- 1 mg/kg (3-fold higher dose of MED) SCO-267 did not induce desensitization in N-STZ-1.5 Rats

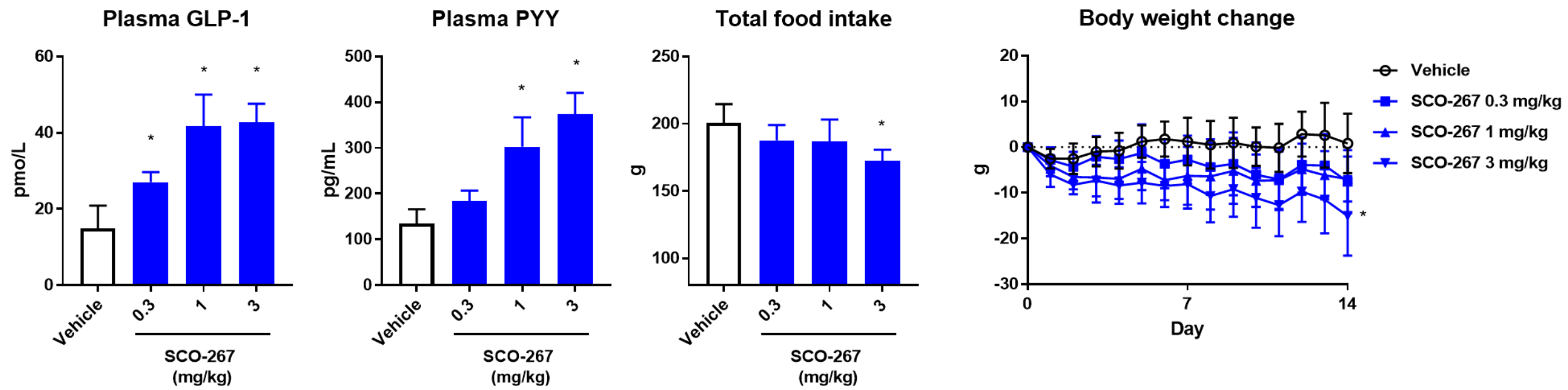
# Repeated Dosing Effects in DIO-rats (Obese Model)

Male F344 rats (49-week-old)  
 High fat diet (M12451M)  
 Baseline BW: 487 g

· Vehicle (p.o.) · SCO-267 (p.o.)

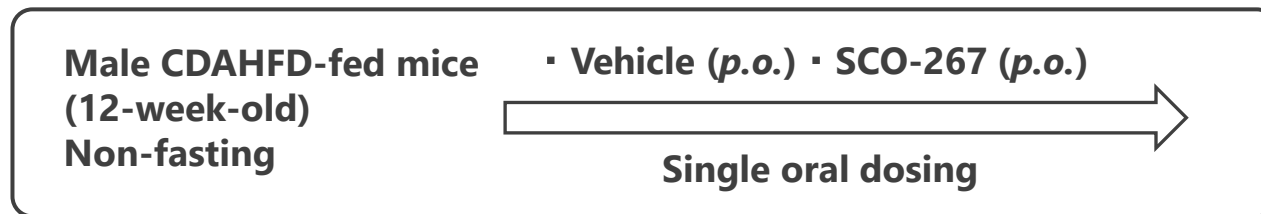
Once daily dosing for 2 weeks → measure GLP-1 and PYY  
 16 h after the 15<sup>th</sup> dosing

\* $P < 0.025$  vs. vehicle by one-tailed Williams' test.  
 Values are presented as mean  $\pm$  S.D. ( $n = 6$ ).

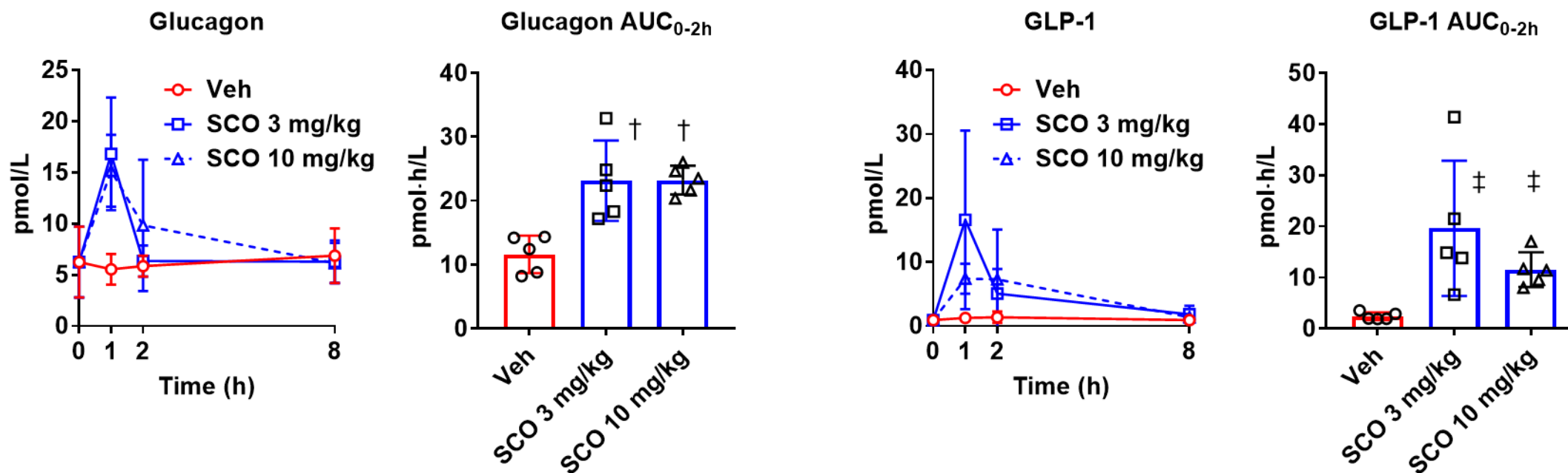


- Plasma GLP-1 and PYY levels remained high 16 h after the final dose of SCO-267
- These hormones contributed to the food intake reduction and body weight loss
- Efficacy on body weight control was durable

# Single Effects in CDAHFD-fed Mice (NAFLD Model)



Values are presented as mean  $\pm$  S.D. (n = 8).  
†P<0.025 vs. vehicle by one-tailed Williams' test.  
‡P<0.025 vs. vehicle by one-tailed Shirley-Williams test.



■ **SCO-267 stimulated glucagon and GLP-1 secretion in a mouse model of NAFLD**

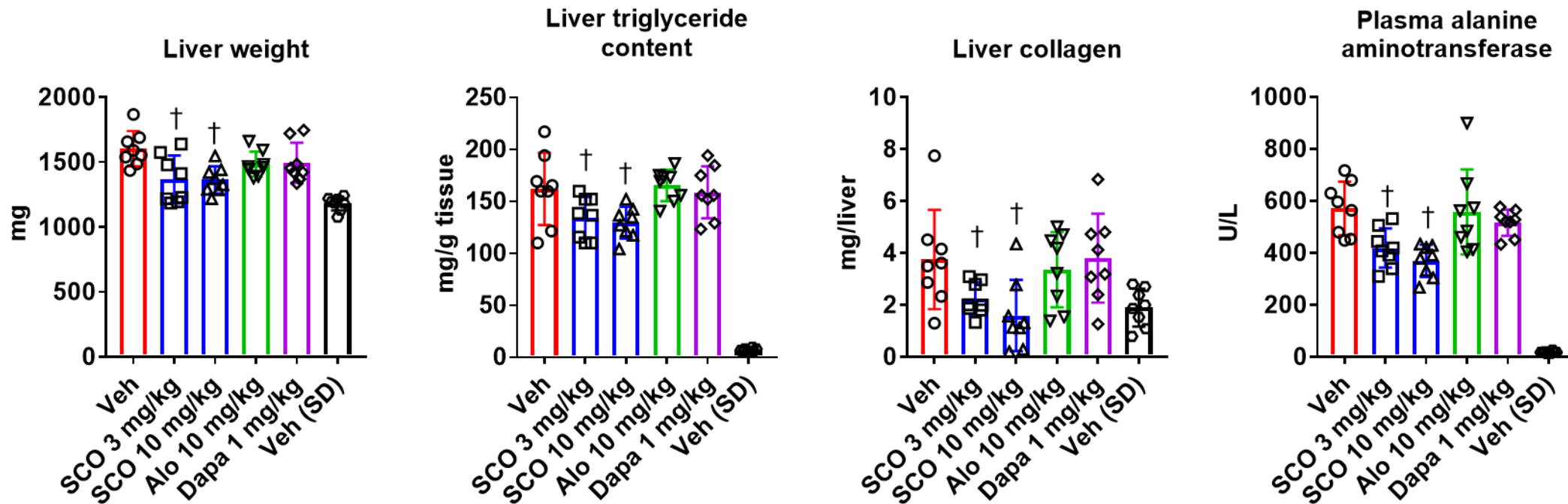
# Repeated Dosing Effects in CDAHFD-fed Mice (NAFLD Model)

Male CDAHFD-fed mice  
(11-week-old)  
Non-fasting

- Vehicle (*p.o.*) • SCO-267 (*p.o.* BID)
- Alogliptin (*p.o.* BID) • Dapagliflozin (*p.o.* BID)

Repeated administration for 4 weeks

Values are presented as mean  $\pm$  S.D. (n = 8).  
†P<0.025 vs. vehicle by one-tailed Williams' test.  
Alo, alogliptin benzoate; Dapa, dapagliflozin.



- SCO-267 decreased liver weight, liver triglyceride content, liver collagen levels, and plasma ALT levels in CDAHFD-fed mice, a non-diabetic animal model of NAFLD.
- These effects were induced without any effects on glucose levels or body weight

## 1. Introduction

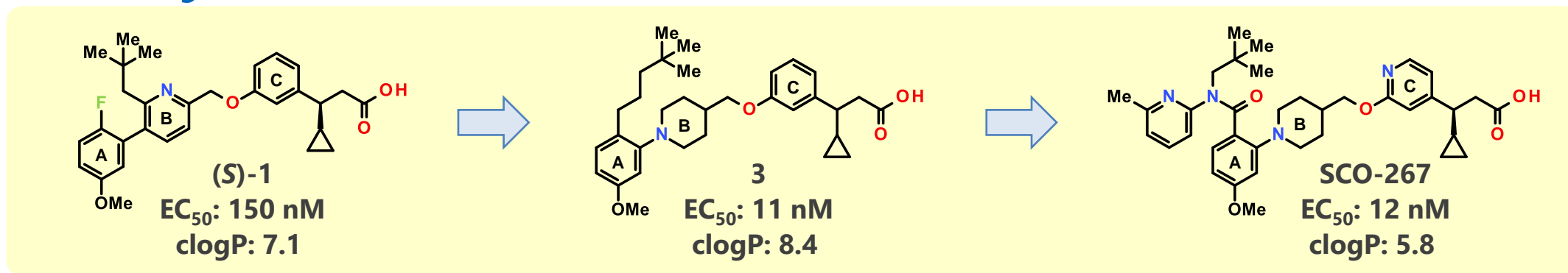
## 2. Med. Chem. Campaign to Discover SCO-267

## 3. Pharmacological Efficacy of SCO-267

- Single Dosing and Repeated Dosing Effects in N-STZ-1.5 Rats (Diabetic Model)
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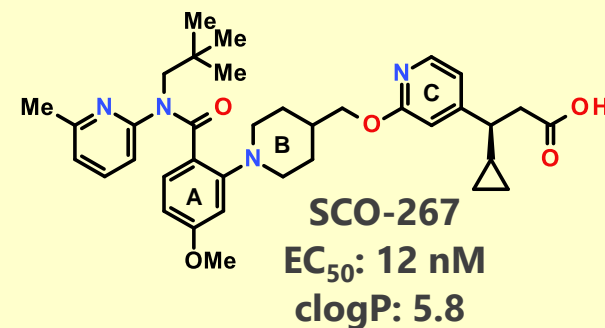
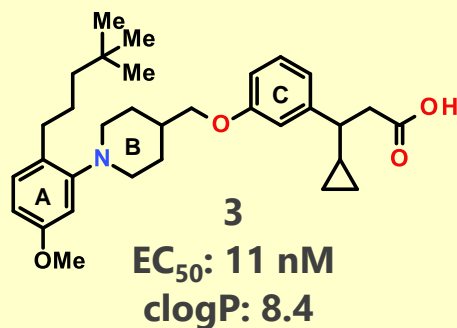
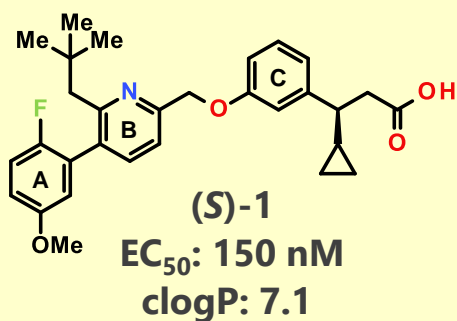
## 4. Summary

# Summary



- New lead compound **3** was discovered by rearrangement of the lipophilic moiety onto the terminal aromatic ring (A) and replacement of central aromatic ring (B) with piperidine linker
- Introduction of amide linker, then incorporation of aromatic ring and suitable lipophilic moiety onto the amide nitrogen showed good balance between agonistic activity and lipophilicity
- Further optimization of terminal ring (C) to reduce the lipophilicity led to the identification of **SCO-267**
- **SCO-267** exhibited potent GPR40 full agonistic activity, good oral bioavailability, and favorable in vitro/in vivo Tox profiles
- **SCO-267** effectively improved glycemic control in N-STZ-1.5 rats (*diabetic model*), decreased body weight in DIO-rats (*obese model*), and improved liver parameters in CDAHFD-fed mice (*NAFLD model*)

# Summary



- *Ph1 clinical study to evaluate safety, pharmacokinetics, and pharmacodynamic effect in healthy adults and people with impaired glucose tolerance is ongoing.*

# Acknowledgement

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Nobuyuki Amano

## ■ Analytical

Motoo Iida

## ■ Toxicol

Yoshimasa Ishimura



# **Thank you for your attention!**

## **&**

# **QA session**

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