University of California
San Francisco
advancing health worldwide™

Type 1 Diabetes; how does it happen, how do we manage it?

School of Medicine

Saleh Adi, MD
Clinical Professor
Pediatric Endocrinology

September, 2013

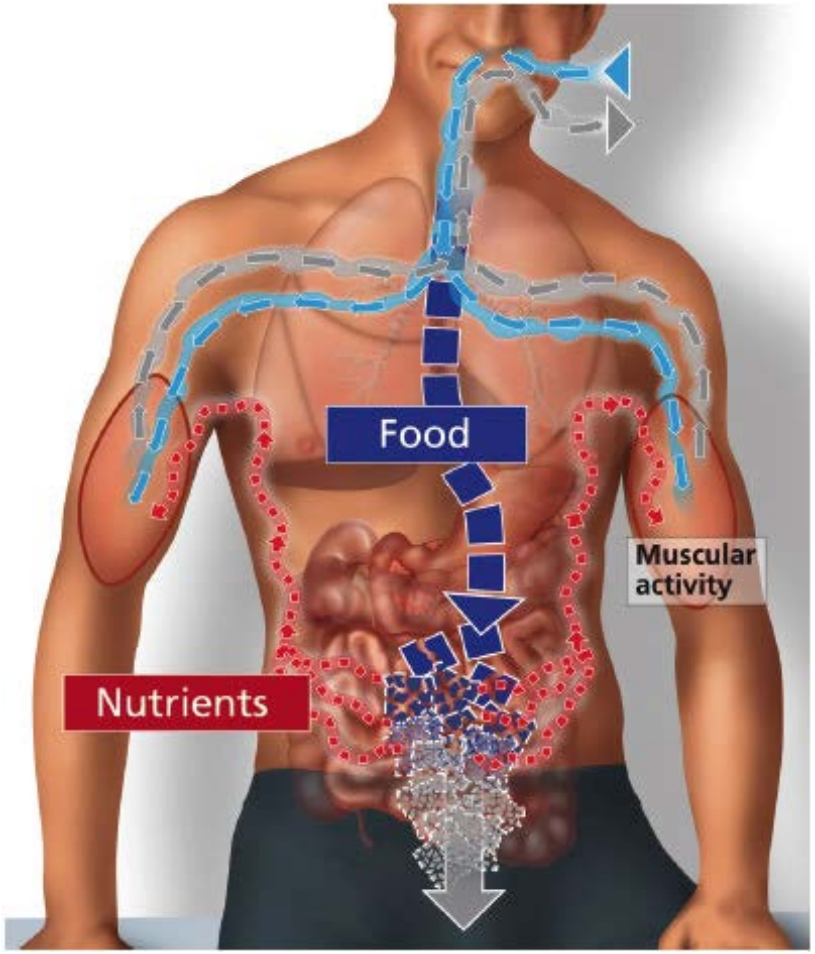
UCSF
University of California
San Francisco

Outline

- Normal physiology
- Types of diabetes
- Type 1 diabetes
- Autoimmunity
- Management: insulin and devices

UCSF
University of California
San Francisco

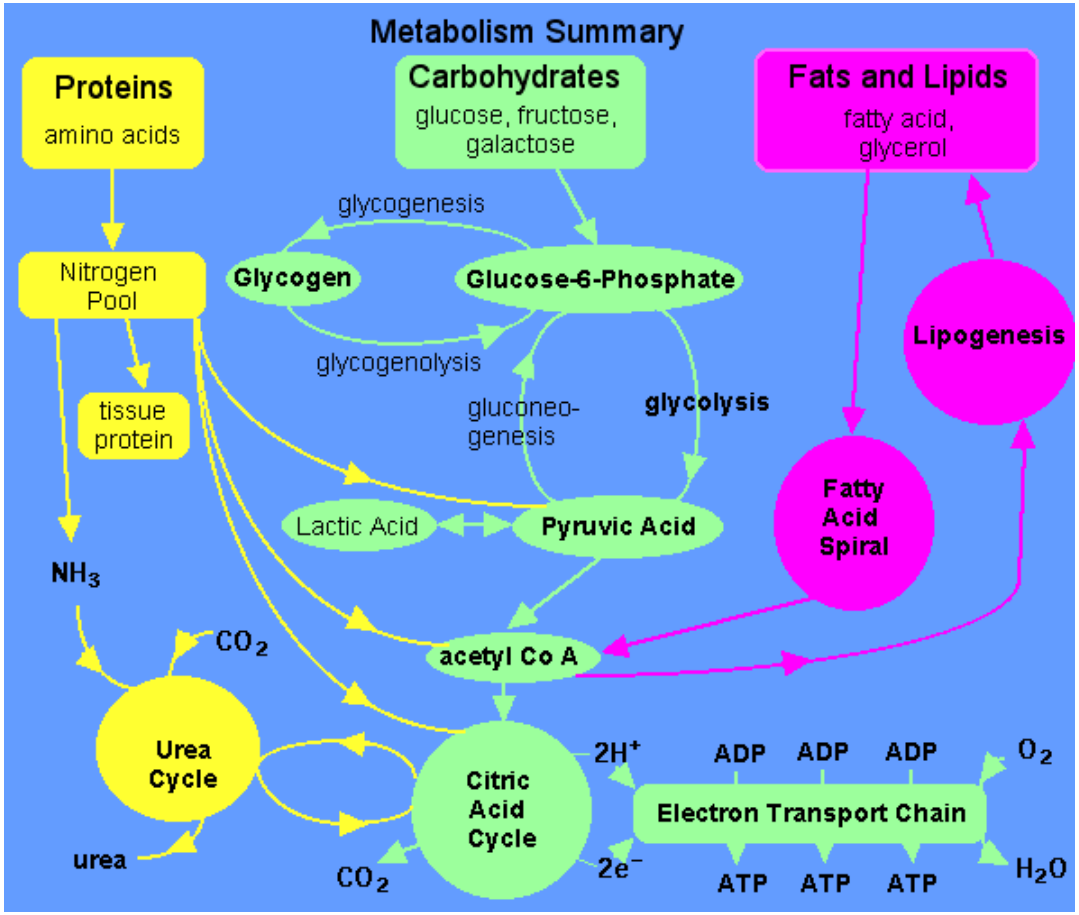
Normal physiology



School of Medicine

UCSF
University of California
San Francisco

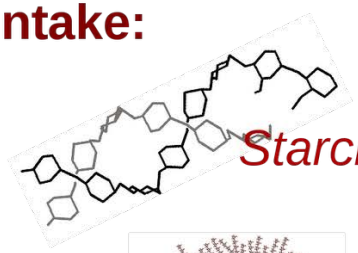
Normal physiology: Nutrition



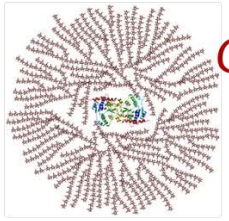
UCSF
University of California
San Francisco

Glucose metabolism

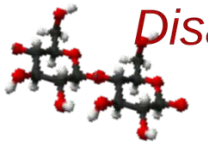
Intake:



Starch

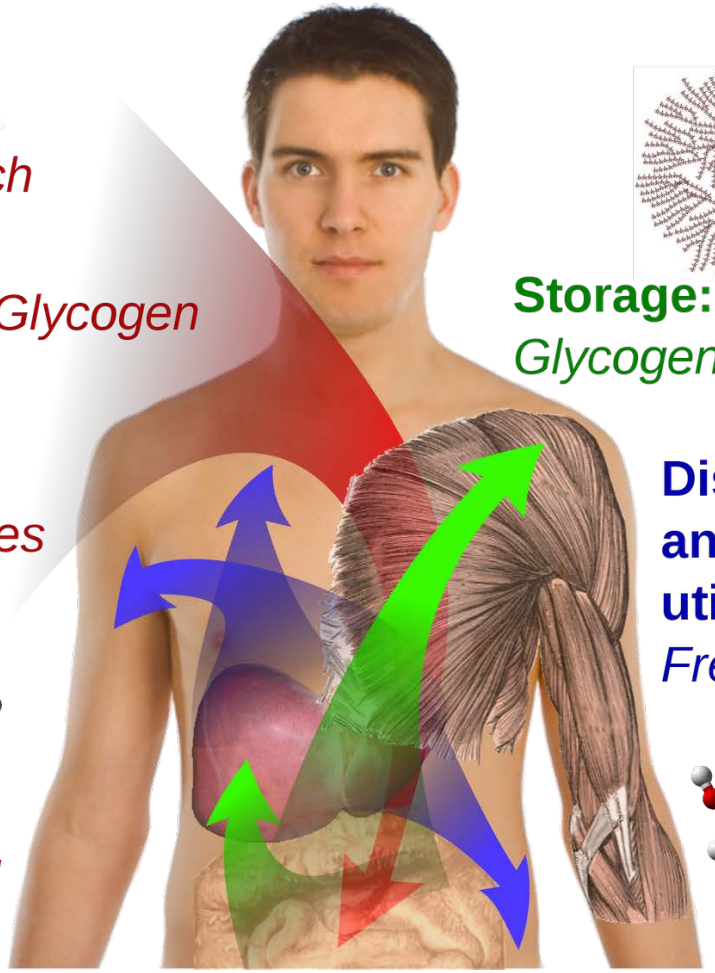


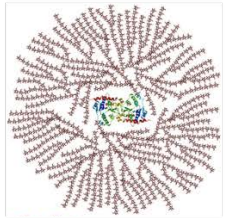
Glycogen



Disaccharides

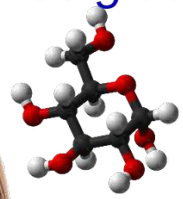
Monosaccharides (glucose, fructose, galactose)





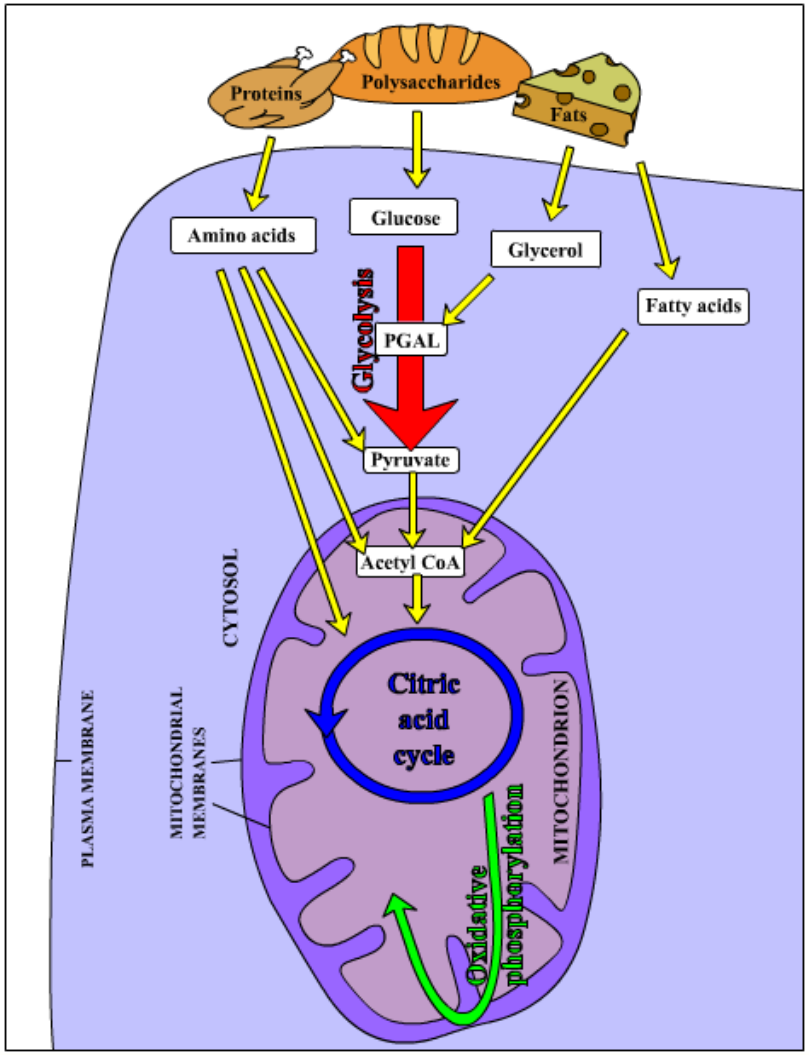
Storage:
Glycogen

Distribution and utilization:
Free glucose



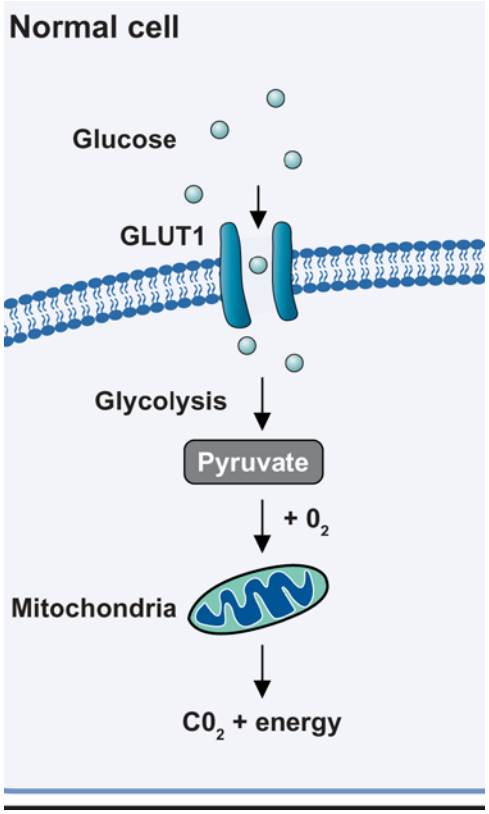
UCSF
University of California
San Francisco

Sugar



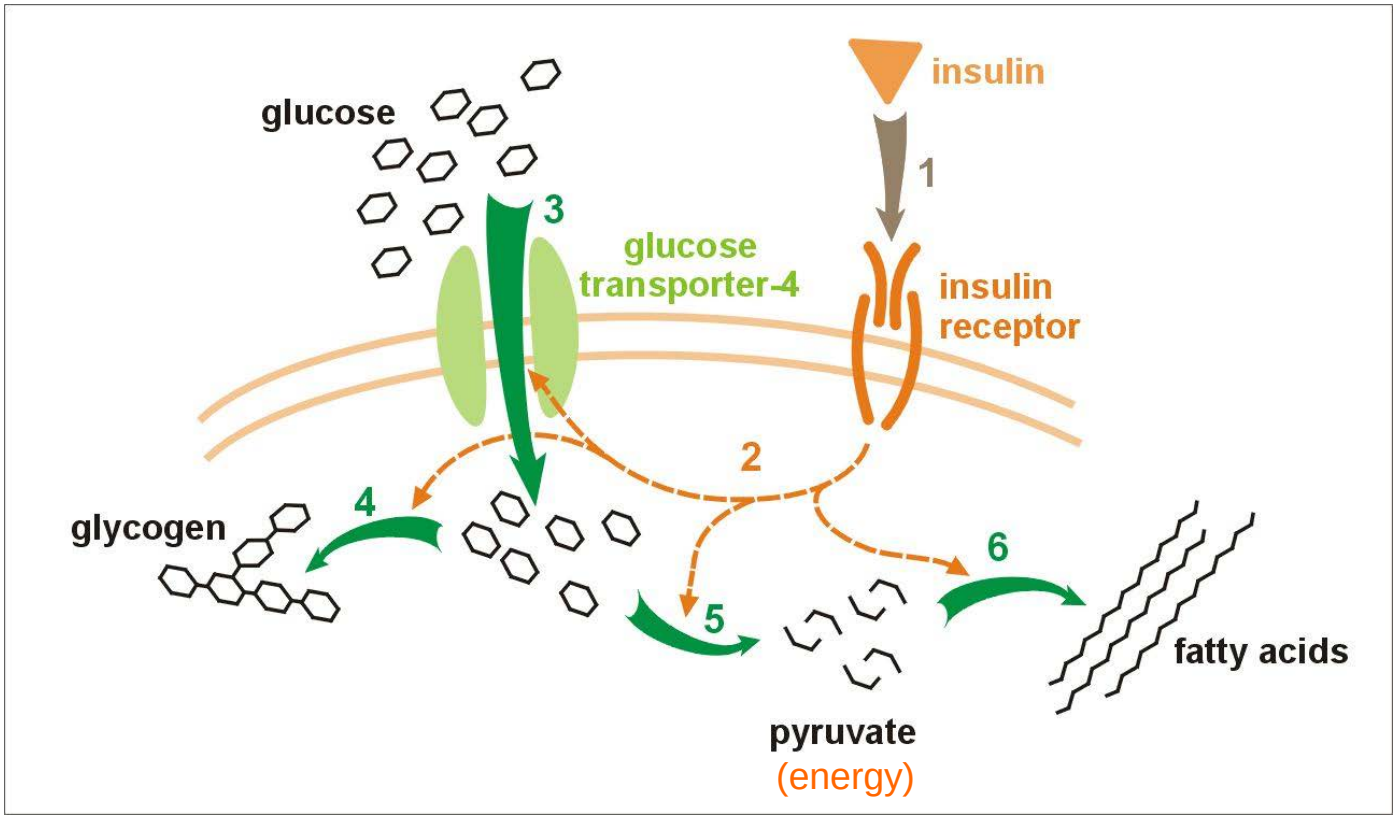
UCSF
University of California
San Francisco

Glucose Metabolism



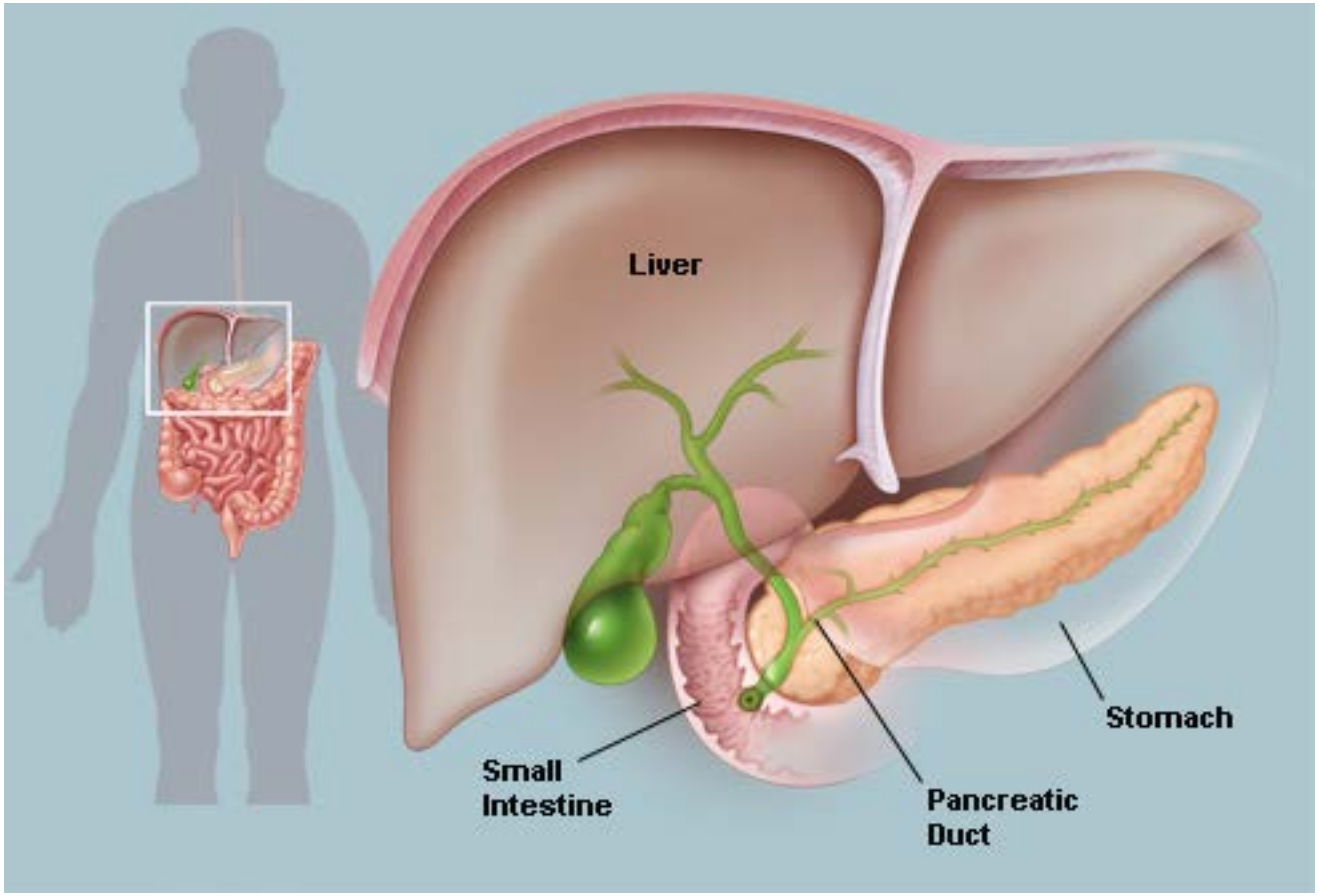
UCSF
University of California
San Francisco

Insulin



UCSF
University of California
San Francisco

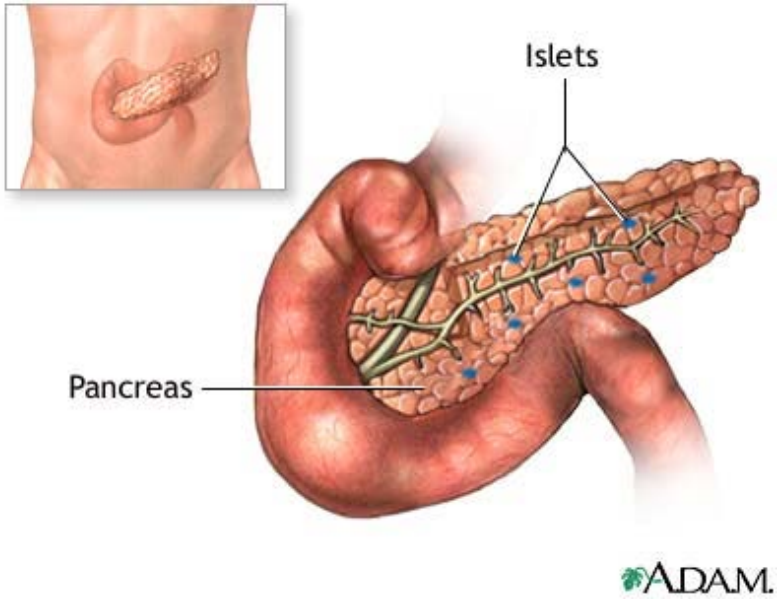
Insulin



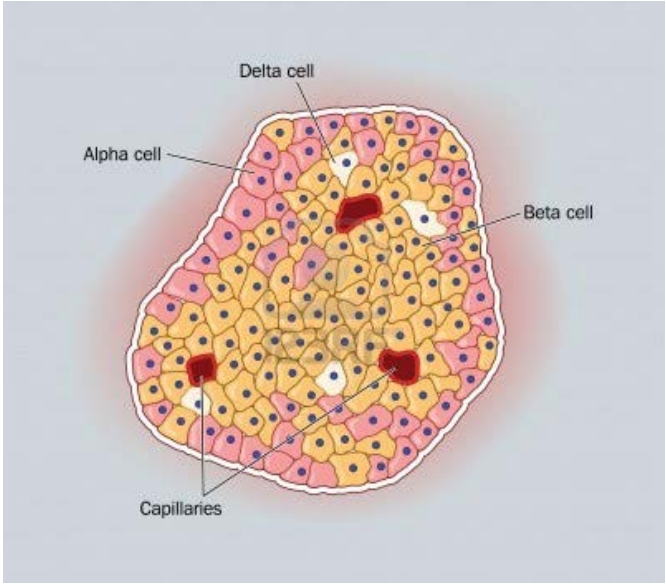
School of Medicine

UCSF University of California San Francisco

Insulin



An islet



UCSF
University of California
San Francisco

Diabetes

- **Glucose cannot enter the cells**
  - **No insulin = Type 1 Diabetes**
  - **Insulin not working = Type 2 Diabetes**
- **Other types, less common**

UCSF
University of California
San Francisco

Diabetes

- **Glucose accumulates in the blood**
- **Spills over in the urine (when level is >180)**
  (Normal is 70-110, up to 140)

  - Takes water with it

  - Increased urine and thirst

UCSF
University of California
San Francisco

Type 2 Diabetes

Insulin not working

- **Overweight and lack of physical activity lead to insulin resistance**
- **We make more insulin to compensate**
- **Eventually, islet cells burn out, cannot make enough**

UCSF
University of California
San Francisco

Type 2 Diabetes

Treatment

- **Eliminate the cause:**

  Decrease weight, increase activity

- **Drugs**

  Help make more insulin
  Help insulin work better
  Lower blood sugar (in other ways)

- **Insulin**

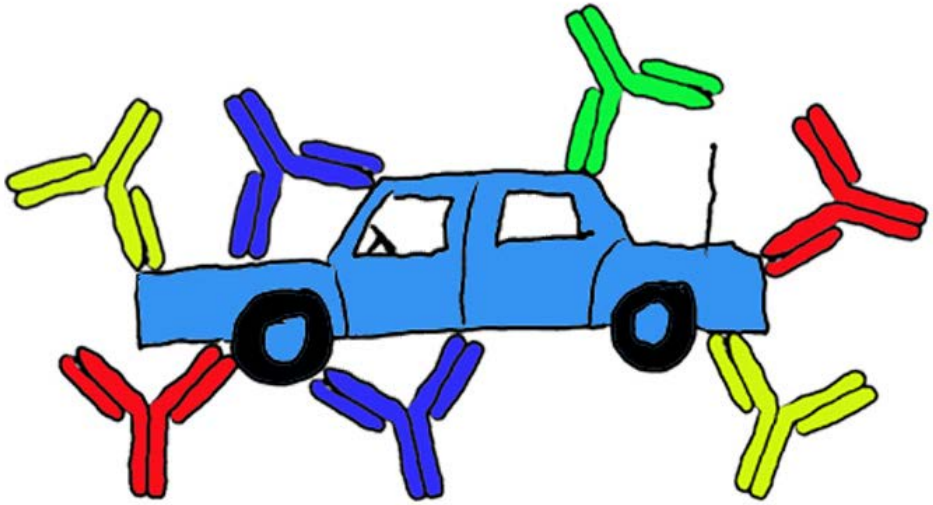
UCSF
University of California
San Francisco

Type 1 Diabetes

No Insulin

- **Trauma – Infection - Surgery**
- **Cystic Fibrosis**
- **Autoimmune (true T1D)**

UCSF
University of California
San Francisco

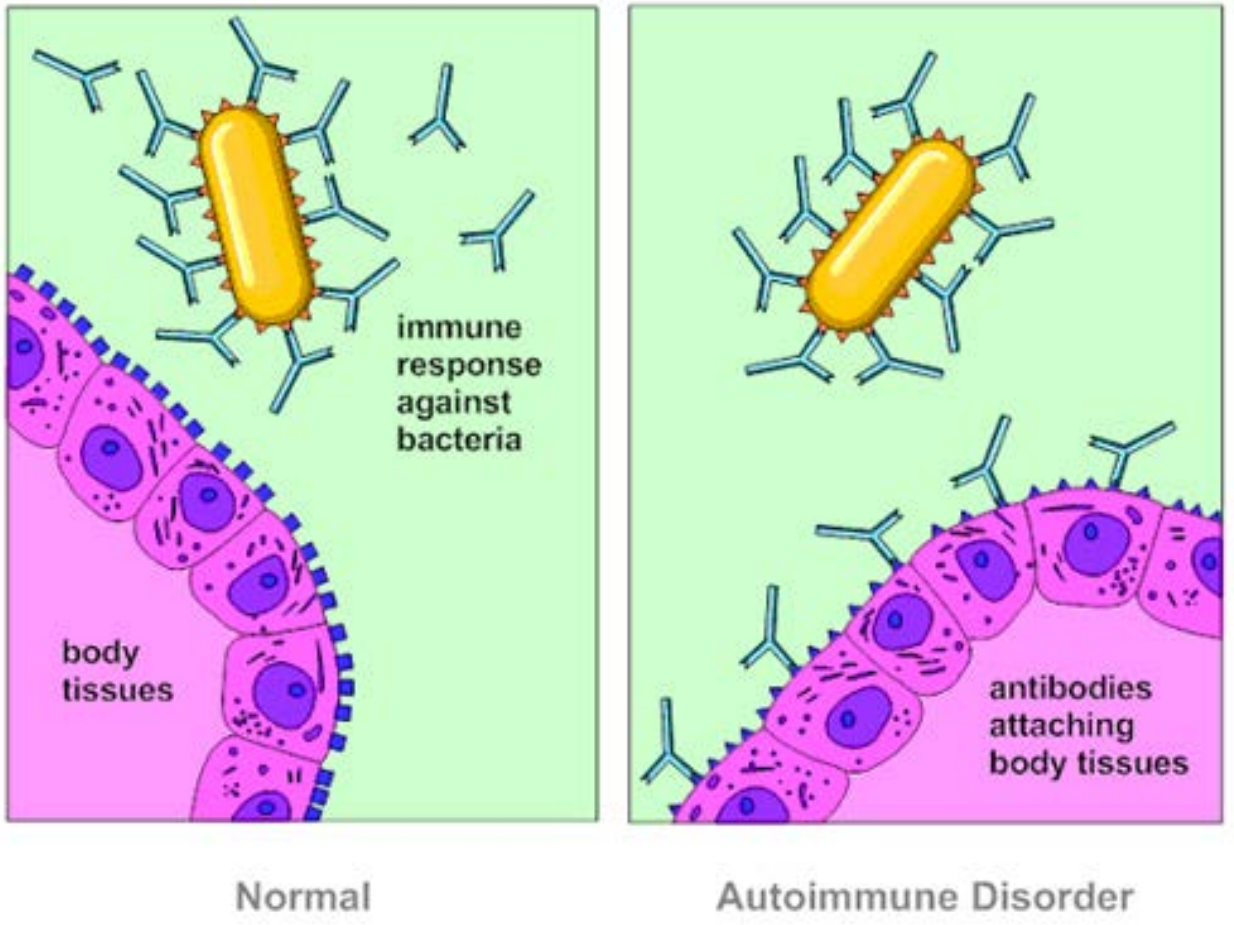


Autoimmunity

School of Medicine

UCSF
University of California
San Francisco

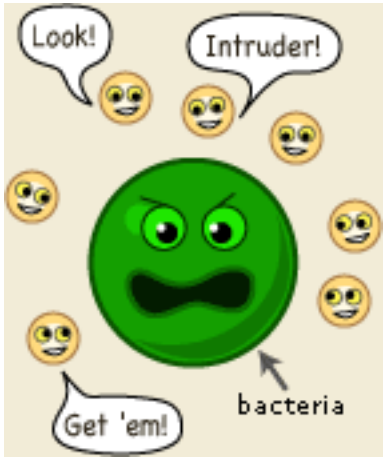
Autoimmunity

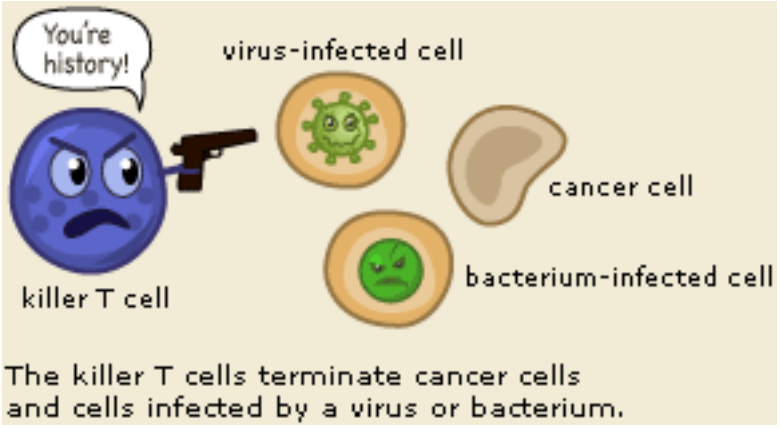


School of Medicine

UCSF
University of California
San Francisco

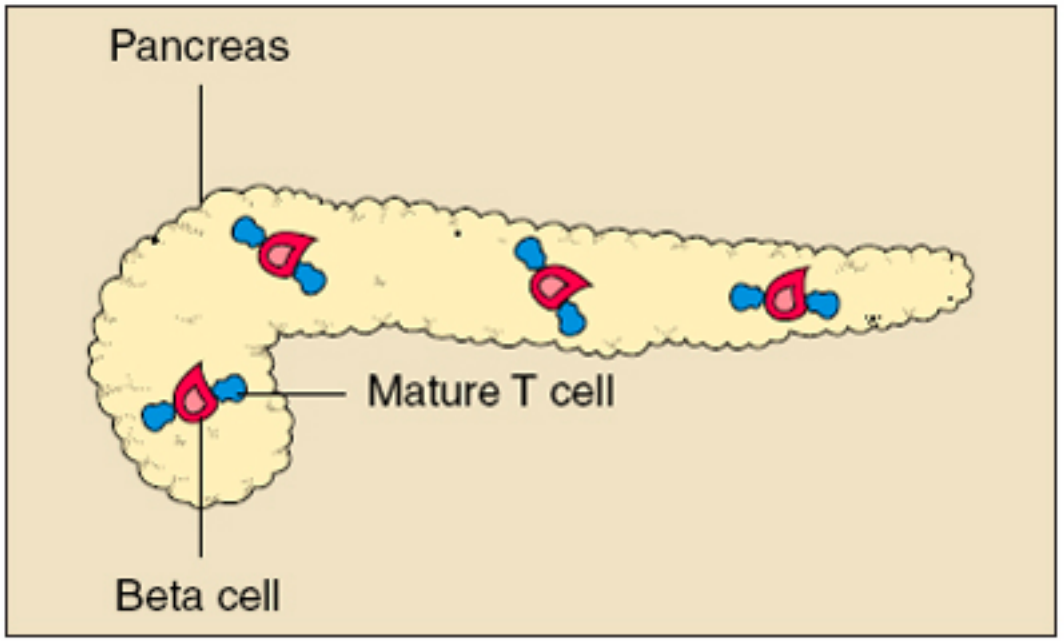
The immune system (very simplified)





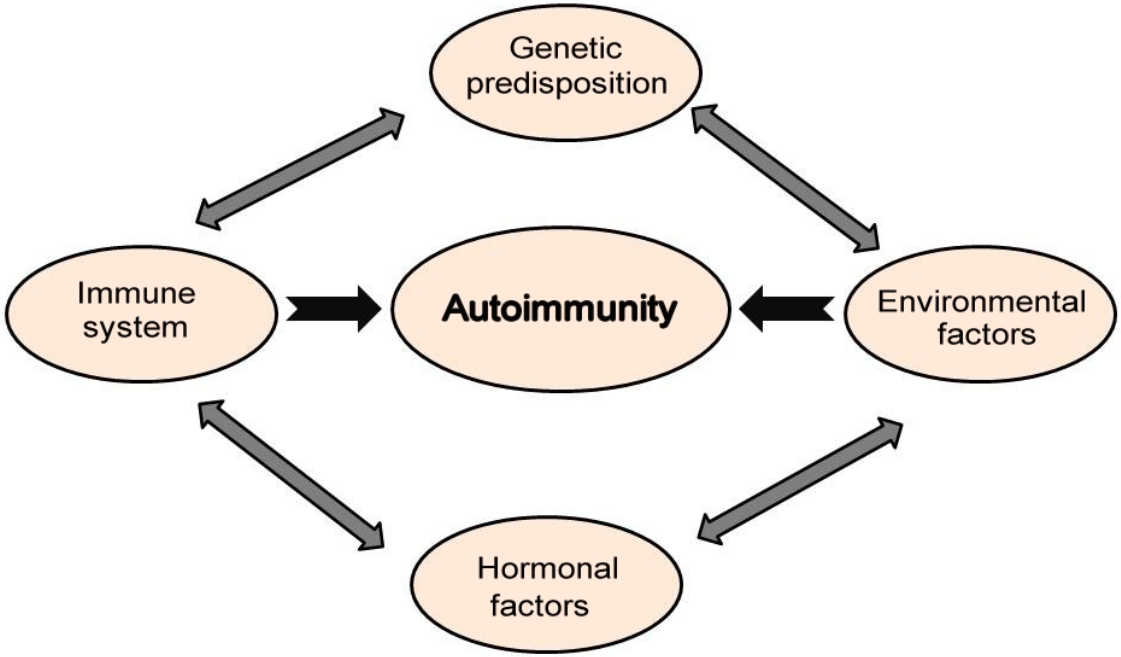
UCSF
University of California
San Francisco

Autoimmunity against Beta cells



UCSF
University of California
San Francisco

Autoimmunity



UCSF
University of California
San Francisco

Type 1 Diabetes

No Insulin

- **Treatment: Take insulin!**

UCSF
University of California
San Francisco

Type 1 Diabetes; Management

In normal physiology, glucose metabolism is exquisitely controlled;

- Blood Glucose (BG) has a tight range
- BG levels are sensed continuously
- Instantaneous response in the β-cells
- Almost immediate and quick effect of insulin
- Short lived effect

UCSF
University of California
San Francisco

Type 1 Diabetes; Management

We're not even close

- We check BG every few hours
- We deliver insulin every few hours
- Insulin action is still too slow
- Deliver insulin in subcutaneous space (it takes a while to reach the blood)

UCSF
University of California
San Francisco

Insulin

1922

UCSF
University of California
San Francisco

Insulin

Frederick Banting & Charles Best

UCSF
University of California
San Francisco

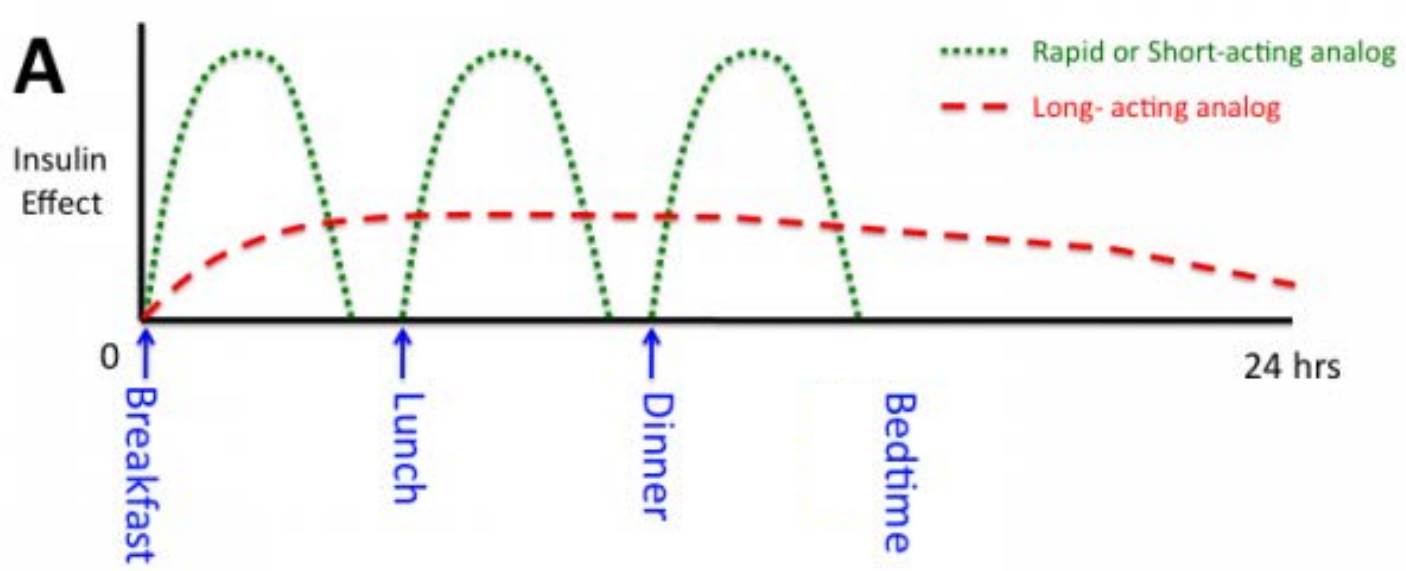
Insulin
1990

UCSF University of California San Francisco

Type 1 Diabetes; Management

We need insulin all the time

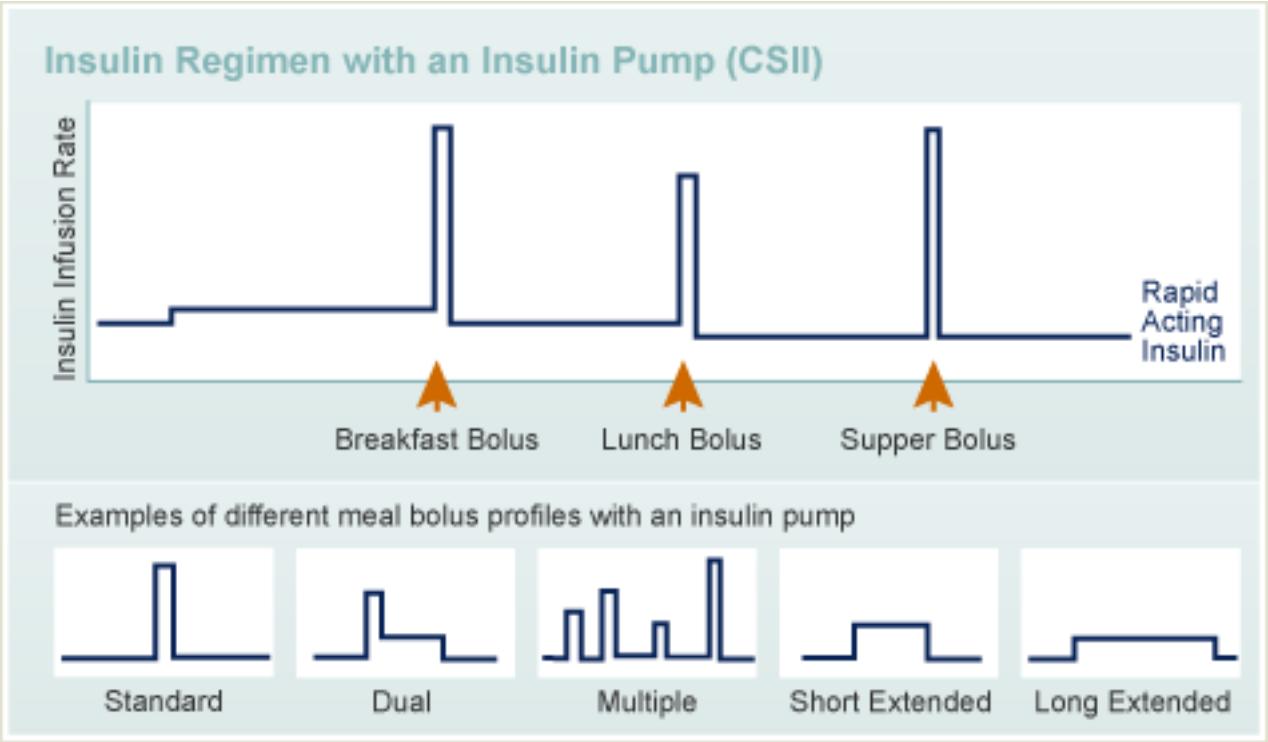
- Long acting insulin, 1 or 2 doses/day
- Short acting insulin, for every meal



UCSF University of California San Francisco

Type 1 Diabetes; Management

Insulin pump, continuous infusion of short acting insulin



UCSF
University of California
San Francisco

Type 1 Diabetes; Management

Daily tasks, before each meal

- Check BG
- Count the carbohydrates in the meal
- Calculate dose of insulin
- Deliver insulin, by injection or insulin pump

UCSF
University of California
San Francisco

Insulin pumps

UCSF
University of California
San Francisco

Insulin pumps

UCSF
University of California
San Francisco

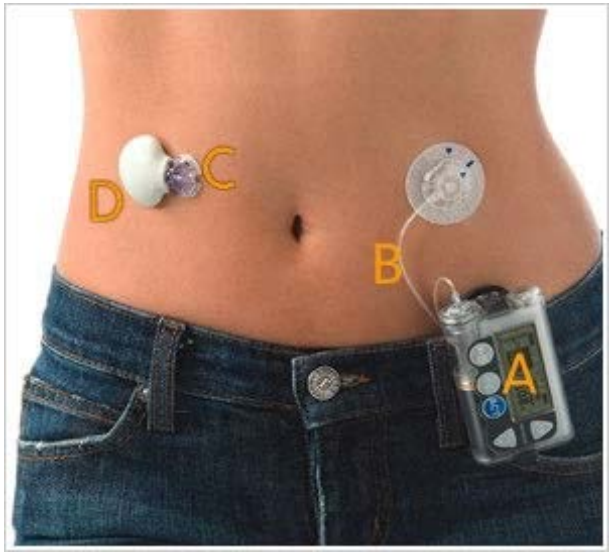
Insulin pumps

UCSF
University of California
San Francisco

Glucose sensors
(Continuous Glucose Monitors)

UCSF
University of California
San Francisco

Glucose sensors
(Continuous Glucose Monitors)



A: pump
B: infusion set
C: sensor
D: transmitter

UCSF
University of California
San Francisco

Type 1 Diabetes; Management

Lots of cool tools, but they don't *think* for us

- What kind of food (fat, fiber, protein)
- Activity (before and after)
- Time of day
- Time of month
- *Constantly making adjustments*

UCSF
University of California
San Francisco

Diabetes logs

UCSF Diabetes Log for Dr/Nurse: ____________ **Please fax to 415-476-8214 (call 415-353-7337 if no reply from us in 3 days)**

Name: _ **Best Phone #** _ **Email:**

Basal Rate Changes @ 11:30 AM April 18

Current Rates	12am	3:00	4:00	5:00	6:00	7:	8:00	9:00	10:	11:00	12:	1:	2:	3:00	4:	5:00	6:00	7:	8:	9:	10:	11:00	
Basal Rate(s)	0.375	0.425	0.600 / 0.450	0.625 / 0.625			0.425 / 0.400	0.350 / 0.325		0.380 / 0.375				0.275		0.275	0.325					0.375	9.380 ~~9.000~~
Carb Ratio(s)	21				14			8:30 21								5:30 21							Total Basal
High BG Ratio (ISF)	60																						
BG Target(s)	+/- 10 100																						

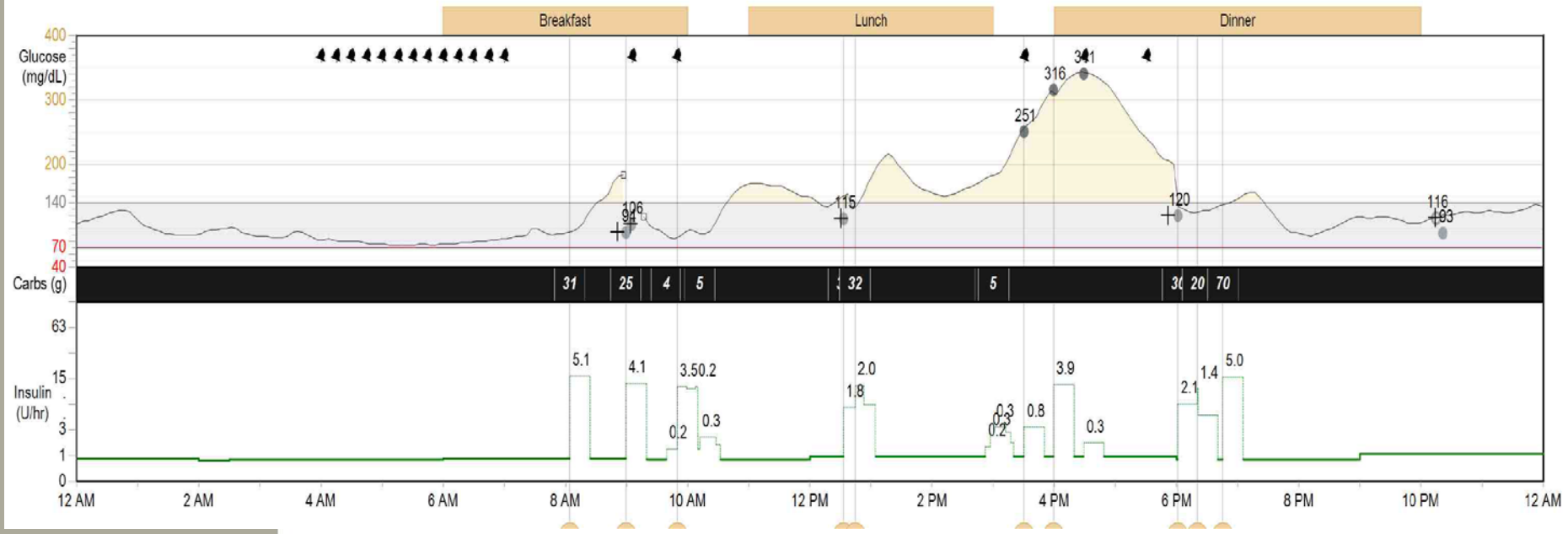
Date: 04/18 Sun	12am	1:33	2:26	3:06	6:	7:33	8:	9:	10:	11:08	12:	1:16	2:	3:10	4:03	5:	6:	7:32	8:13	9:51	10:	11:33	
BG	141	111	101	100		106				154		189		102	104			130	167	227		206	*** 3hr
Carbs										33		24		22	11			25	47				0/100%
Carb Bolus										1.57		2.15		1.05	Ø***			1.19	*** 2.25				Combo
High BG Bolus	Ø due to [illegible]									.90		↑ inc.						.50	Ø due to [illegible]	0.70		.50	(Shrimp beans)
Basal changes/Temp basal		12:35 —	60%	3:15											4:15–4:45 – 100%								
Exercise *(minutes)*															4:15–4:45 StairMaster								
Ketones																							
Set Change																							
Comments	*4:57am – BG=137; .60 BG bolus				** 11g – uncovered fig newton – pre-StairMaster					4:46 – BG=80													

Date: 04/19 Mon	12am	1:13	3:09	5:16	6:44	7:	8:	9:55	10:03	11:	12:41	1:14	2:	3:09	4:33	5:12	6:	7:28	8:37	9:[illegible]	10:	11:43	
BG		194	143	132	114			159	143		180	158		179	154	119		130	228	–		112	**** 3hr
Carbs					31			30	25		87				5	26		25	58	7			0/100%
Carb Bolus					2.20			2.40	1.20		5.25				*** Ø	1.55		1.19	**** 2.75	0.35			Combo
High BG Bolus		1.20	.40	.45	Ø due to [illegible]			↑ inc			↑ inc.					↑ inc		.27	1.25				(polpette)
Basal changes/Temp basal														Pump suspended		5:00 —	–40%	7:30				11:45 – 50%	
Exercise *(minutes)*												1:25 – Gym	2:10	3:30 — Basketball Practice		5:00							
Ketones																							
Set Change																							
Comments	* 5:59 – BG=136 .20 BG bolus							** 1:33 – BG=155; 5g uncovered during gym			*** 5g uncovered during basketball			**** 9:56 – BG = 206; Ø BG bolus due to [illegible]									

Date: 04/20 Tue	12am	1:45	:	5:19	6:32	7:	8:	9:	10:33	11:	12:45	1:	2:52	3:44	4:50	5:	6:	7:	8:41	9:26	10:37	11:19	
BG	104	138		153	111				194		129		314	254	243				177	–	68	118	** 3hr
Carbs					31				35		98		26		25				36	20	8		0/100%
Carb Bolus					2.20				2.05		5.05		3.85		2.70				** 1.70	.95	*** Ø		Combo
High BG Bolus		.50		.90	Ø due to [illegible]				↑ inc.		↑ inc.		↑ inc.		↑ inc.				1.30			Ø due to [illegible]	(Crab Cakes + Chips)
Basal changes/Temp basal	— 50%	1:45												Pump Disconnected							10:40 — – 50%	11:20	
Exercise *(minutes)*									10:30 – Gym	11:05				3:45 – Basketball Game	4:50								
Ketones																							
Set Change																	6:40						
Comments	*10:23 – BG=160			10:39 – BG=167 10:59 – BG=175				** 1/2 cup nonfat milk															

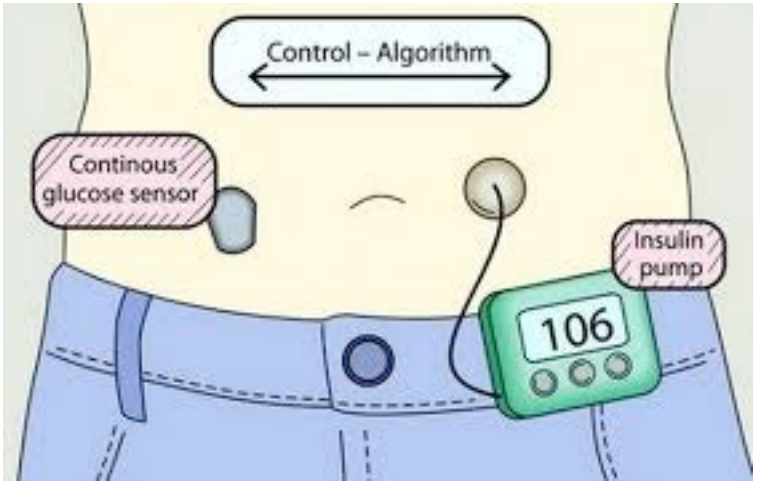
UCSF University of California San Francisco

Diabetes logs



UCSF
University of California
San Francisco

Closing the loop



UCSF
University of California
San Francisco

Closing the loop
The Artificial Pancreas

University of California
San Francisco

advancing health worldwide™

UCSF

University of California
San Francisco

advancing health worldwide™