

Seahorse XF 原理技术与应用分享

实时-动态分析活细胞能量代谢并揭示细胞功能的改变

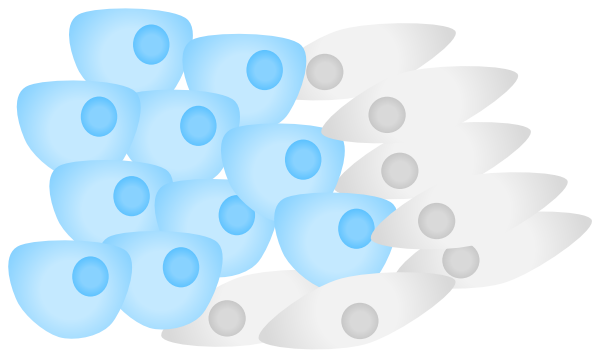
王群 产品经理



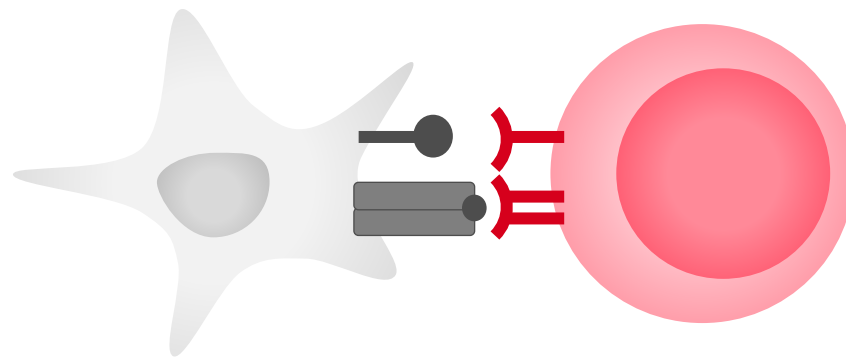
Agilent Seahorse XF Assays 了解细胞能量代谢对细胞功能至关重要

Go beyond what cells are to reveal what they DO

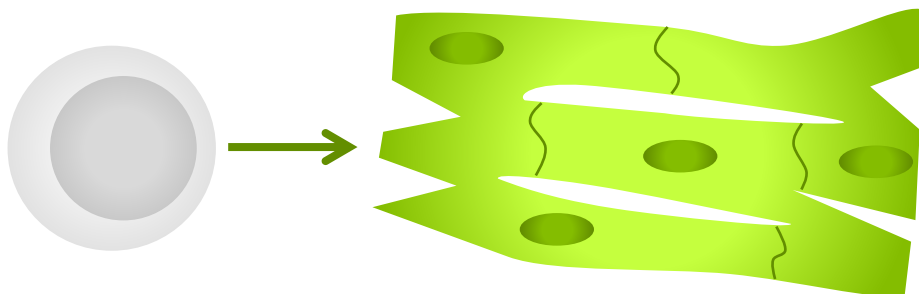
肿瘤细胞增殖



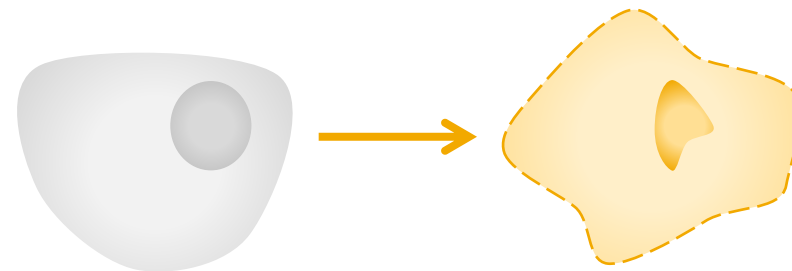
免疫细胞激活



干细胞分化



细胞死亡



XF assays measure the rate change of the two key energy metabolism pathways

Glycolysis

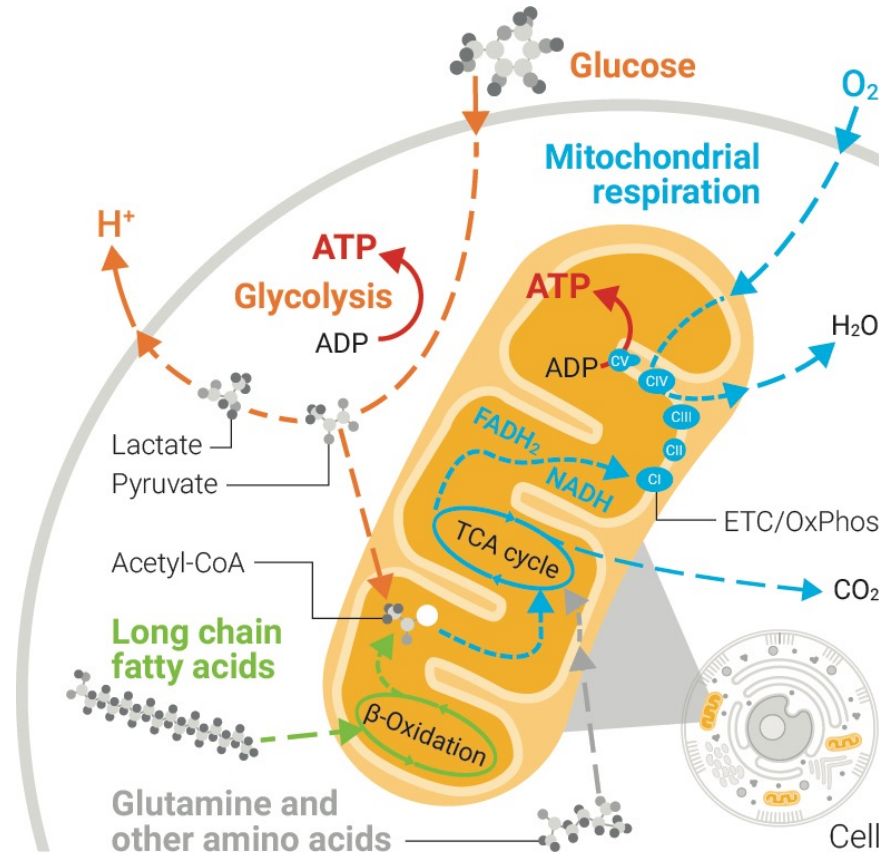
Anaerobic conversion of glucose to lactate

ECAR

(mpH/min)
Extra Cellular
Acidification Rate

PER

(pmol [H⁺]/min)
Proton Efflux Rate



Respiration

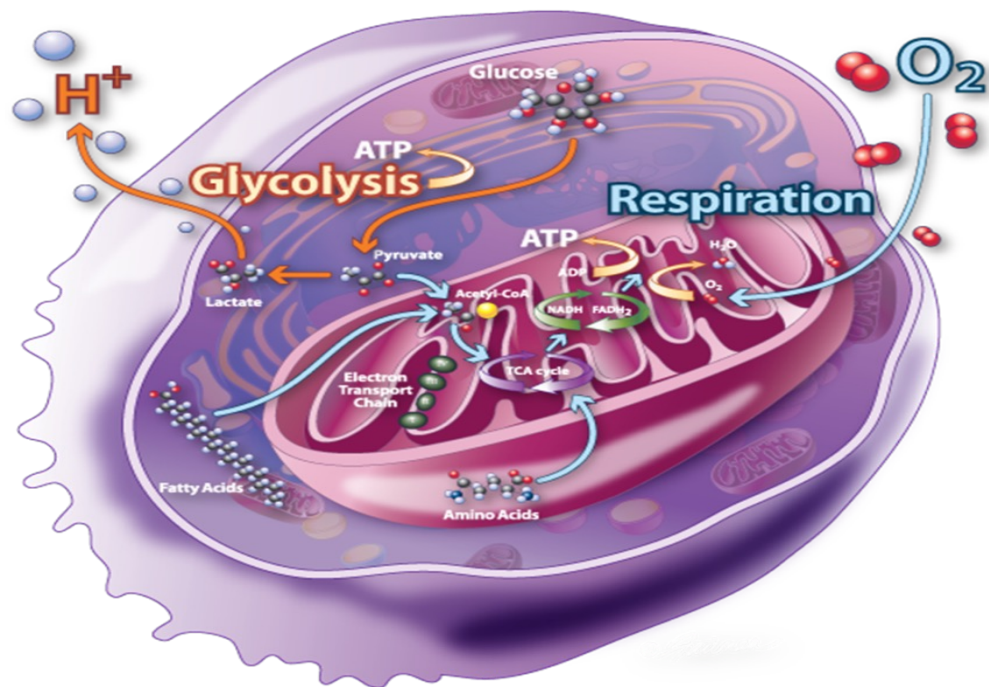
Oxidation of glucose, fatty acids, amino acids

OCR

pmol [O₂]/min

Oxygen Consumption Rate

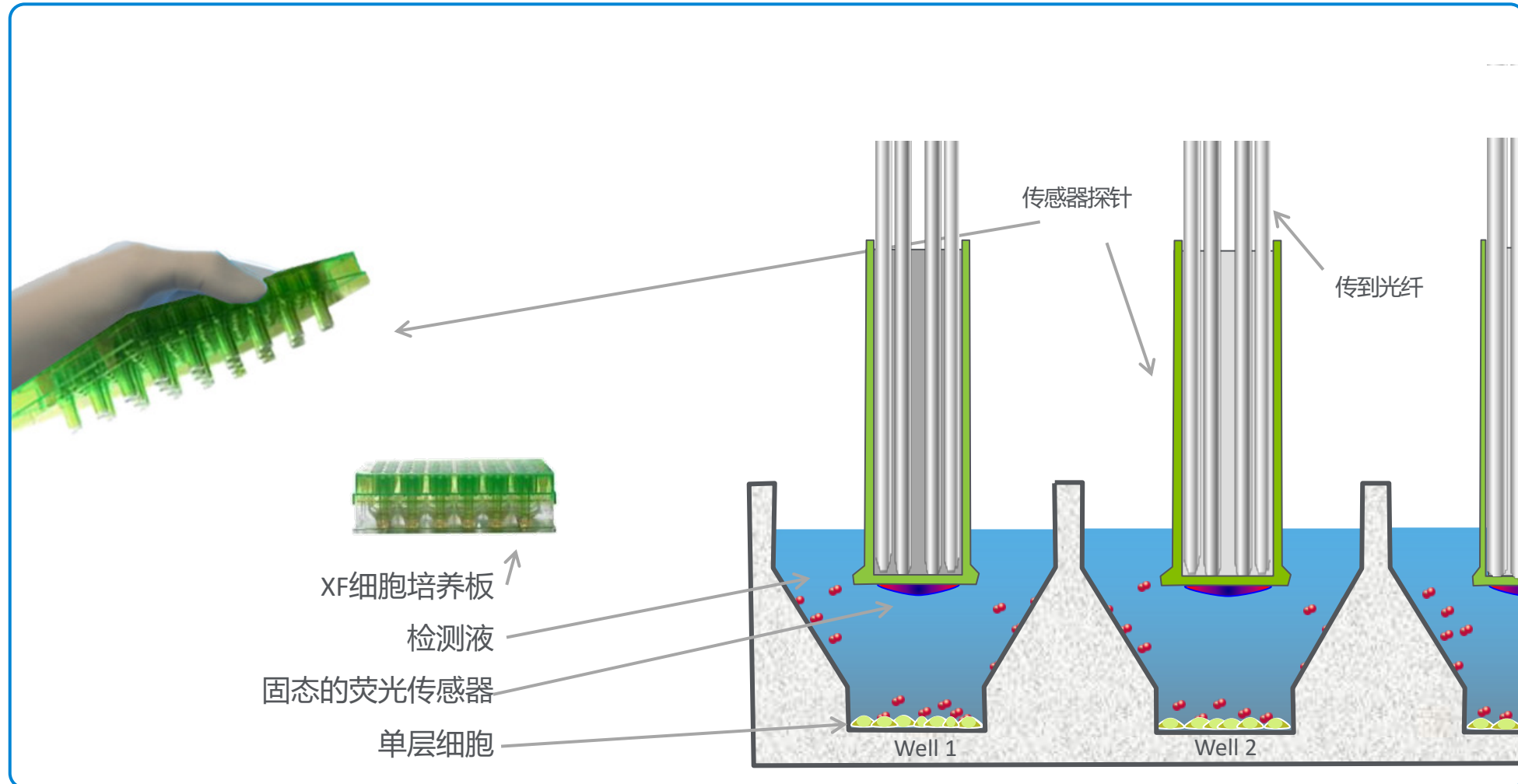
用 Seahorse XF 分析仪测量功能性代谢



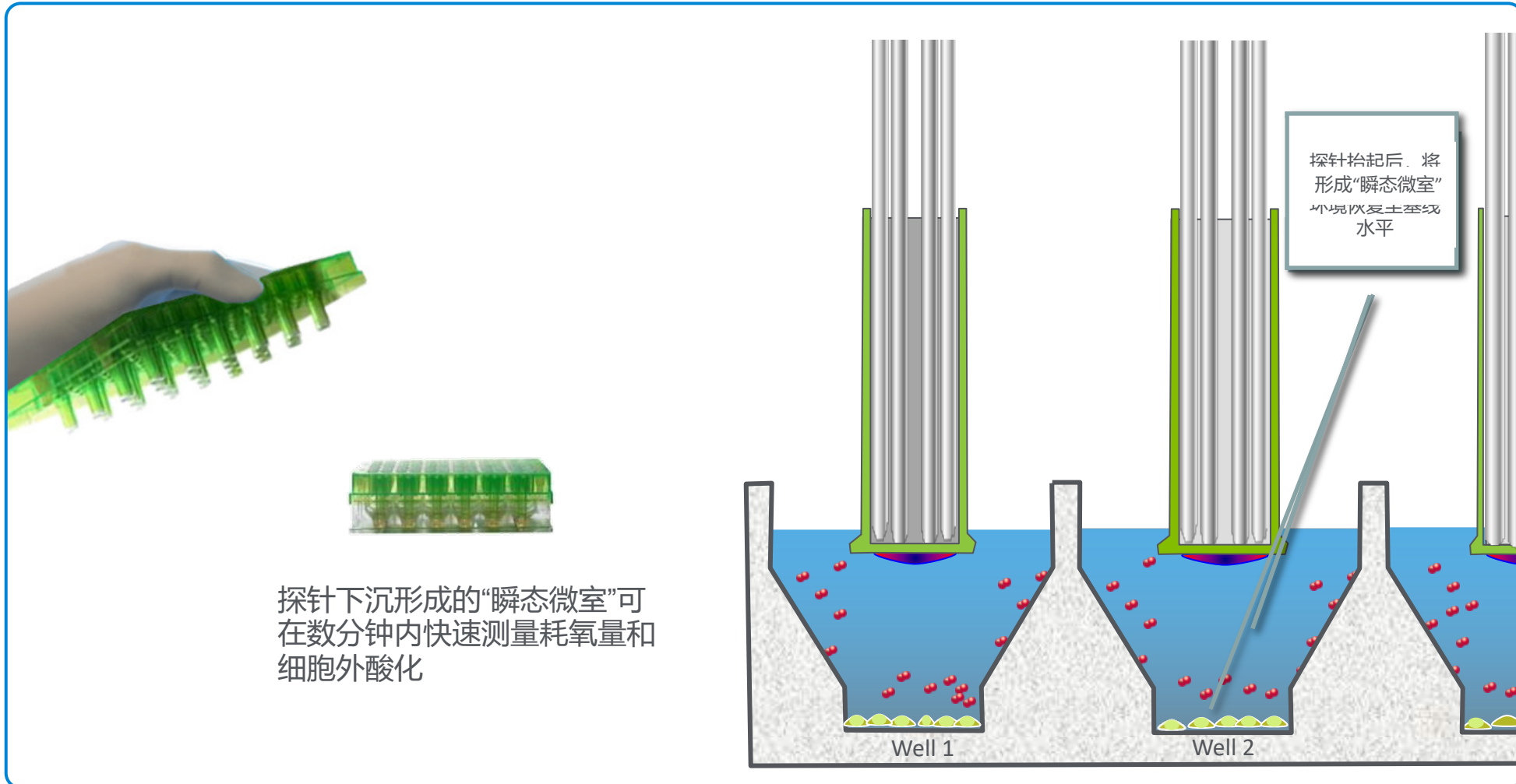
氧气消耗速率 (OCR): 线粒体氧化呼吸的指标

细胞外酸化率 (ECAR/PER): 糖酵解的指标

Measuring Mitochondrial Respiration and Glycolysis in a Microplate



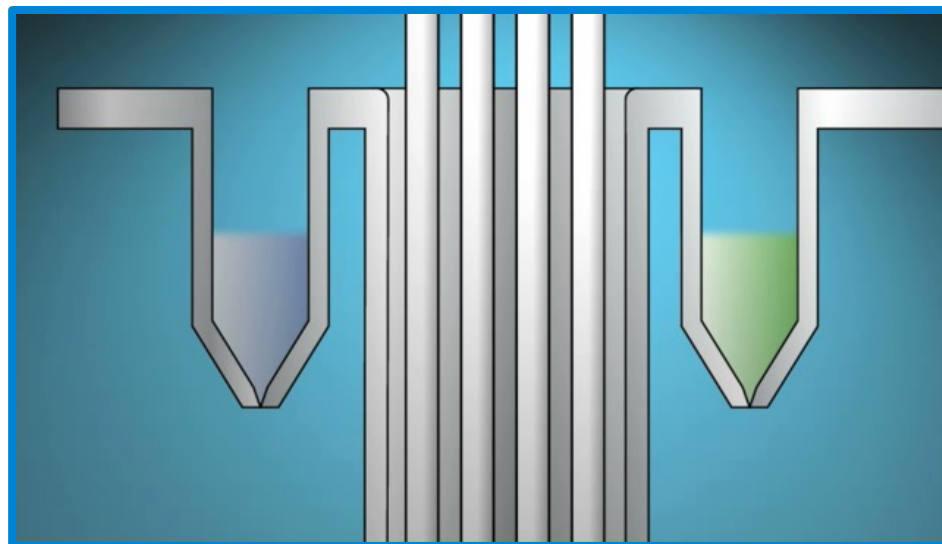
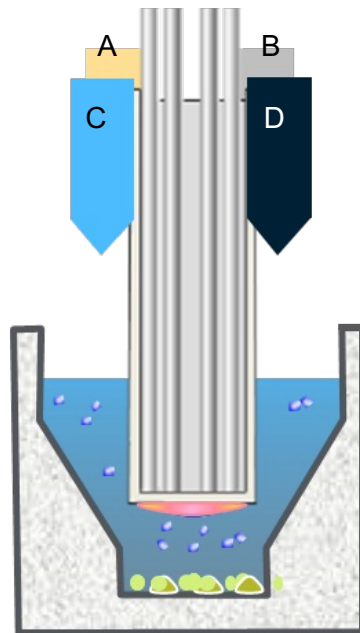
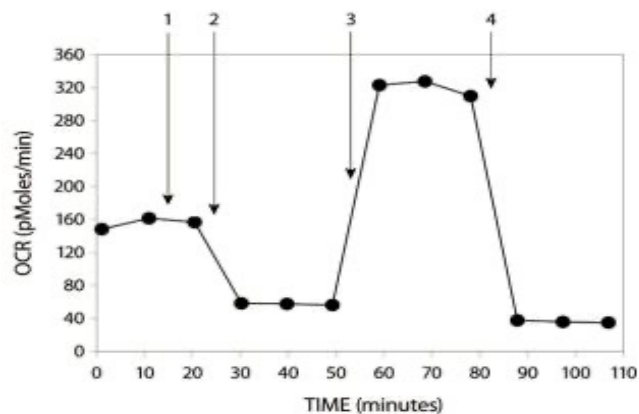
Measuring Mitochondrial Respiration and Glycolysis in a Microplate



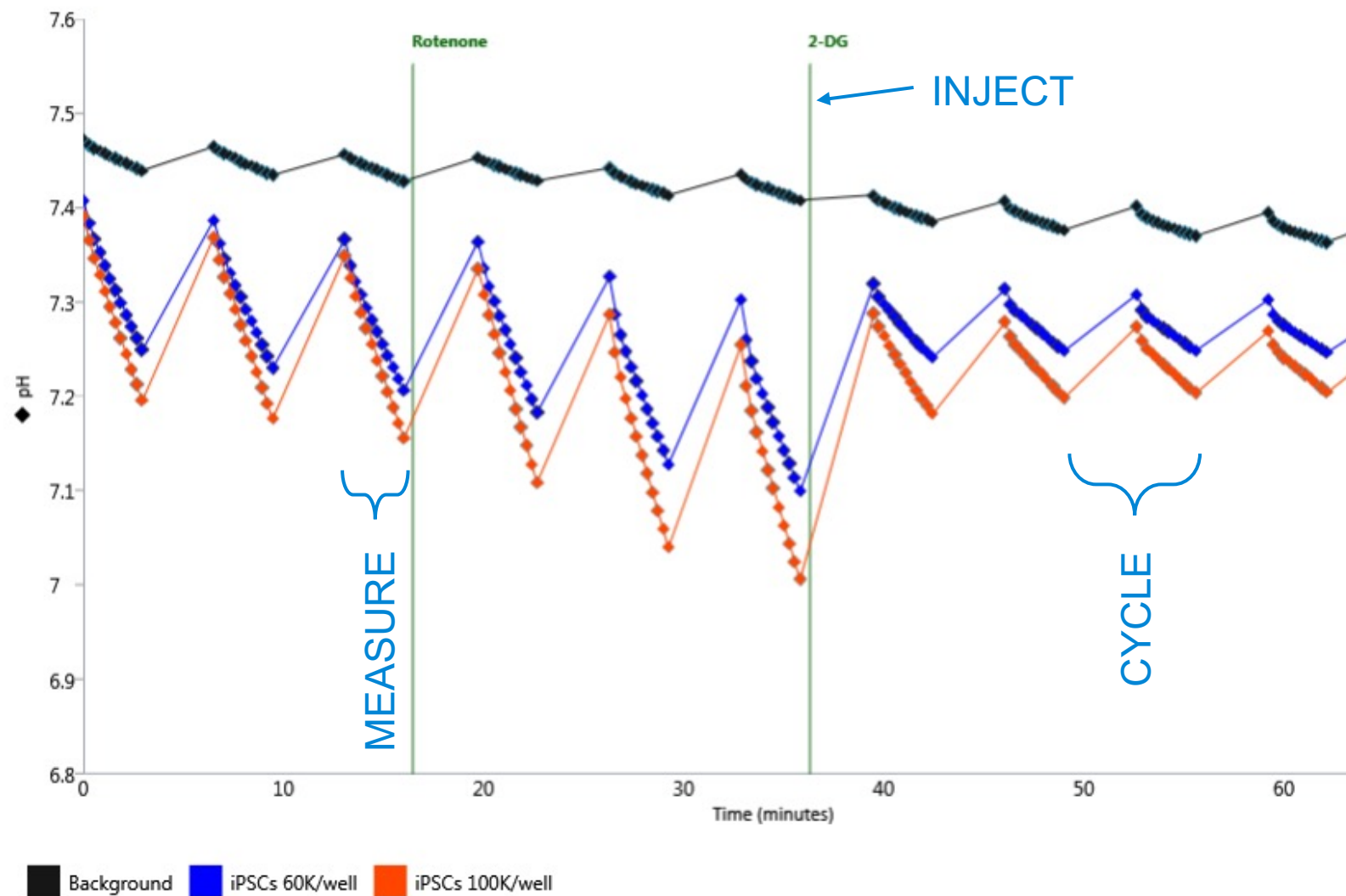
Automated Drug Injection Ports Enable Kinetic, Functional Data

—实时分析药物对细胞功能的影响

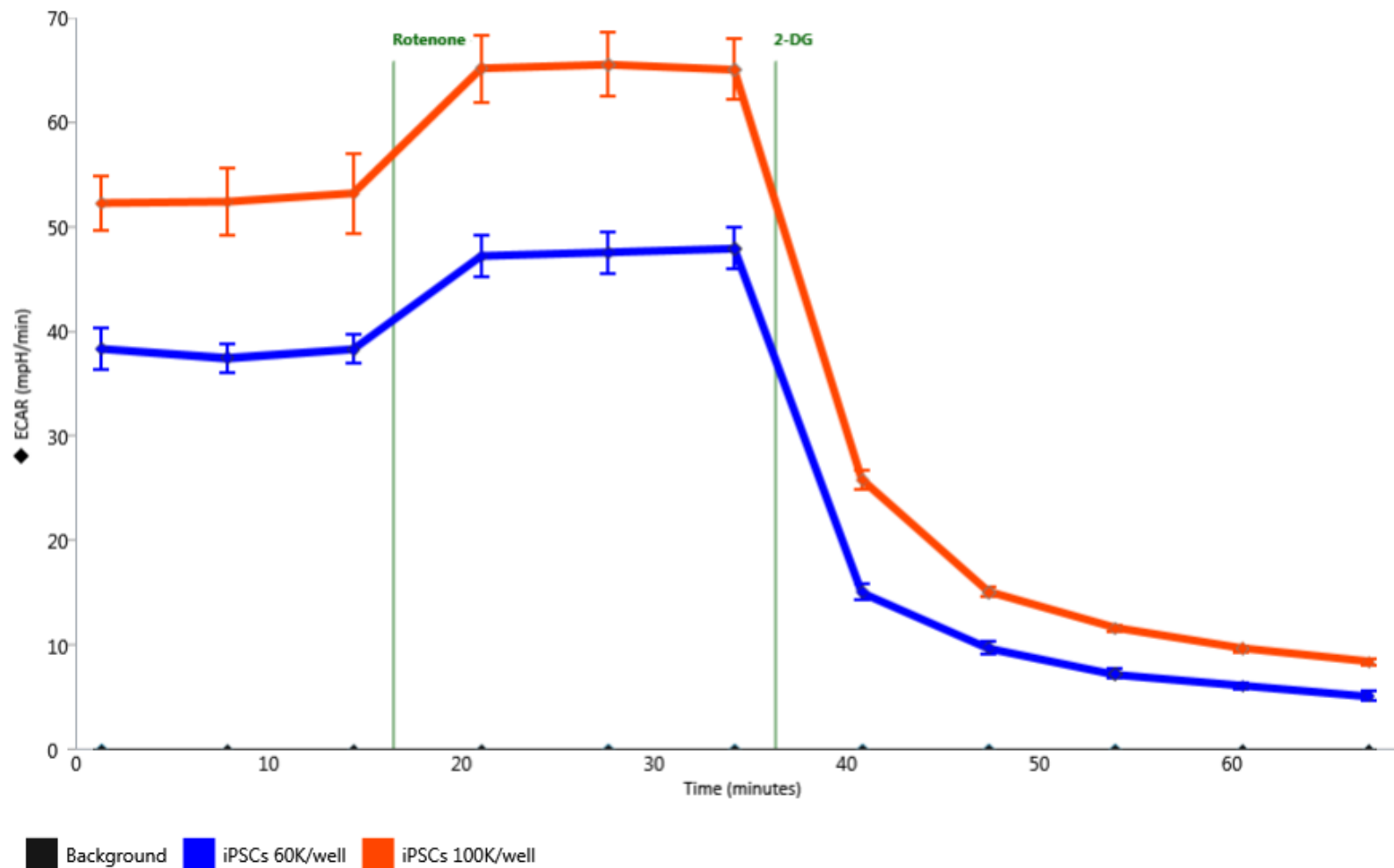
- 每个细胞孔可实时加入4次药物；
- 可加入抑制剂、激活剂、底物或目的药物；
- 整板细胞孔同时加药；
- 用户可定义加药程序；



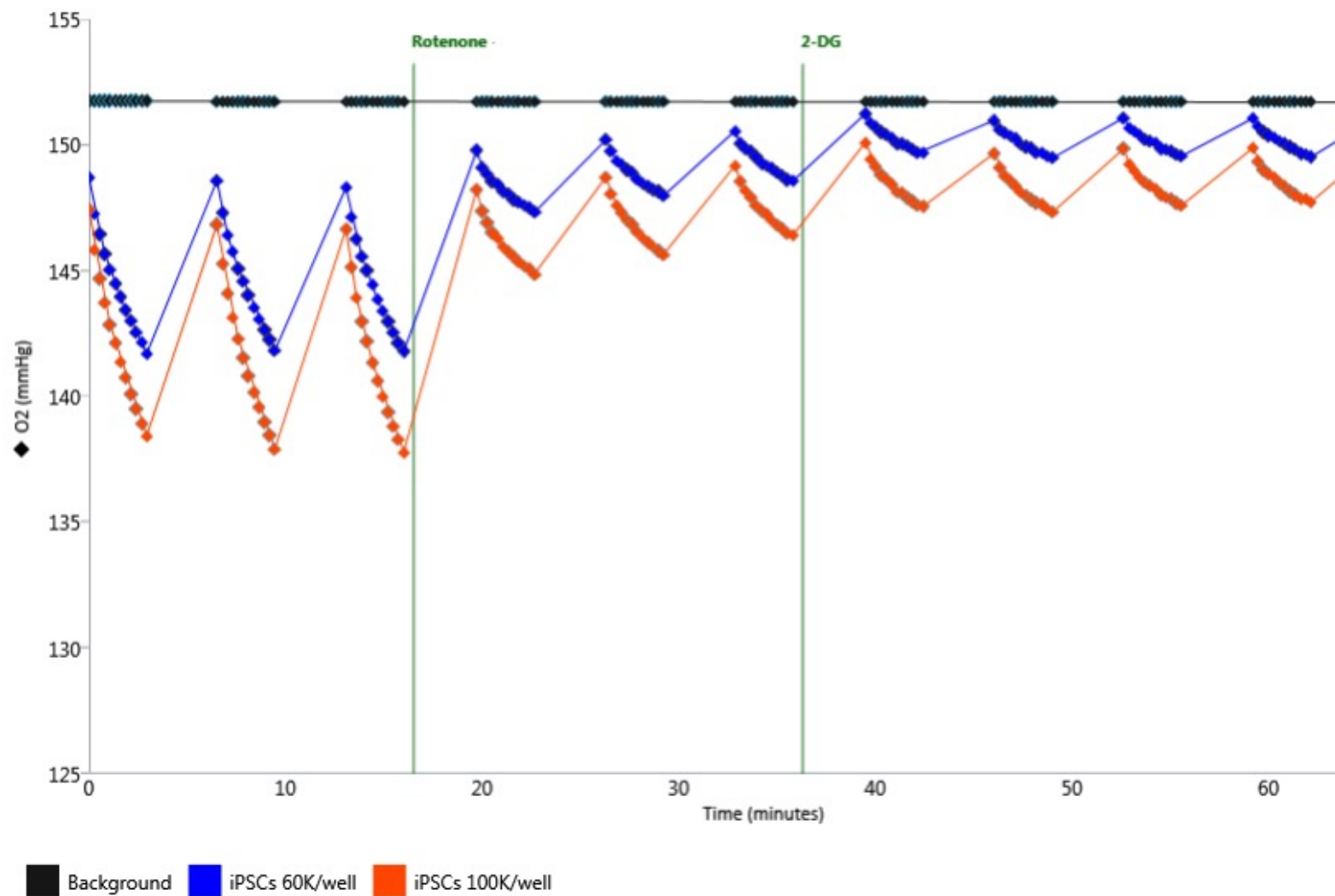
实时动态测量原始数据: pH vs. time → ECAR



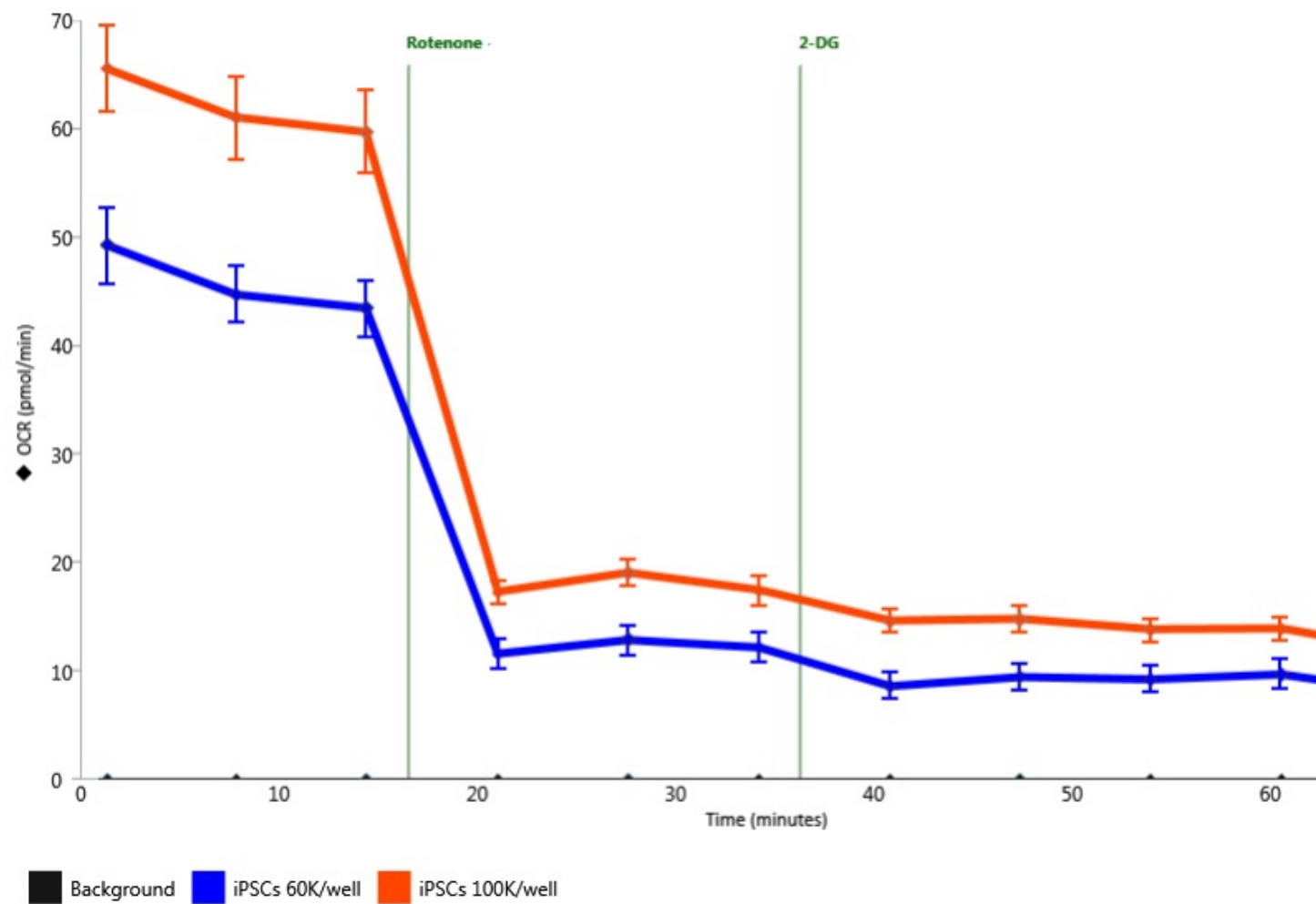
自动计算出胞外酸化速率(ECAR)

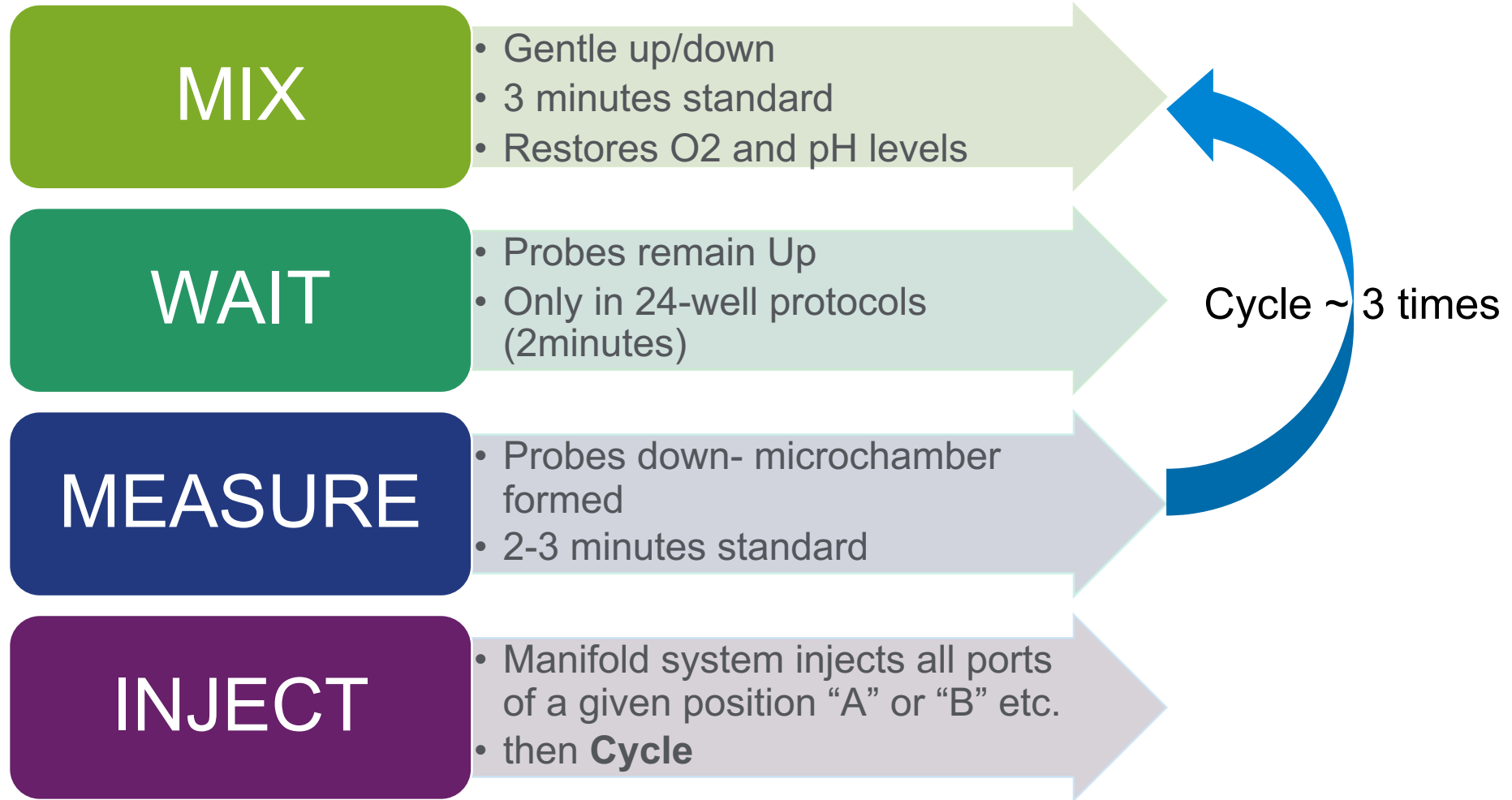


实时动态测量原始数据: O₂ vs. time → OCR



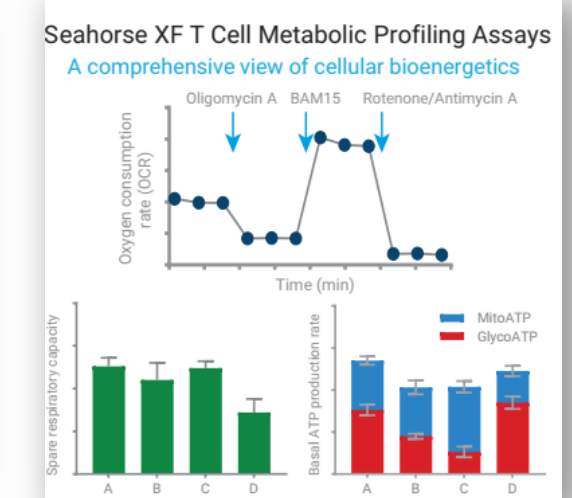
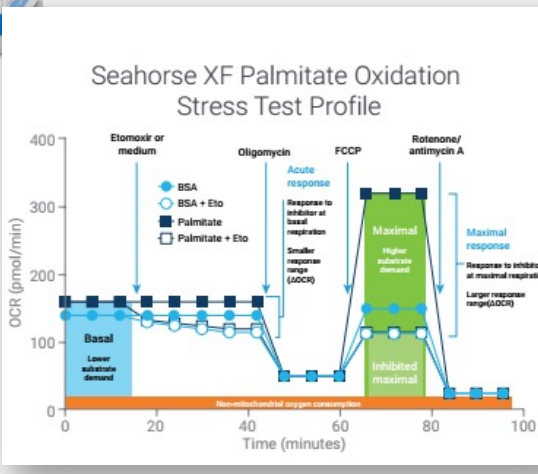
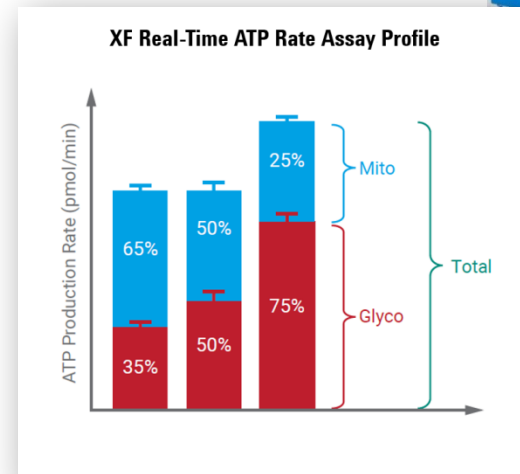
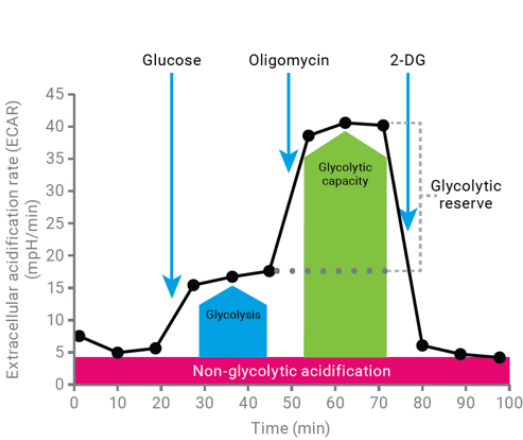
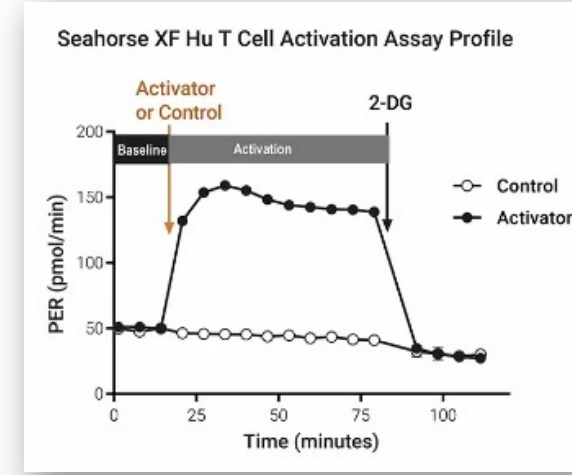
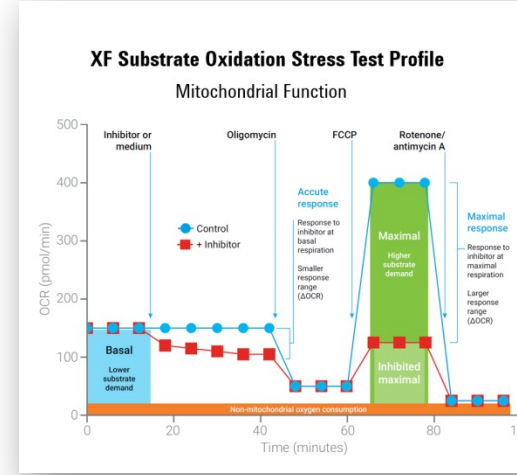
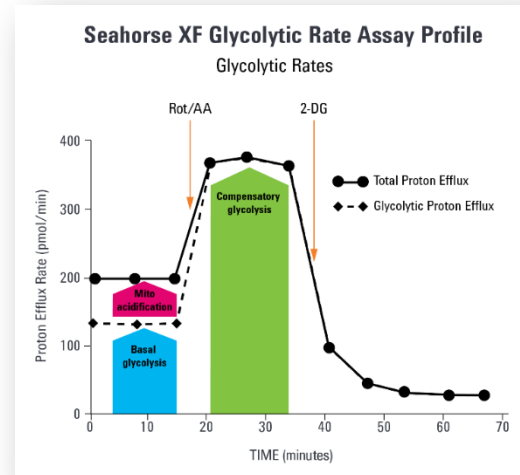
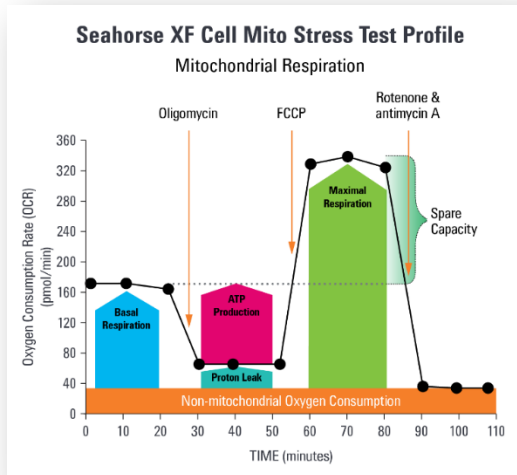
自动计算出氧气消耗速率(OCR)





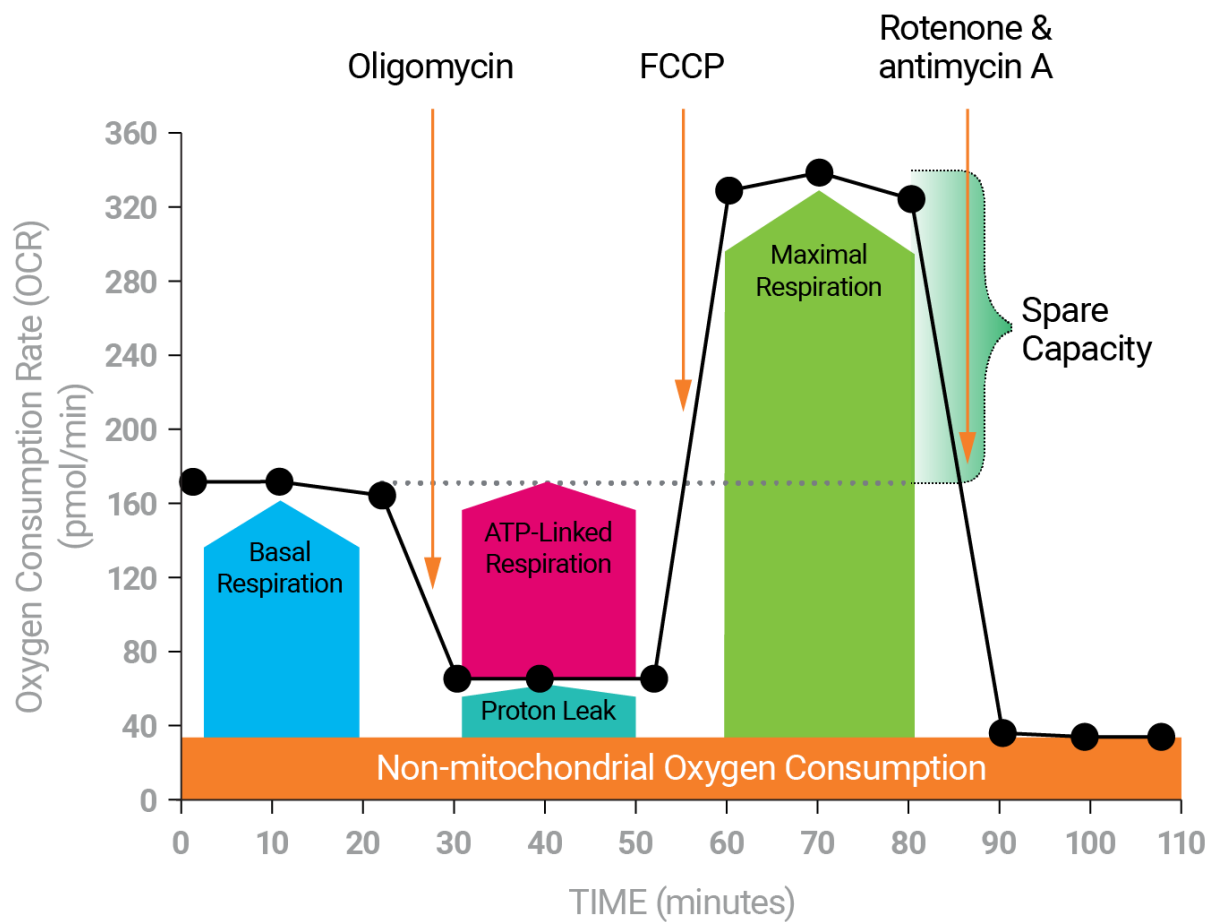
Seahorse 标准化试剂盒

针对代谢途径研究, OXPHOS, Glycolysis, and FAO



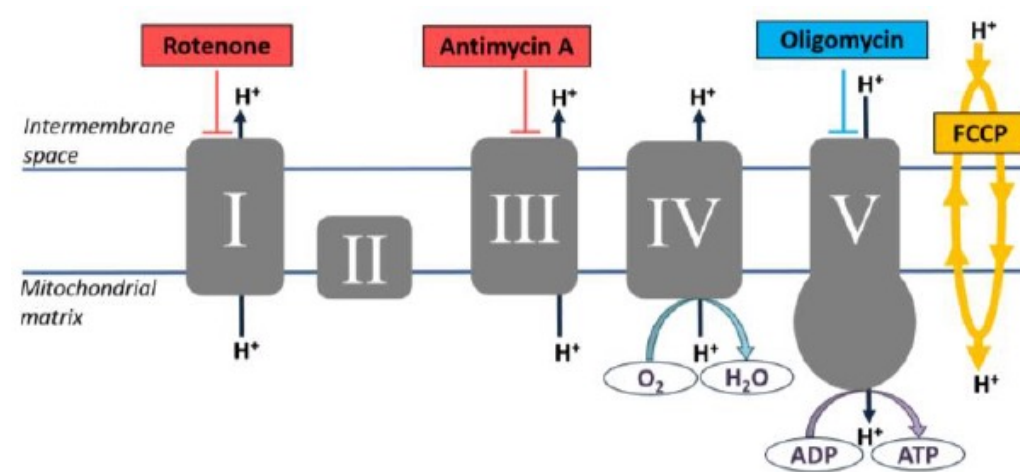
XF Cell Mito Stress Test Assay

评估线粒体功能

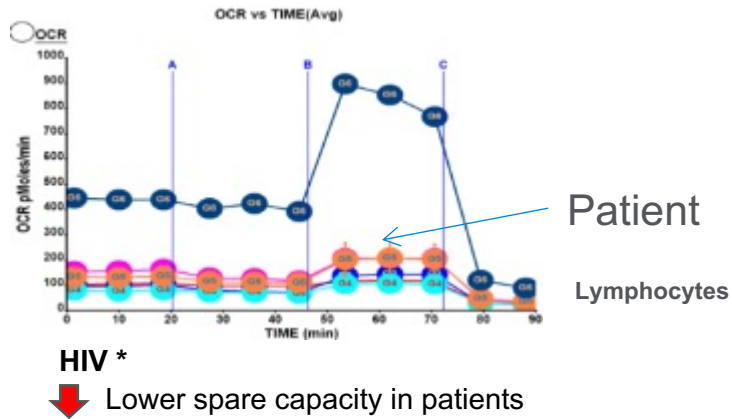


关键参数

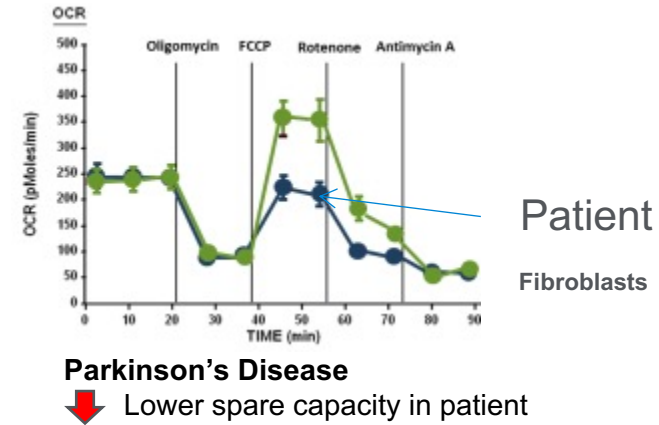
- 基础呼吸
- ATP关联呼吸
- 最大呼吸
- 备用呼吸能力
- 质子渗漏



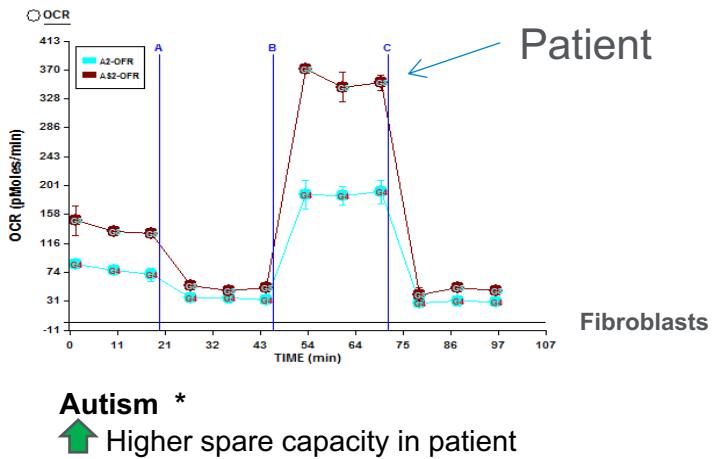
疾病中的线粒体功能 “概况”



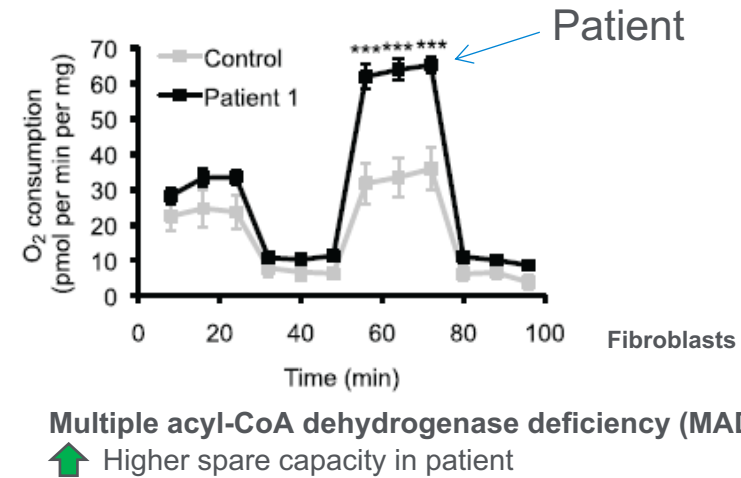
Data courtesy of Sher Hendrickson, NCI/NIH Frederick



Data courtesy of James Bennet Lab, University of Virginia

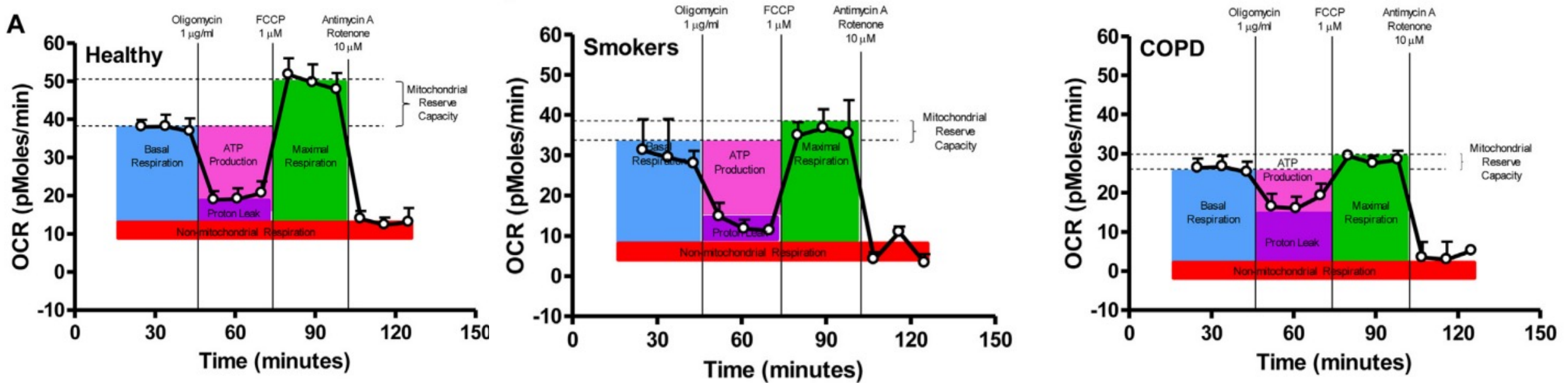


Data courtesy of Dr. Pinar Coskun, Dept of Neurobiology and Behavior at UC Irvine

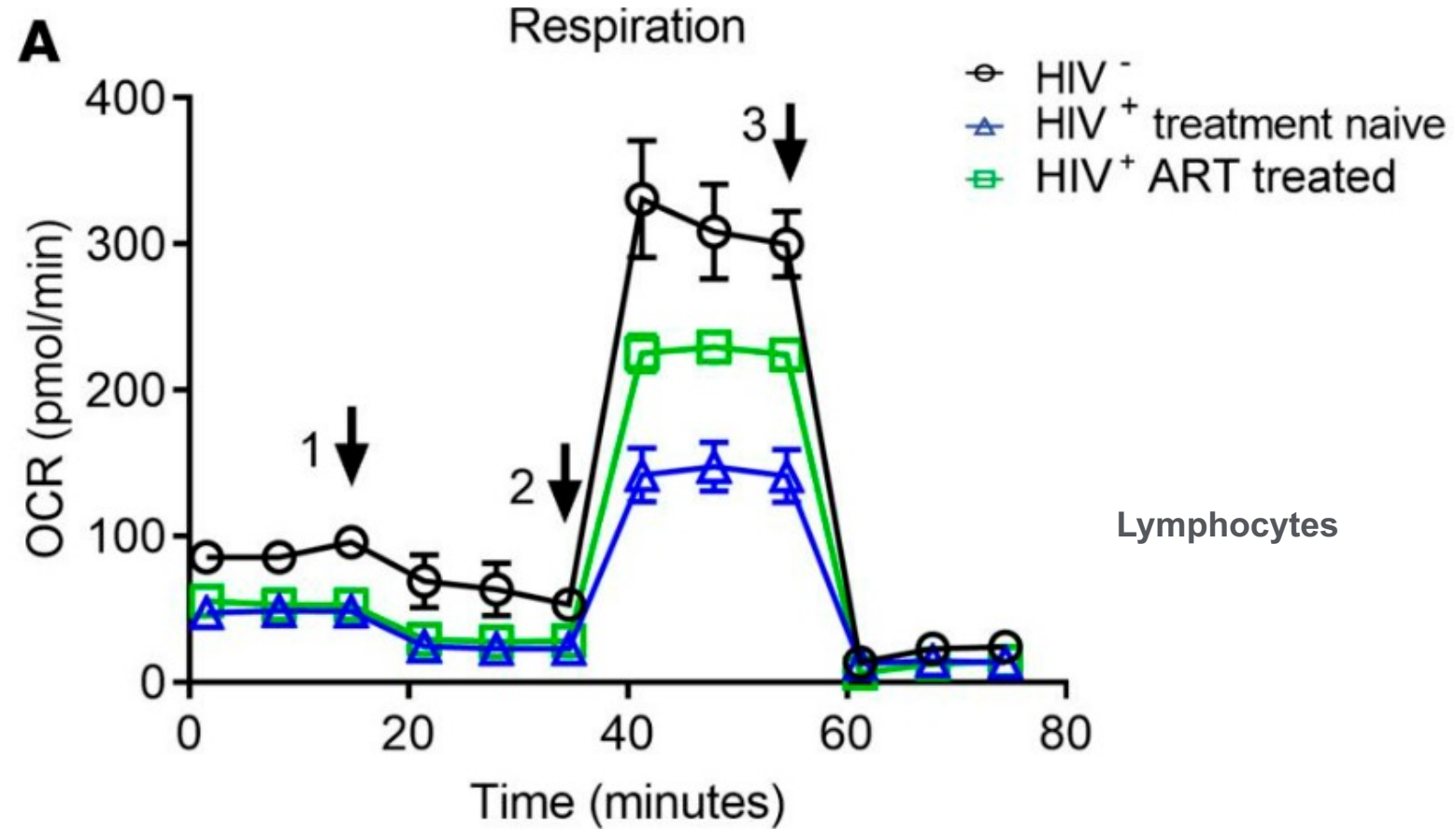


PLoS One. 2009 Dec 17; 4(12):e8329., Song Y et al

炎症和氧化应激在慢性阻塞性肺疾病(COPD)患者中起重要作用。作者在COPD患者的ASM细胞中发现了线粒体功能障碍和过多的线粒体ROS，通过实验证明了慢性阻塞性肺病患者线粒体功能障碍与线粒体ROS水平过高有关。



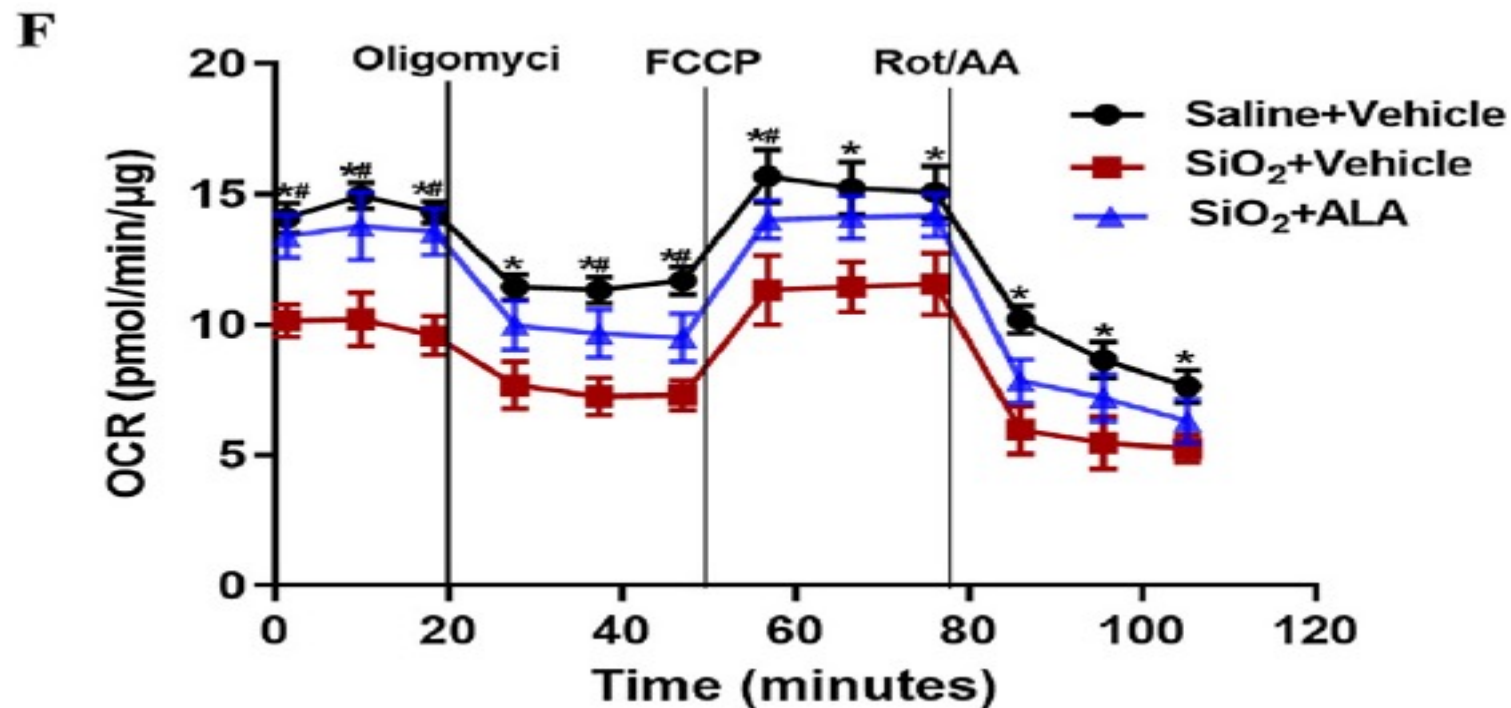
Oxidative stress-induced mitochondrial dysfunction drives inflammation and airway smooth muscle remodeling in patients with chronic obstructive pulmonary disease IF 14.290 1 X J ALLERGY CLIN IMMUNOL 2015



Korencak, Marek et al. "Effect of HIV infection and antiretroviral therapy on immune cellular functions." *JCI insight* vol. 4,12 e126675. 20 Jun. 2019, doi:10.1172/jci.insight.126675

α -硫辛酸激活小鼠的 AMPK/PGC1 α 通路改善线粒体功能来减轻二氧化硅诱导的肺纤维化

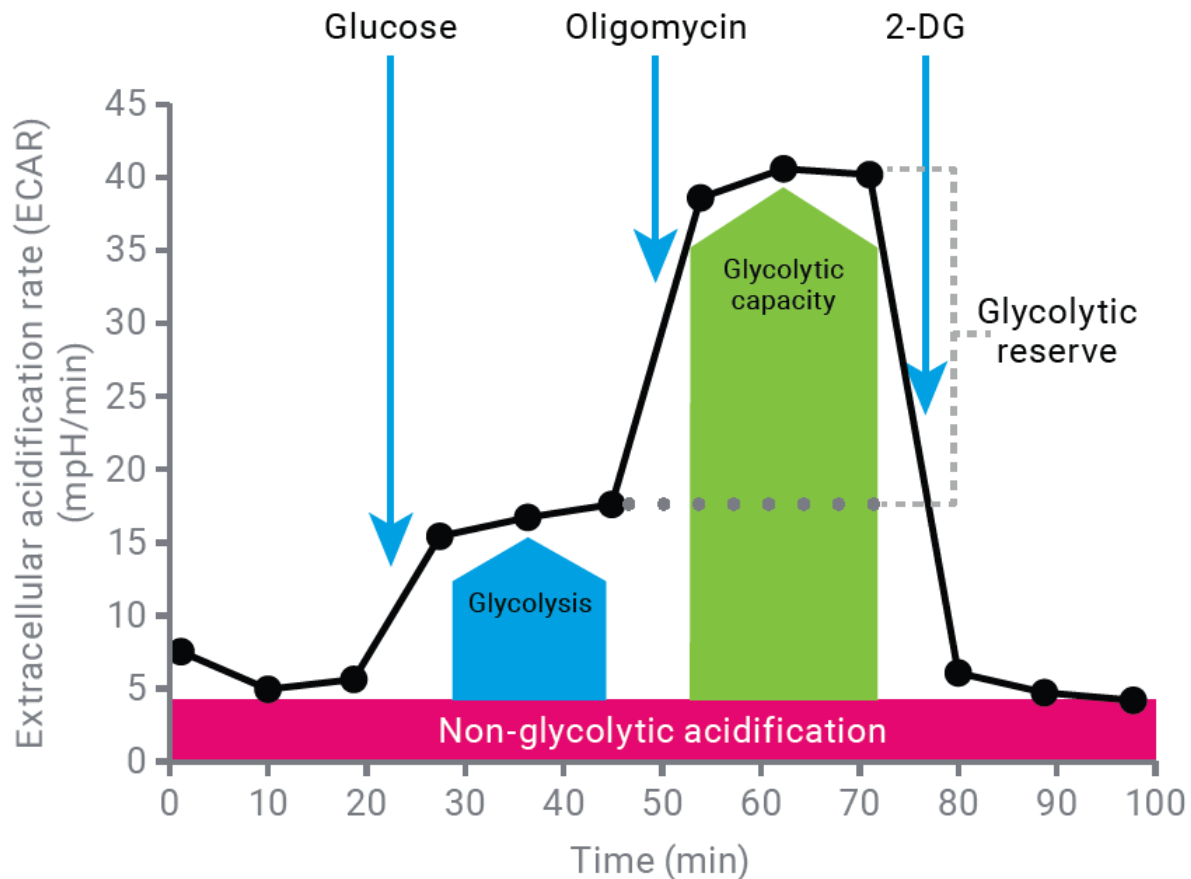
Alpha-lipoic acid attenuates silica-induced pulmonary fibrosis by improving mitochondrial function via AMPK/PGC1 α pathway activation in C57BL/6J mice (*Chang M et al. Toxicol Lett. 2021 Oct 10;350:121-132.*)



通过肺组织实验表明二氧化硅存在下线粒体不同程度受损，但加入ALA后可显著改善线粒体功能

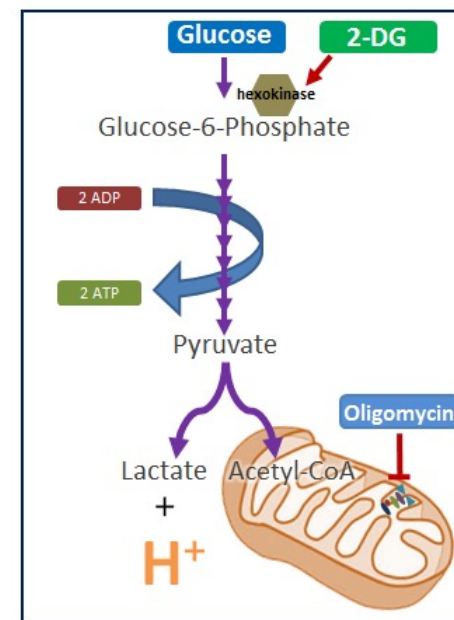
XF Glycolysis Stress Test Assay

实时测定糖酵解功能

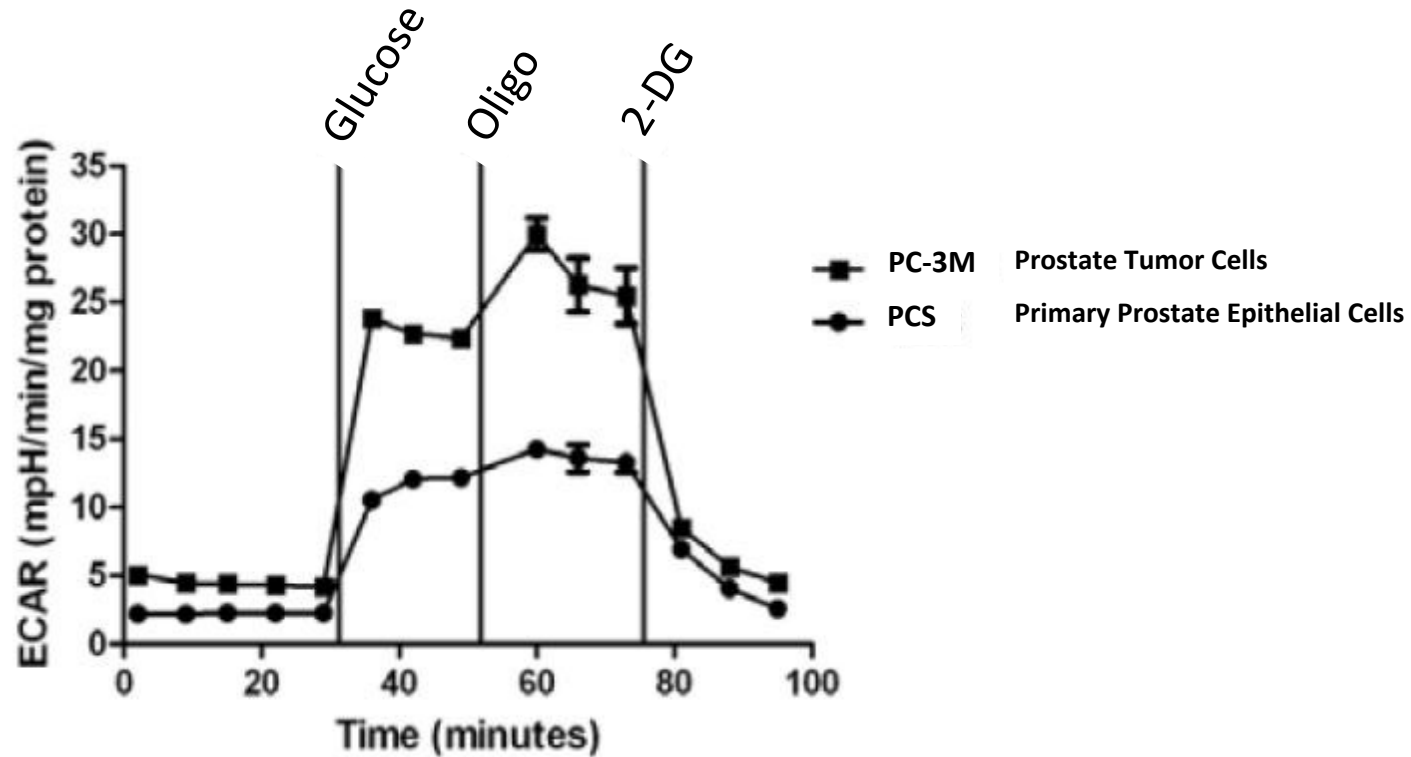


关键参数

- 糖酵解
- 糖酵解能力
- 糖酵解储备



Warburg效应---肿瘤细胞中典型的糖酵解增加



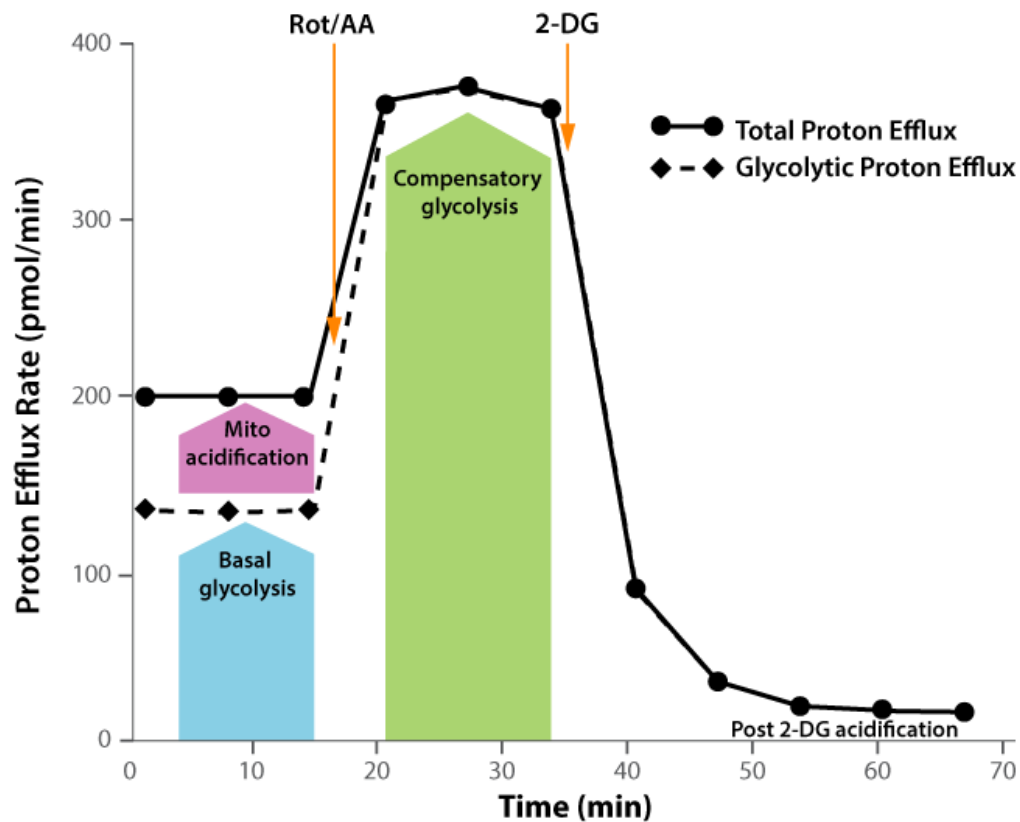
Free Base Lysine Increases Survival and Reduces Metastasis in Prostate Cancer Model

Ibrahim-Hashim, et al., *J Cancer Sci Ther* 2011, S1

XF Glycolysis Stress Test Assay

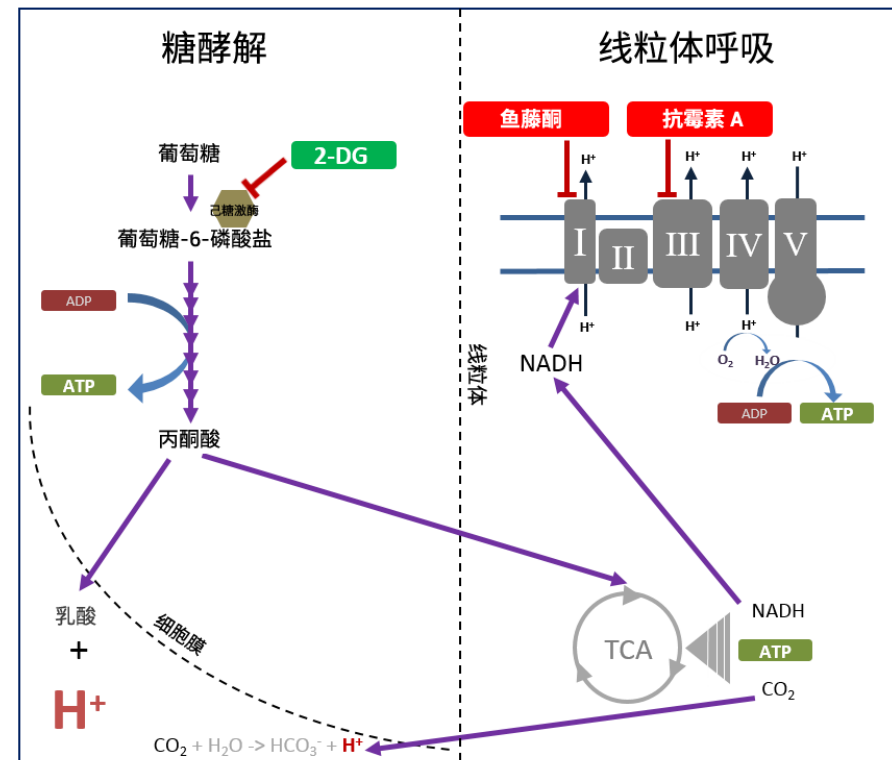
实时测定糖酵解功能

Seahorse XF Glycolytic Rate Assay Profile



关键参数

- 基础糖酵解 Glyco-PER
- 线粒体酸化 Mito-PER
- 补偿性糖酵解



优势：

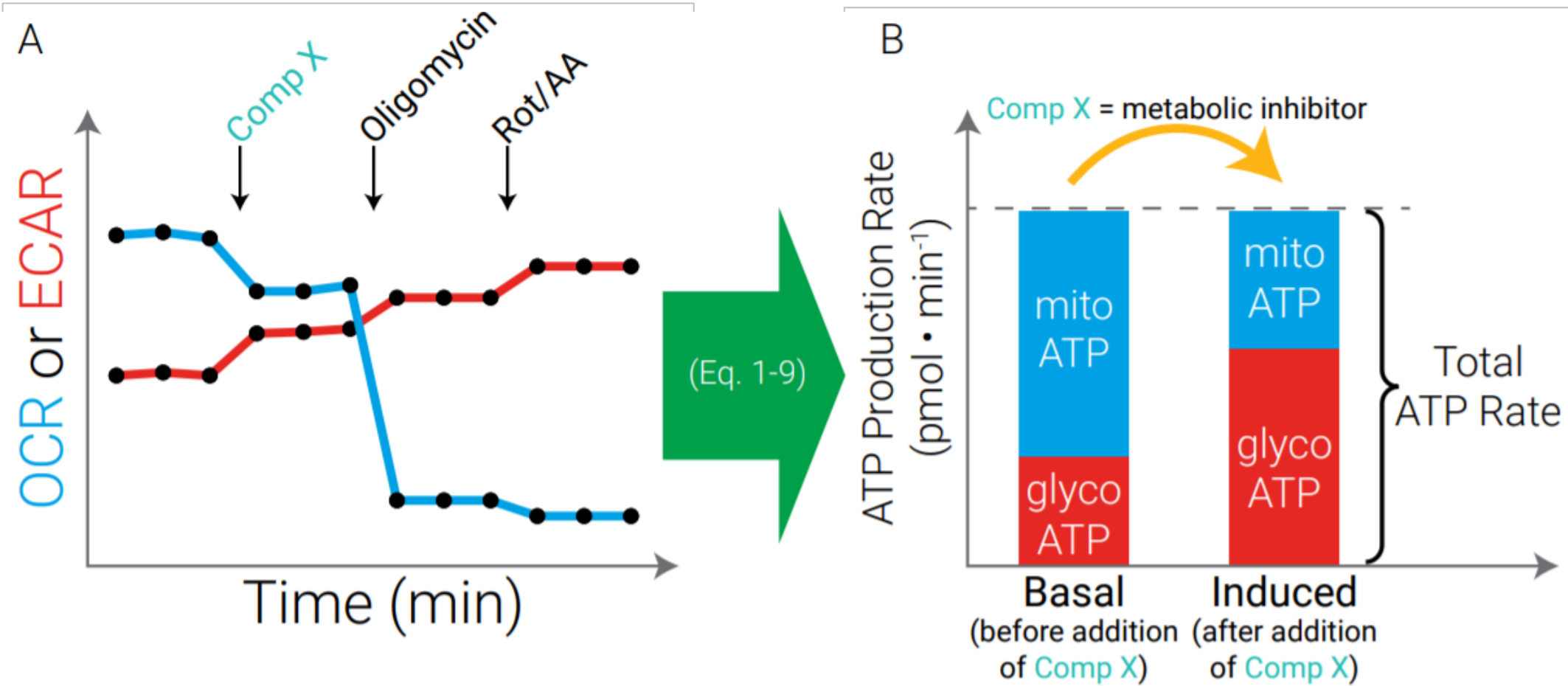
- 检测 CO₂ 对胞外酸化的贡献值
- 检测相当于乳酸的糖酵解速率值
- 定量测量：PER(pmol/min)

Agilent Seahorse XF Real-Time ATP Rate Assay

实时测定细胞ATP产生速率，解析能量供应及代谢转换

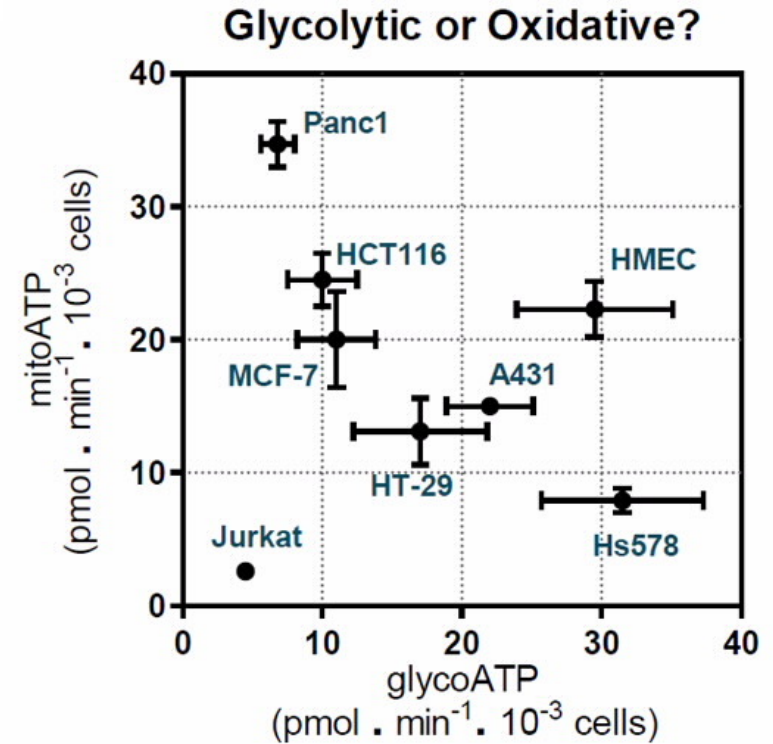
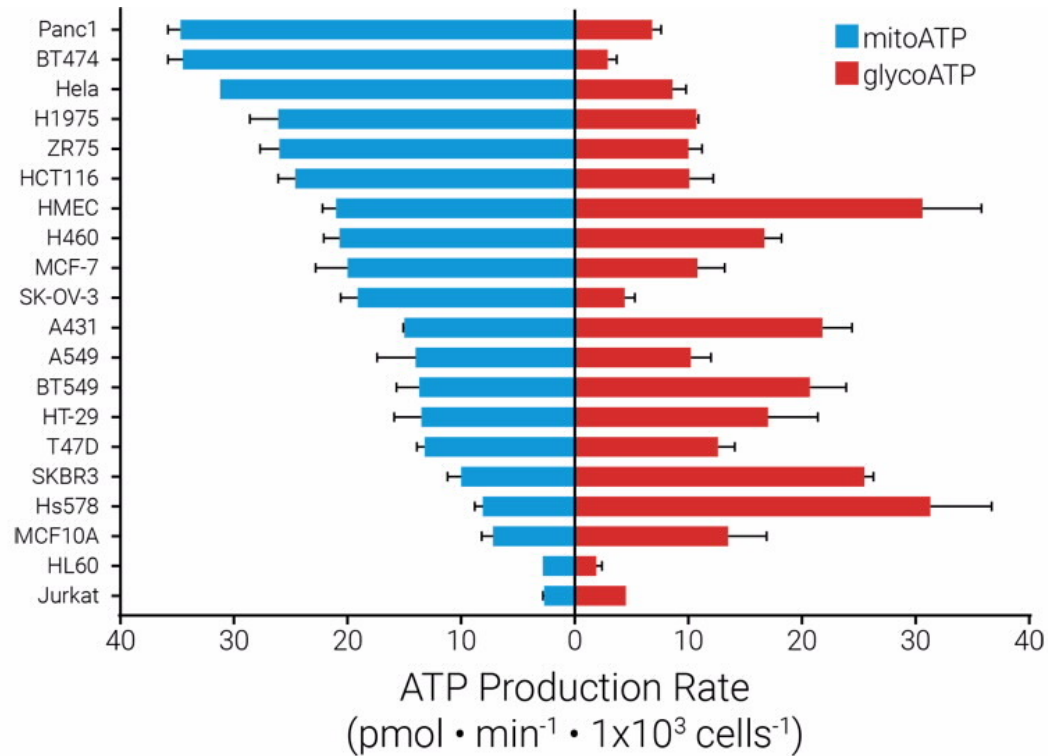


一种可在活细胞中**同时、实时量化线粒体呼吸和糖酵解过程中ATP产生速率**的测定方法。



XF Real-Time ATP Rate Assay

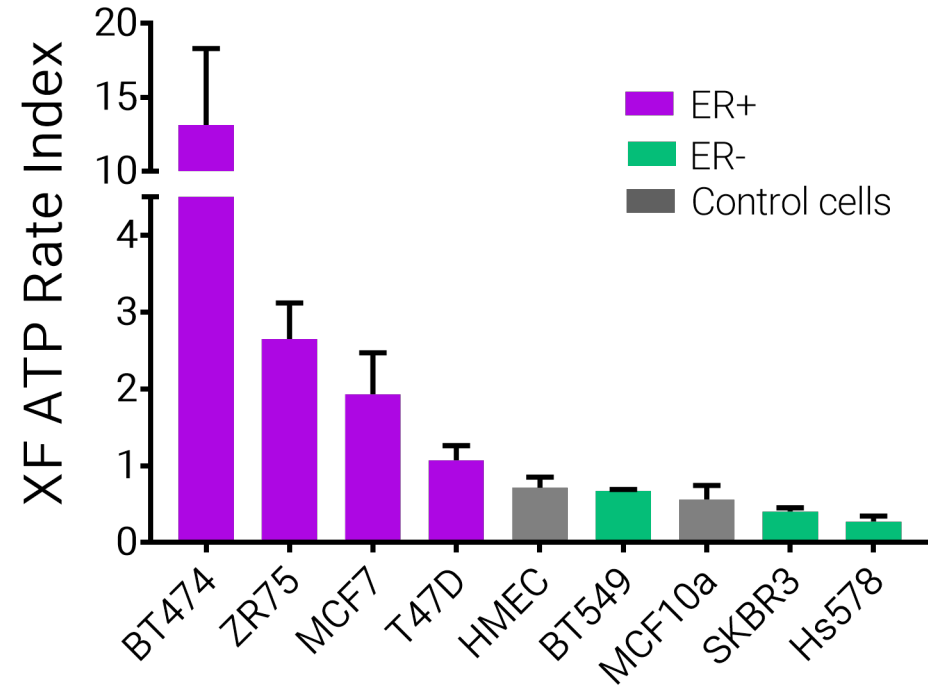
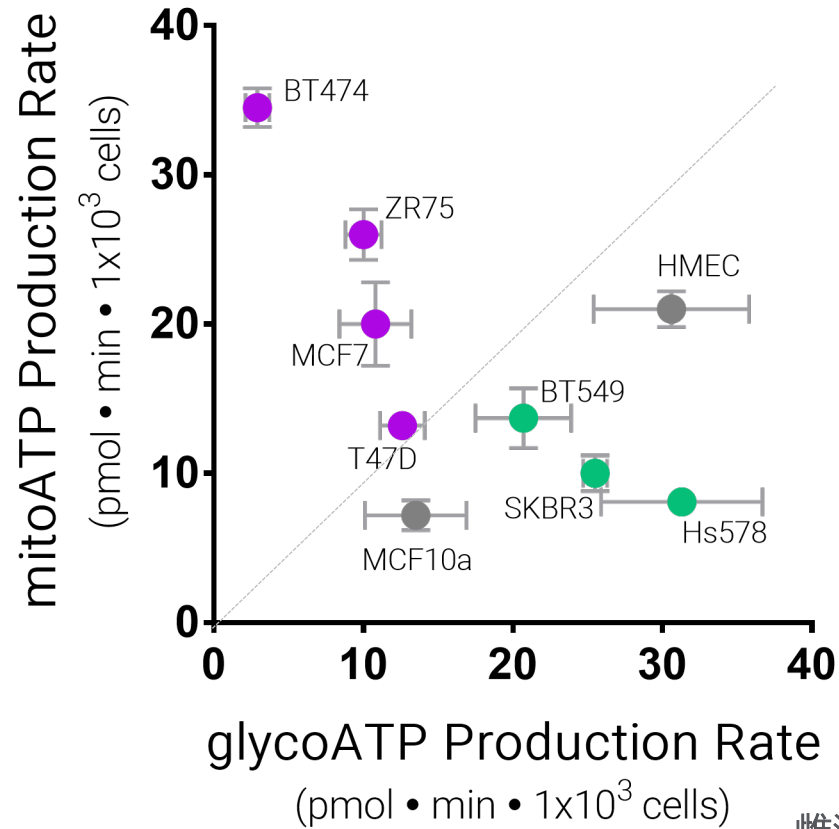
不同细胞具备不同的ATP产生表型



同时定量出OXPHOS和糖酵解通路产生的ATP

雌激素受体阳性(ER+)的乳腺癌细胞相比雌激素受体阴性(ER-)或对照的细胞更具氧化性

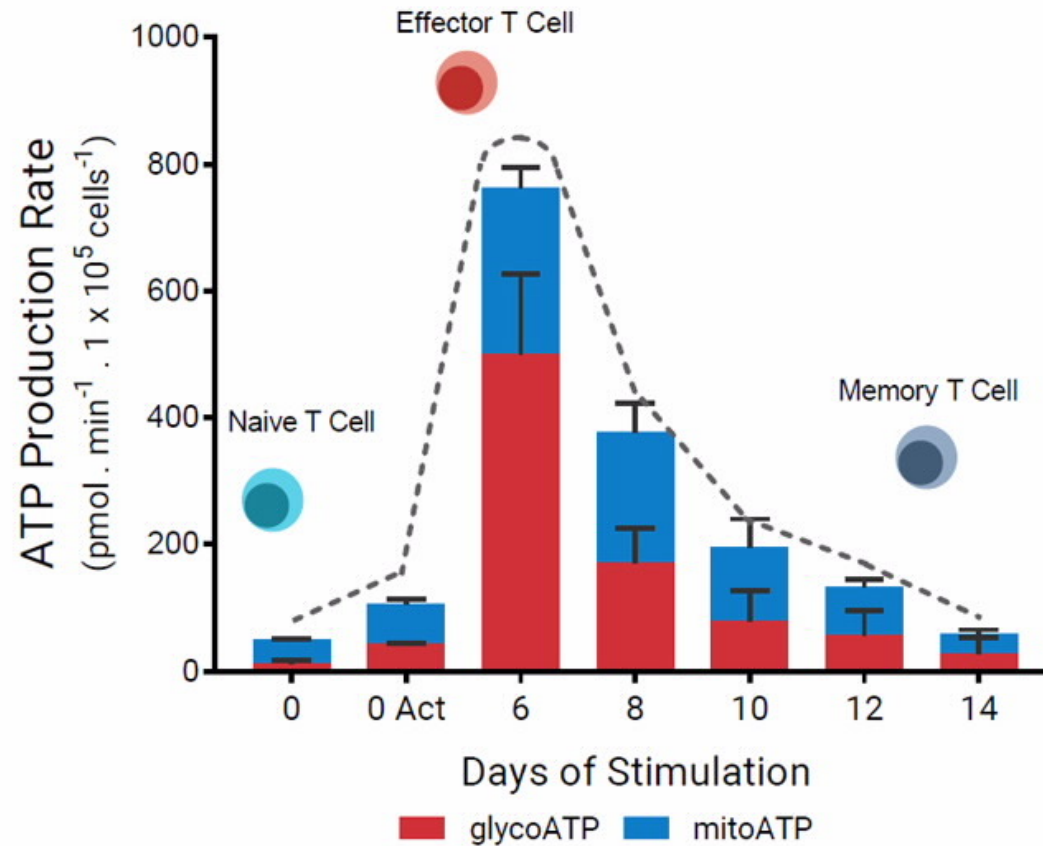
Energetic map



雌激素受体阳性(ER+)的乳腺癌细胞相比雌激素受体阴性(ER-)或对照的正常人乳腺上皮细胞更具氧化性

XF Real-Time ATP Rate Assay

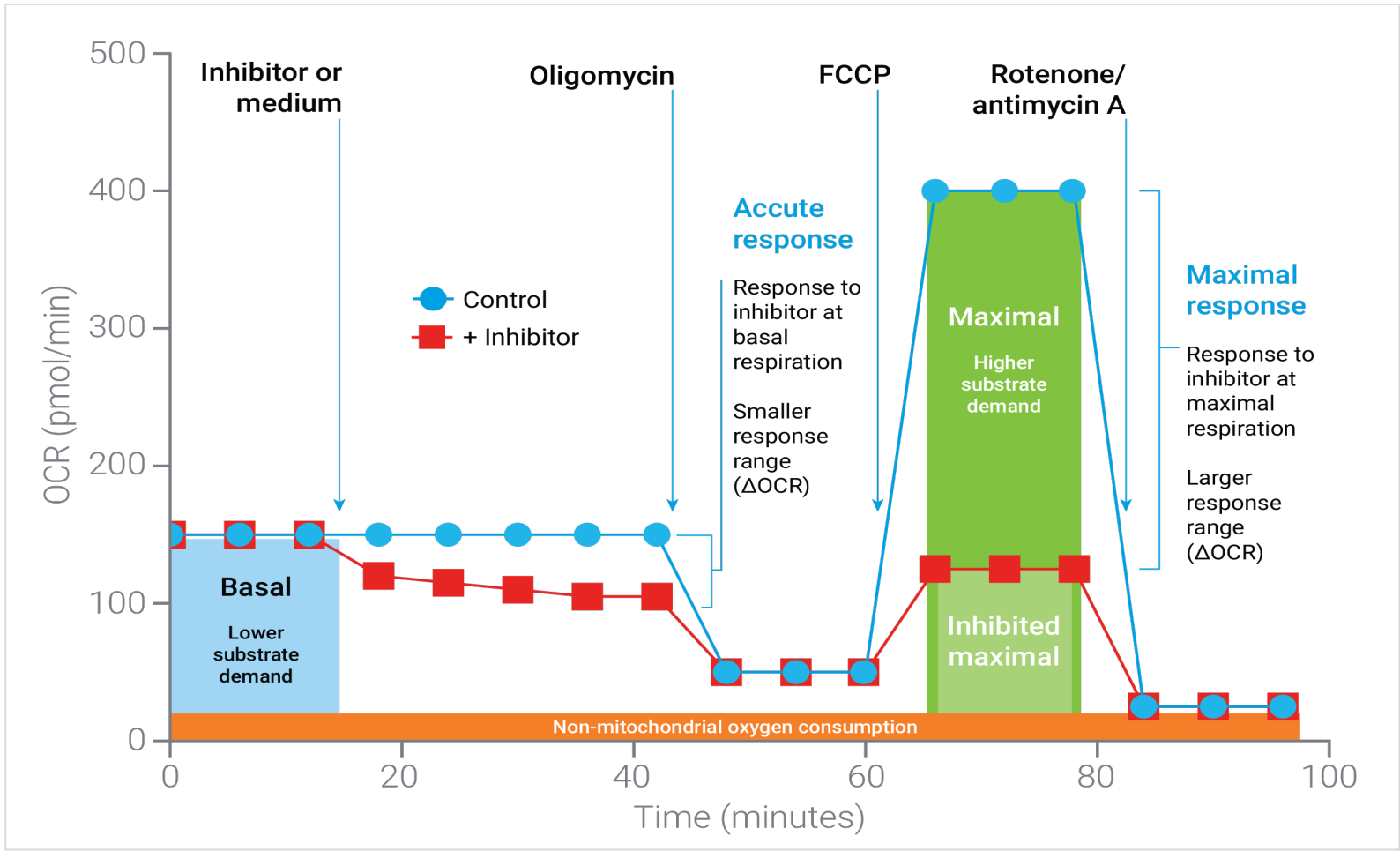
T细胞分化过程中的ATP产生变化



ATP产生速率揭示细胞活动变化，例如细胞增殖、分化、激活等

XF Substrate Oxidation Stress Test

探究底物氧化通路确定细胞线粒体底物氧化水平与疾病的关系



关键参数

□ 基础OCR

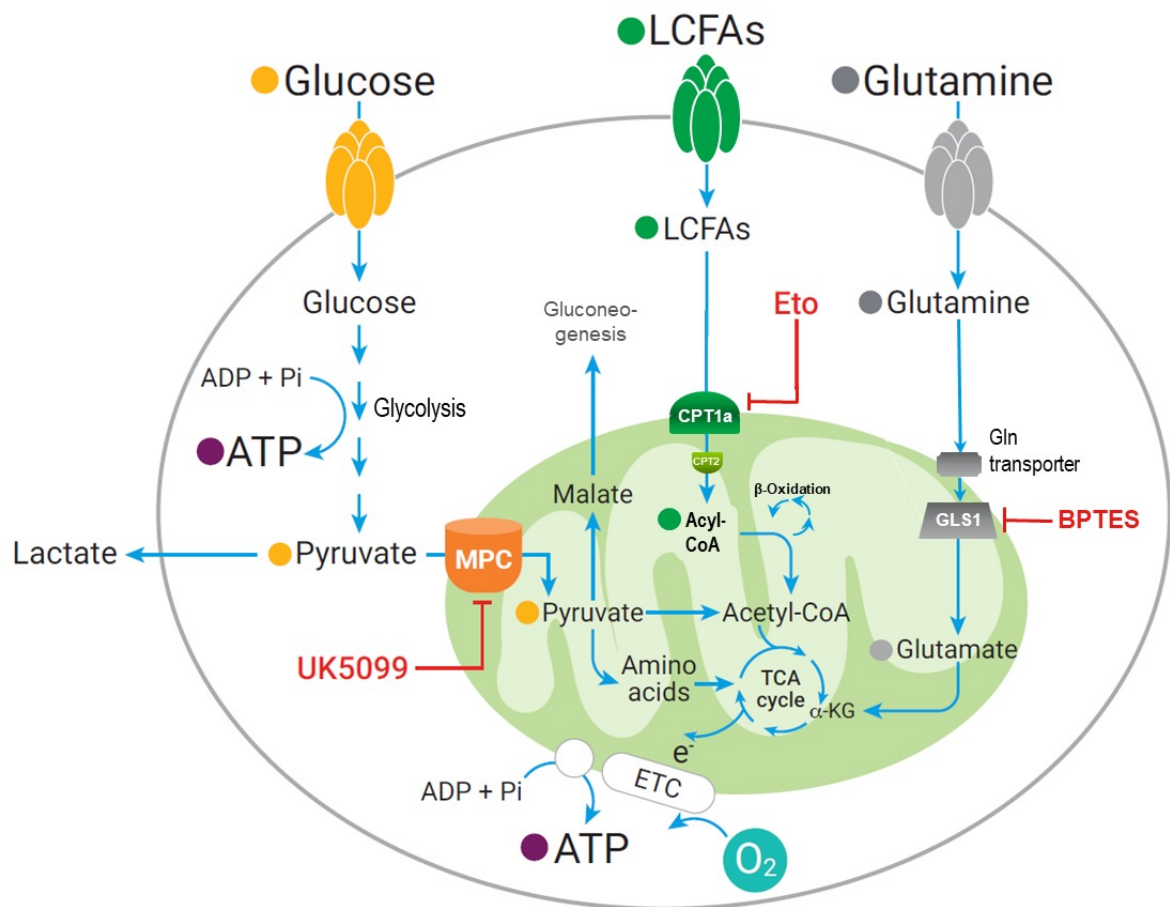
□ 急性响应

□ 最大OCR

XF底物氧化压力测试是基于已被广泛认可的用于测量线粒体功能的XF细胞线粒体压力测试的，使用优化的代谢途径特异性抑制剂来揭示细胞氧化三种主要底物的能力。

Assessment of Specific Substrate Oxidation: How It Works?

使用代谢途径——特异性抑制剂来评估特定底物的氧化



UK5099 (抑制葡萄糖氧化)

线粒体丙酮酸载体(MPC)的抑制剂，MPC将丙酮酸运输到线粒体中

Etomoxir (抑制长链脂肪酸氧化)

肉碱棕榈酰转移酶-1 (CPT-1)的抑制剂，CPT-1对于长链脂肪酸从细胞质基质转运到线粒体中氧化至关重要
(注: 浓度 $> 4 \mu M$ 会对线粒体呼吸产生脱靶效应)

BPTES (抑制谷氨酰胺氧化)

谷氨酰胺酶(GLS1)的抑制剂。GLS1将谷氨酰胺转变为谷氨酸，谷氨酸再转变为 α -酮戊二酸，通过TCA循环氧化
(注: BPTES 不抑制GLS2)

多种多样的应用



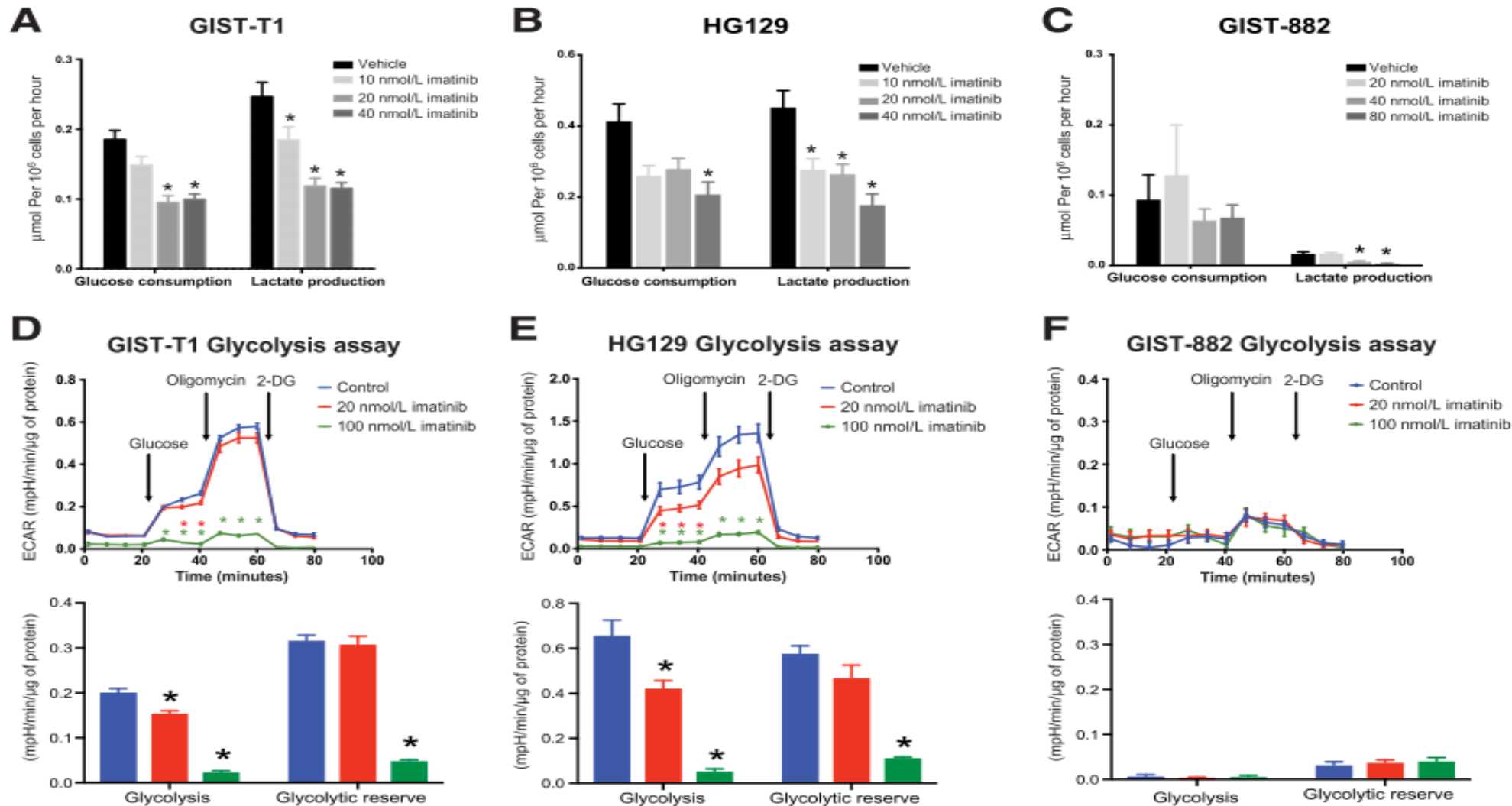
Mitochondrial Inhibition Augments the Efficacy of Imatinib by Resetting the Metabolic Phenotype of Gastrointestinal Stromal Tumor

Gerardo A. Vitiello¹, Benjamin D. Medina¹, Shan Zeng¹, Timothy G. Bowler¹, Jennifer Q. Zhang¹, Jennifer K. Loo¹, Nesteene J. Param¹, Mengyuan Liu¹, Alec J. Moral¹, Julia N. Zhao¹, Ferdinand Rossi¹, Cristina R. Antonescu², Vinod P. Balachandran¹, Justin R. Cross³, and Ronald P. DeMatteo¹



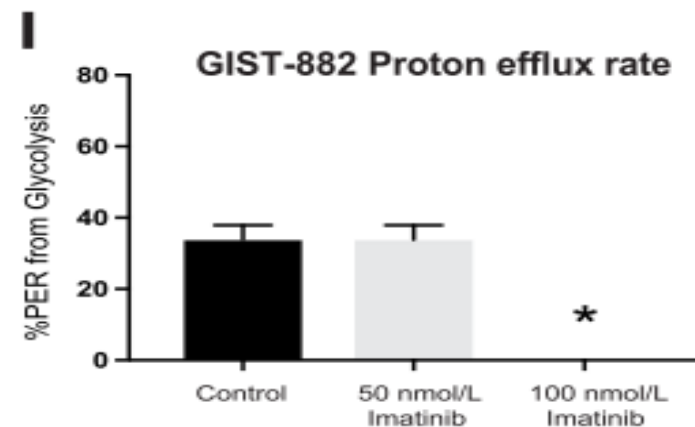
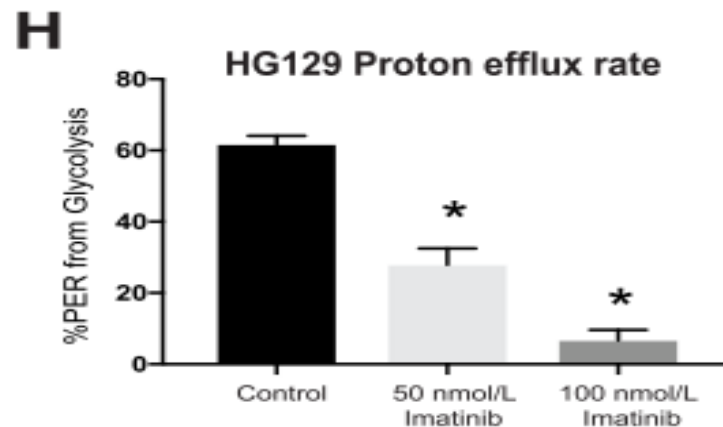
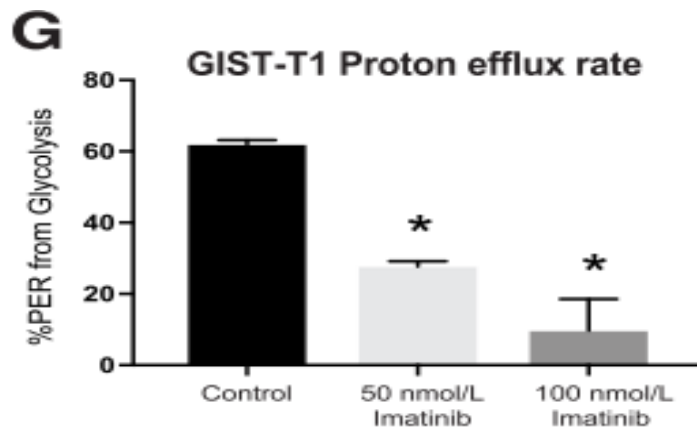
Clin Cancer Res. 2018 Feb 15;24(4):972-984.

伊马替尼减少胃肠间质肿瘤细胞系葡萄糖的摄取和糖酵解的能力



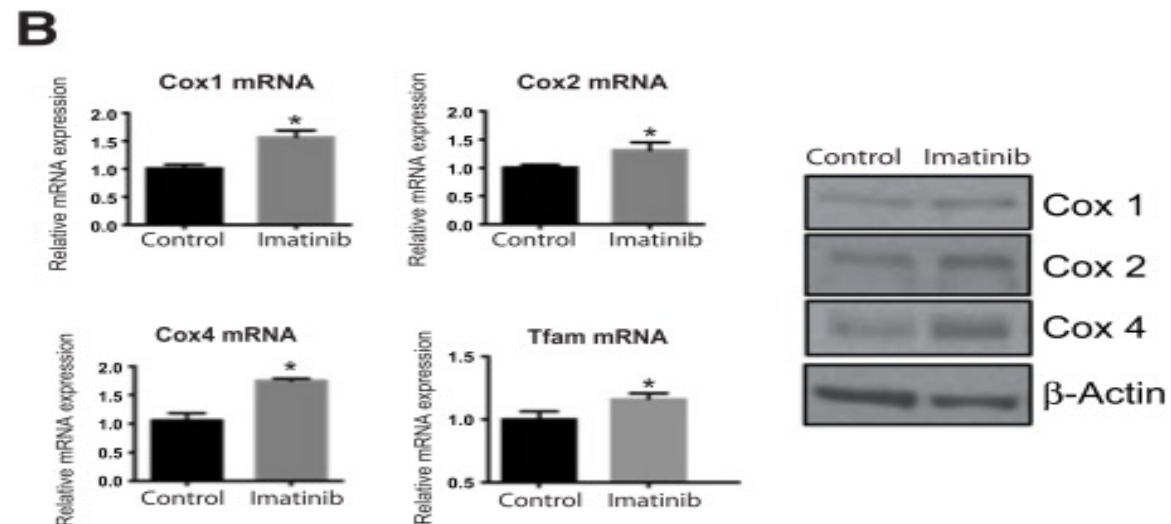
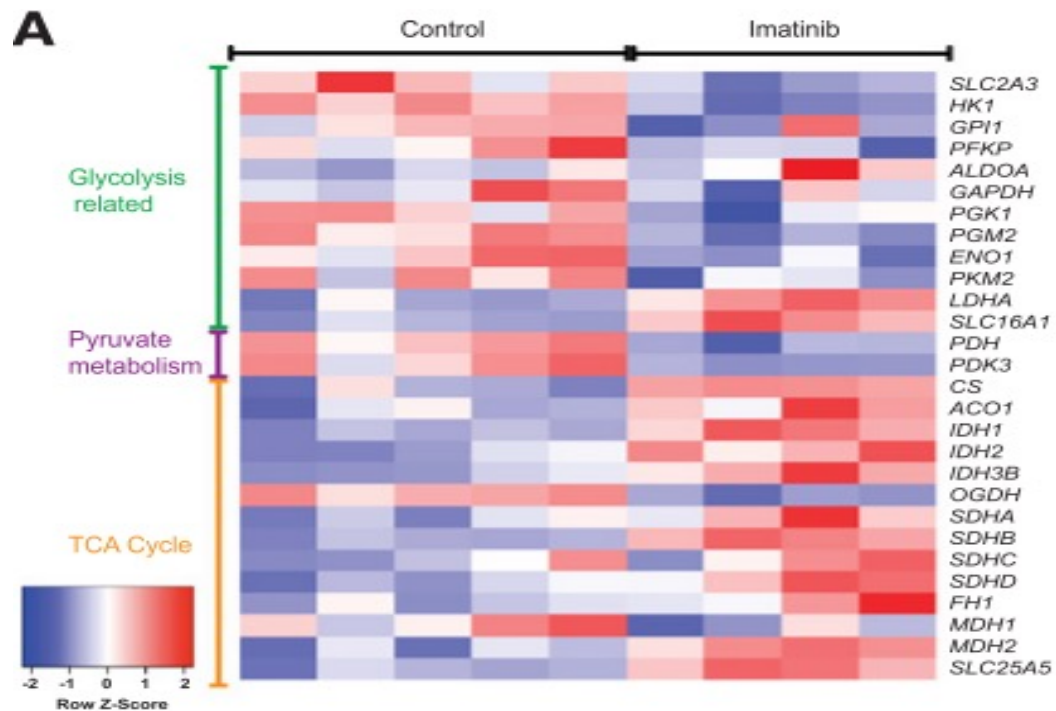
Vitiello GA et al. Clin Cancer Re. 2018

伊马替尼减少胃肠间质肿瘤细胞系的糖酵解速率



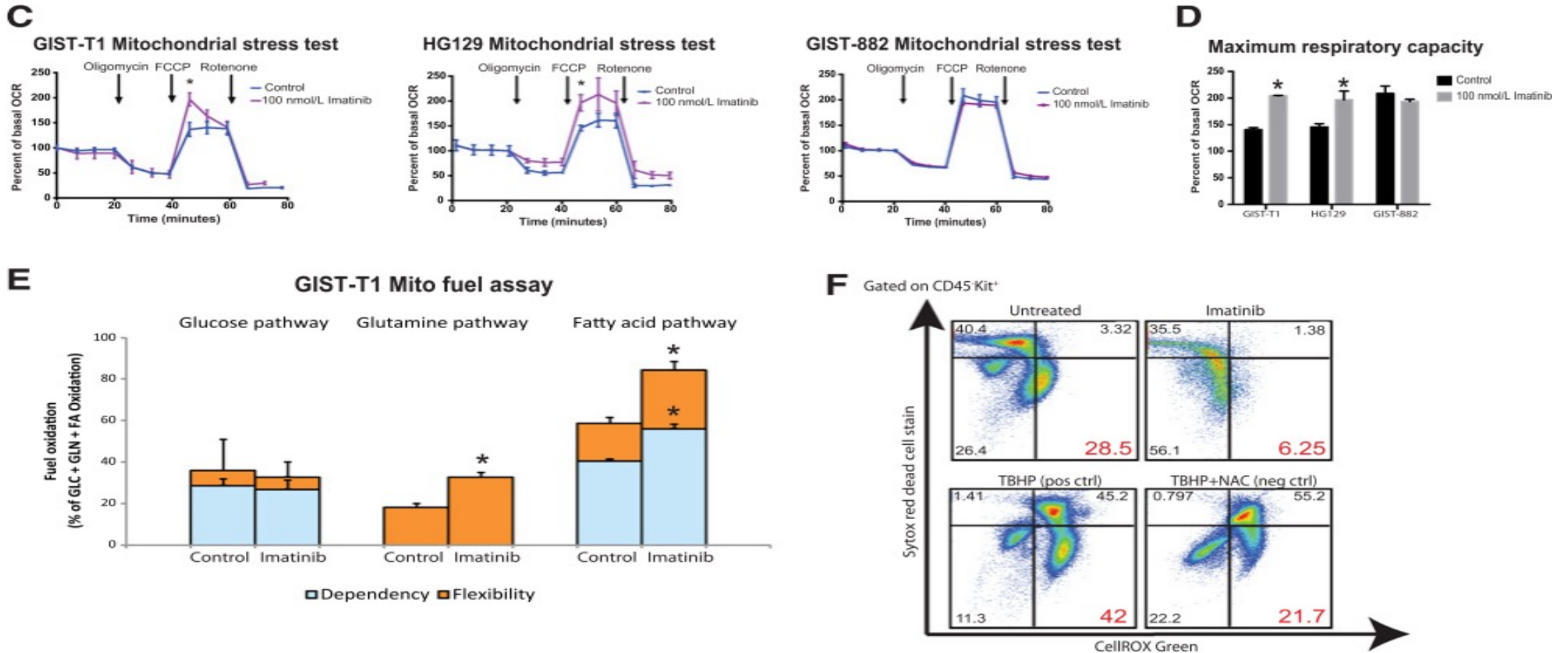
Vitiello GA et al., Clin Cancer Res. 2018

伊马替尼的治疗与线粒体动力学改变密切相关



Vitiello et al., Clin Cancer Res 2018

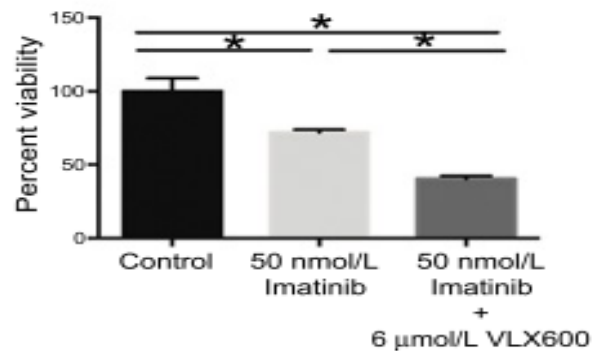
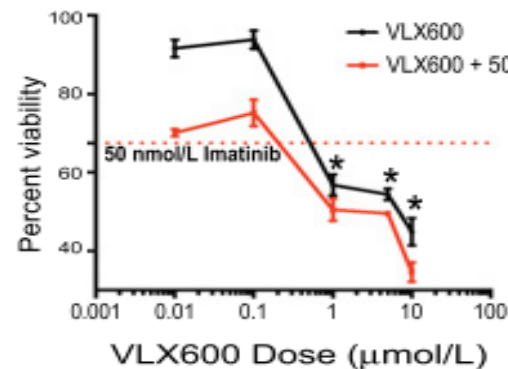
伊马替尼的治疗与线粒体动力学改变密切相关



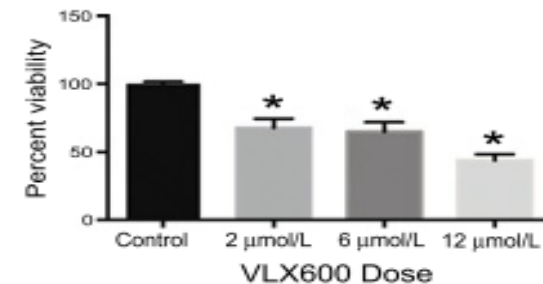
Vitiello et al., Clin Cancer Res 2018

线粒体抑制对胃肠间质肿瘤细胞系和异种移植产生了抗增殖的效果

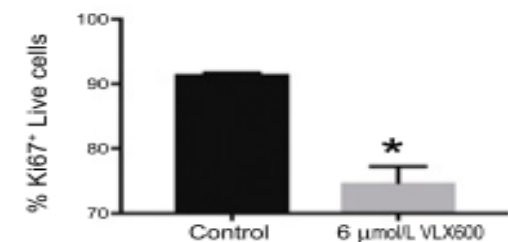
A GIST-T1



B GIST-T1



% Ki67+ Live cells

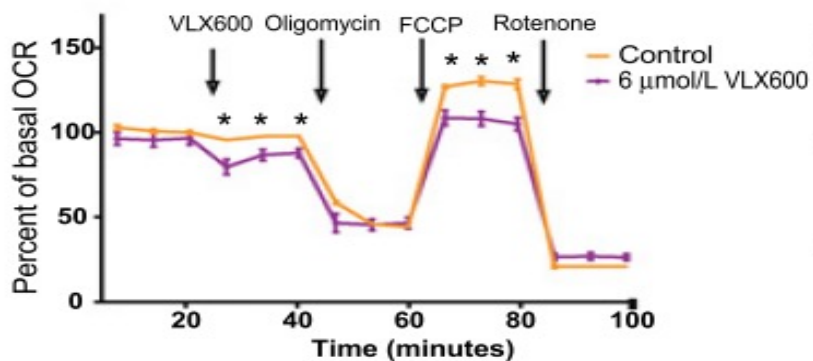


C

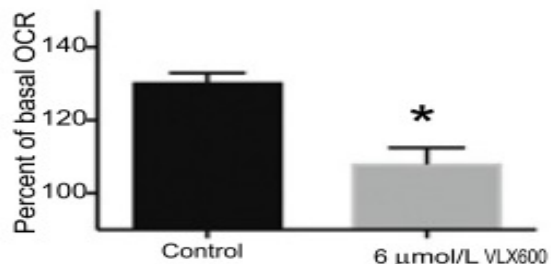
Vitiello et al., Clin Cancer Res 2018

线粒体抑制对胃肠间质肿瘤细胞系和异种移植产生了抗增殖的效果

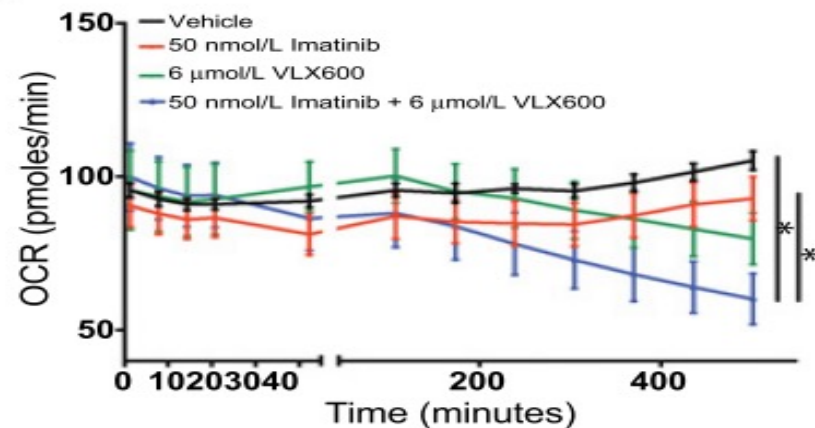
GIST-T1 Mitochondrial stress test



Maximum respiratory capacity

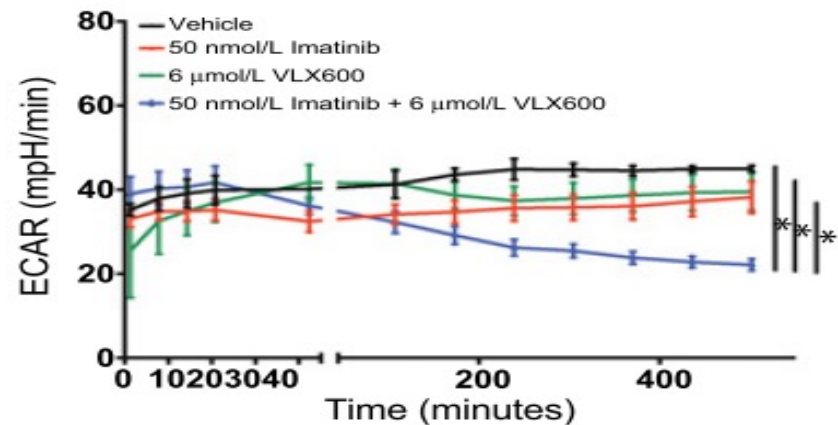
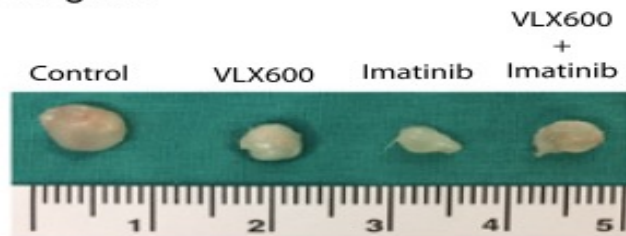
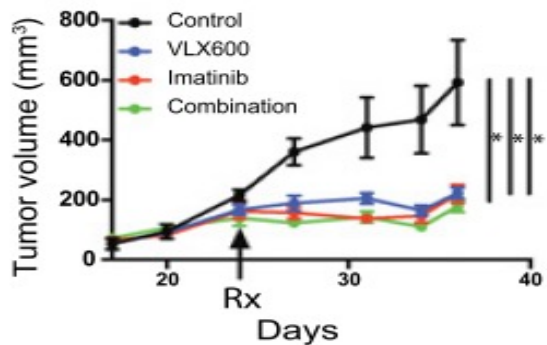


D



E

GIST-T1 Xenograft



Vitiello et al., Clin Cancer Res 2018

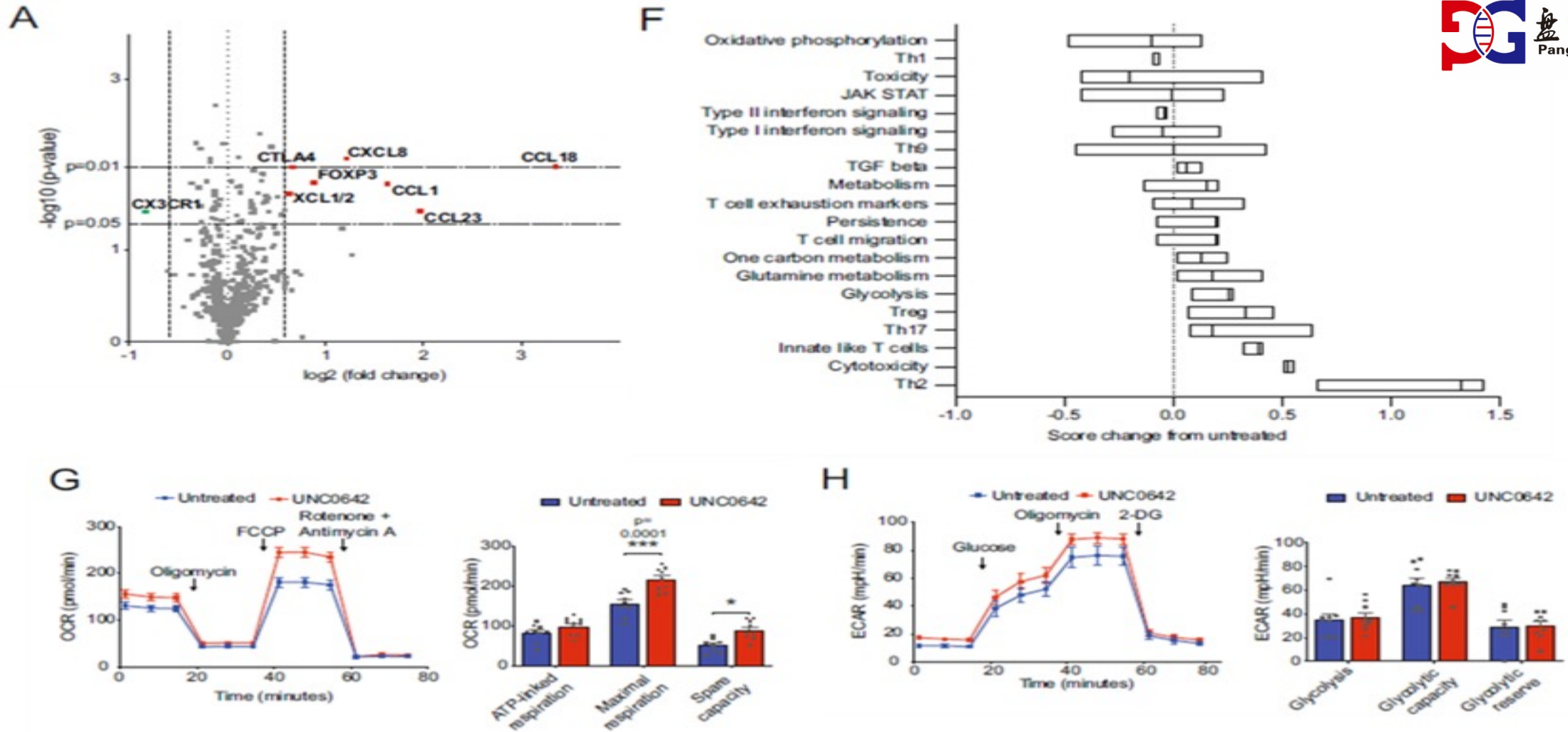
[nature](#) > [nature communications](#) > [articles](#) > article

Article | [Open Access](#) | [Published: 02 February 2023](#)

G9a/GLP inhibition during ex vivo lymphocyte expansion increases in vivo cytotoxicity of engineered T cells against hepatocellular carcinoma

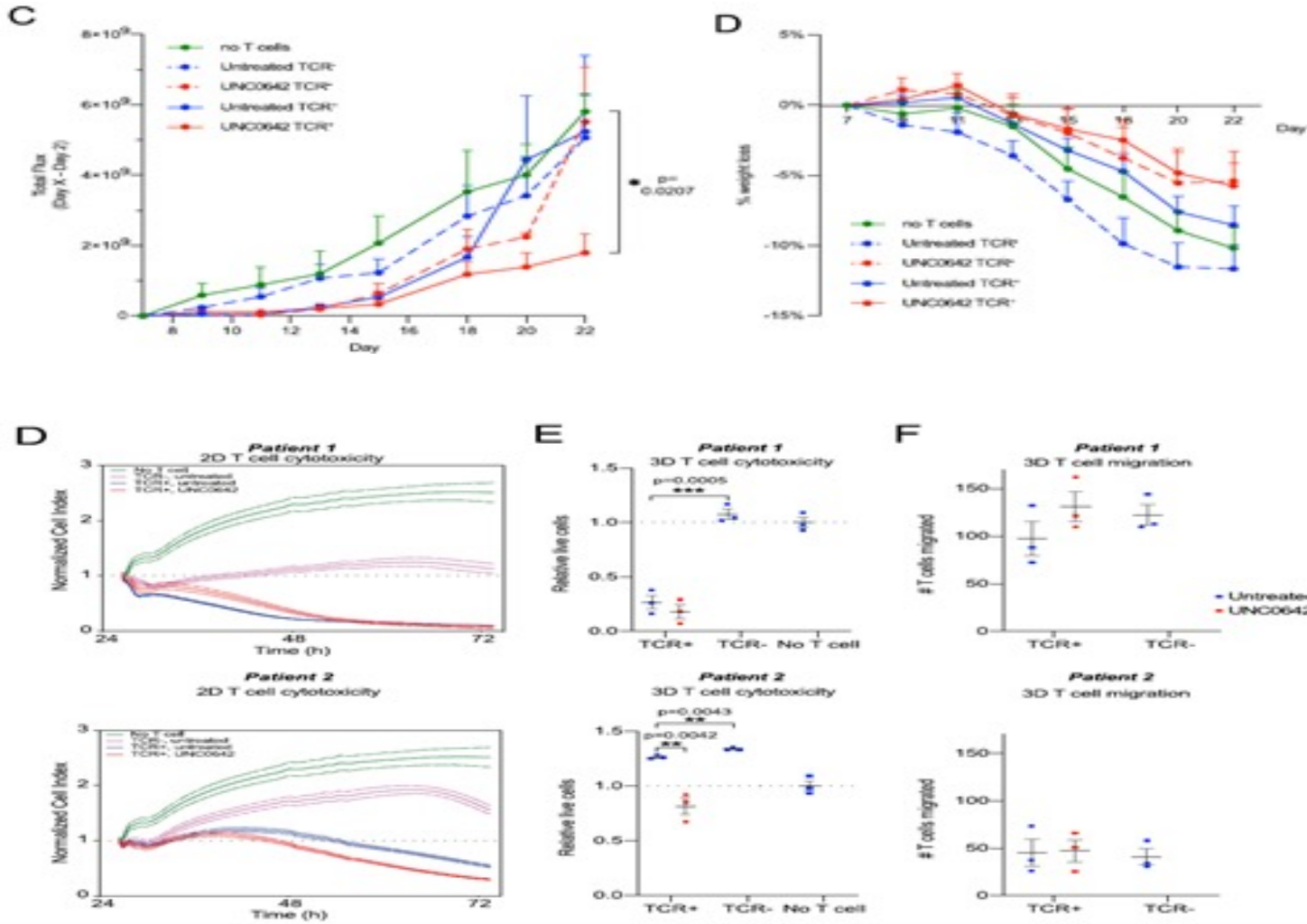
[Maxine S. Y. Lam](#), [Jose Antonio Reales-Calderon](#), [Jin Rong Ow](#), [Joey J. Y. Aw](#), [Damien Tan](#), [Ragavi Vijayakumar](#), [Erica Ceccarello](#), [Tommaso Tabaglio](#), [Yan Ting Lim](#), [Wang Loo Chien](#), [Fritz Lai](#), [Anthony Tan Tanoto](#), [Qingfeng Chen](#), [Radoslaw M. Sobota](#), [Giulia Adriani](#), [Antonio Bertoletti](#), [Ernesto Guccione](#) & [Andrea Pavesi](#) 

[Nature Communications](#) **14**, Article number: 563 (2023) | [Cite this article](#)



UNC0642改变细胞因子和杀伤途径基因转录水平，也包括能量代谢途径的改变

抑制G9a/GLP在小鼠体内模型和病人样本中都增强了TCR-T细胞杀伤效力



小鼠体内模型中，UNC0642明显减少小鼠肿瘤负荷以及缓解体重下降，可能是通过改善T细胞在肝脏中的持久性和细胞毒性提高TCR-T细胞的体内抗肿瘤活性。

任何实验都需要数据归一化才能得出有效的结论，尤其是涉及样本数目差异时，对于使用安捷伦Seahorse XF技术的实时细胞代谢分析，每孔细胞数是数据归一化普遍接受的参考值。



应用场景一

客观判断细胞汇合度，协助摸索细胞密度，提高实验效率，减少实验成本；

应用场景二

汇合度快速扫描监测细胞成长过程，协助确定上机时间；

应用场景三

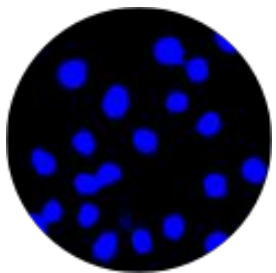
检测上机前细胞状态，减少实验失败概率；

应用场景四

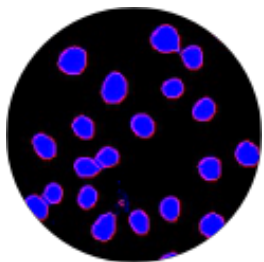
快速准确地对Seahorse XF 8/24/96孔细胞板进行原位全孔成像计数分析，进行结果归一化

For Research Use Only. Not for use in diagnostic procedures.

Falcon S300可快速准确地对Seahorse XF 8/24/96孔细胞板进行原位全孔成像计数分析，用于校正存在细胞数差异的Seahorse分析数据。



原位染色



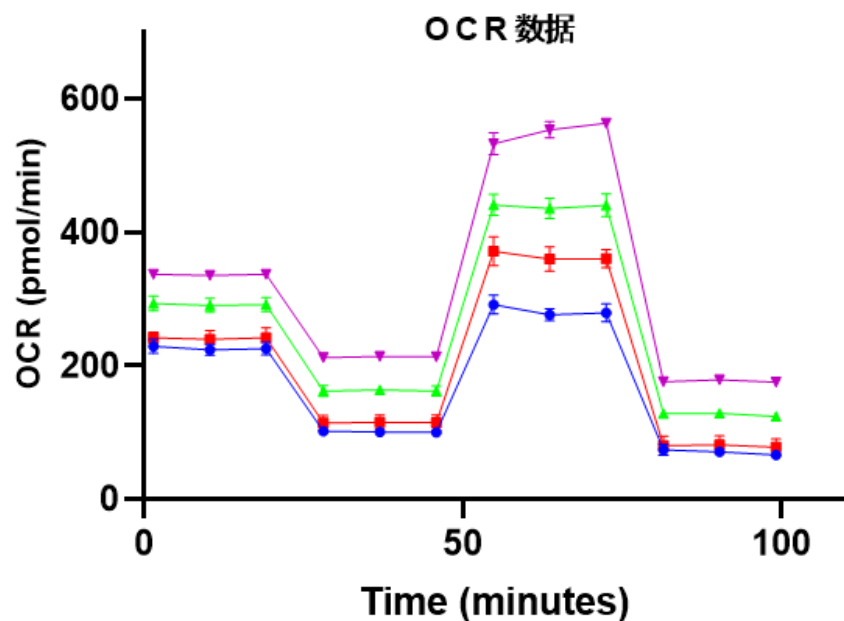
核计数

	1	2	3	4	5	6	7	8	9	10	11	12
A	0	16214	16245	16893	17242	16893	16593	18321	16788	18432	17843	0
B	17446	18022	16841	17325	17367	16332	18231	17973	17355	17256	17992	17652
C	12562	12473	11895	13124	12981	11596	11769	12179	12512	13056	12885	12156
D	11693	11378	12658	11553	12778	13122	13272	12655	12339	13021	12889	12011
E	21452	21992	22546	23012	22882	21054	21554	22543	23112	22134	23356	23545
F	22553	22378	21331	23389	21766	22498	22466	23213	22329	22965	21886	22519
G	8745	8521	7983	8320	8129	7879	7982	8322	8341	9031	9110	8860
H	0	7971	8281	8289	8302	7865	7960	8289	8109	8367	8108	0

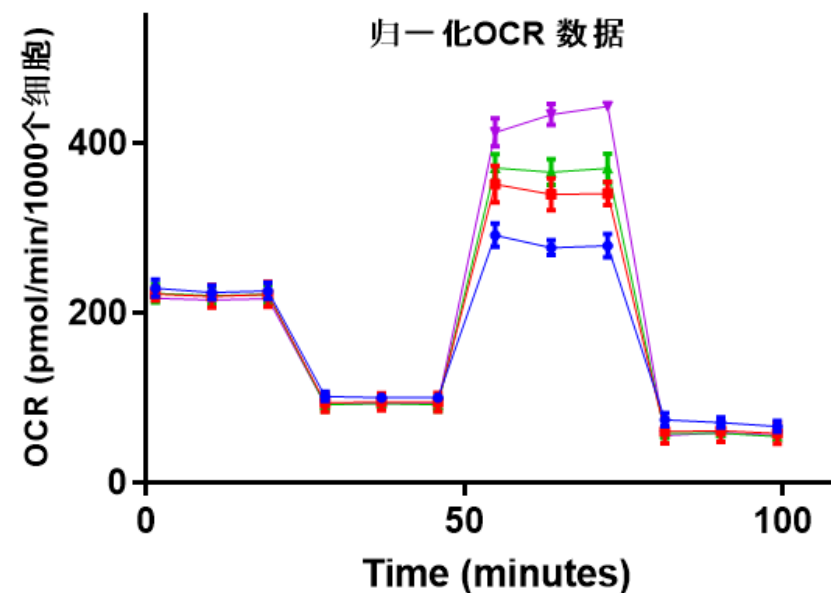
For Research Use Only. Not for use in diagnostic procedures.

Seahorse 数据归一化

全孔原位成像计数结果导出后，复制进Seahorse Wave软件，可直接对数据结果进行归一化。



不同密度梯度HeLa细胞归一化之前
线粒体压力测试结果



不同密度梯度HeLa细胞归一化之后
线粒体压力测试结果

For Research Use Only. Not for use in diagnostic procedures.

Alicelligent 细胞能量代谢试剂盒介绍



细胞能量代谢试剂盒产品特点

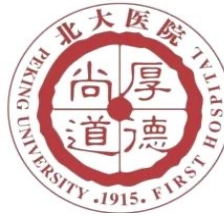


种类：≥10

产品优势

- 优势1：化合物“即开即用，按次配比”，无需其他溶剂溶解，简化实验流程；
- 优势2：葡萄糖、丙酮酸盐、谷氨酰胺三种底物已预混，减少检测培养液配置的操作步骤，一次性使用，减少浪费。

细胞能量代谢试剂盒用户群



细胞能量代谢试剂盒市场推广活动



Cell Metabolism 盘古生物 Pangu Bioscience

助力代谢 好礼钜惠

开学季

[活动介绍]
活动期间购买Alicelligent[安理]细胞能量代谢试剂盒及Seahorse检测服务的用户



首次购买安理**试剂盒**送上机辅导**1**次

推新活动
新用户购买 **Alicelligent安理**试剂盒/检测服务, 首单赠50元京东卡

满赠活动
累积消费满5000, 赠100元京东卡
累积消费满1万, 赠200元京东卡
累积消费满1.5万, 赠400元京东卡
累积消费满2万, 赠600元京东卡

活动时间 2023/9/1-2023/9/30

电话: 010-87888360/4008009630
本次活动最终解释权归盘古生物所有



文献奖励
Alicelligent 助力代谢 精彩无限

第01期

活动介绍

活动期间凡使用Alicelligent[安理科技]细胞能量代谢试剂盒发表文章的用户, 且文章正文中清楚标明公司名称 (**Alicelligent**) 字样及试剂盒介绍 (产品货号: **ALS22012** 等) 字样即可领取奖励。

奖励说明

奖励额度依据文章发表时期刊最新的SCI影响因子, 具体奖励如下:

影响因子:

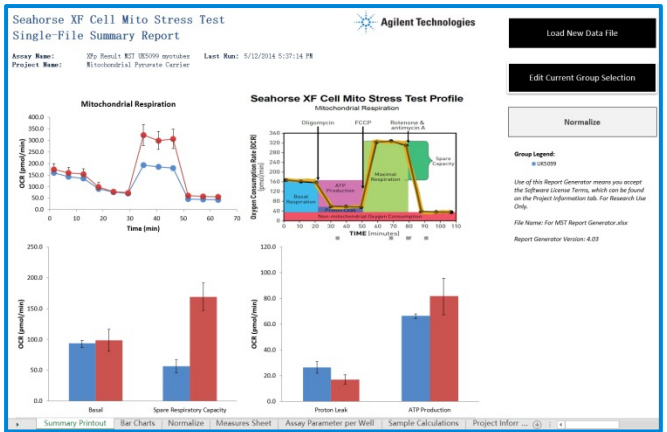
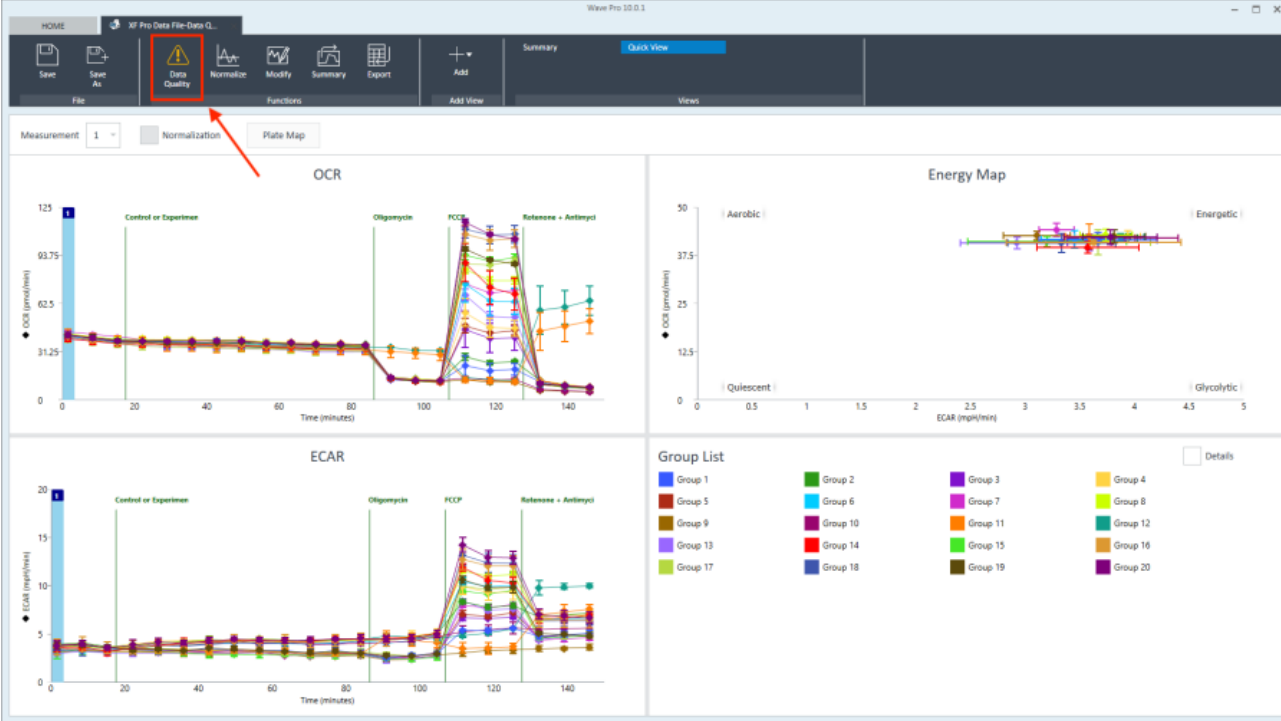
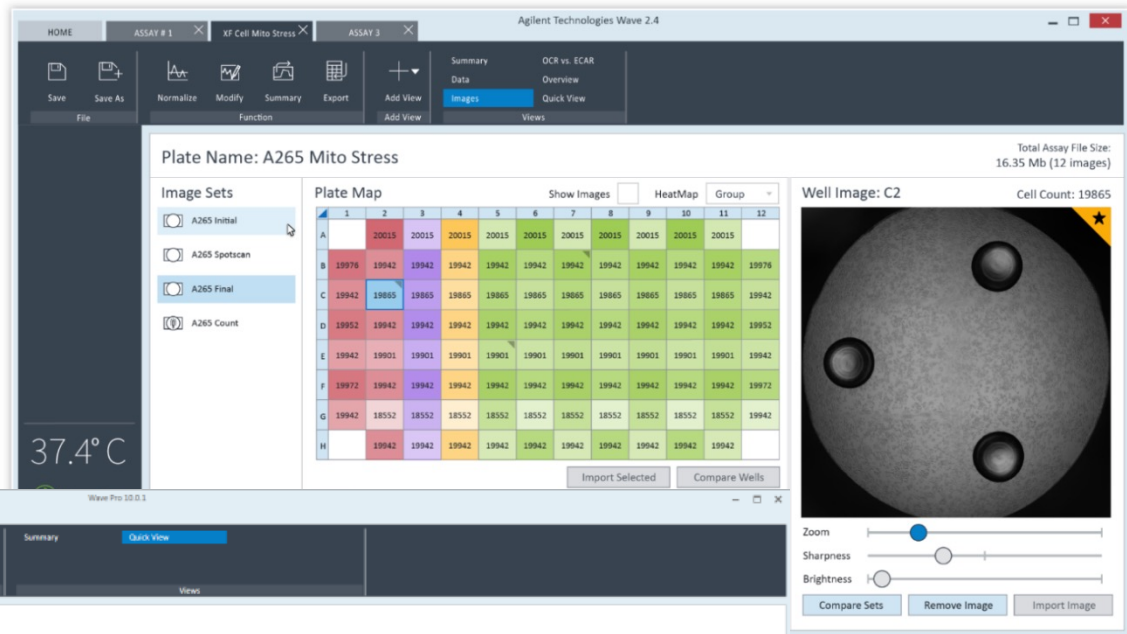
- IF \geq 1奖励200元;
- IF \geq 2奖励400元;
- IF \geq 3奖励600元;
-

以此类推。

Intuitive Software for Data Collection and Analysis (桌面版)

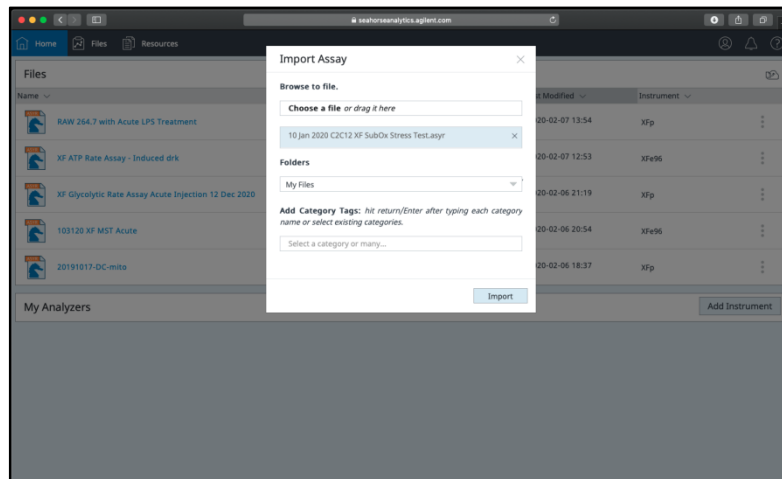
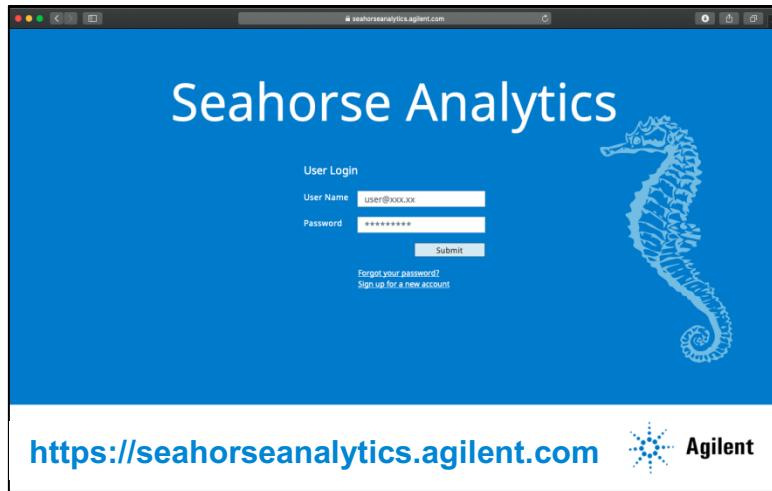
Seahorse Wave Pro

<https://www.agilent.com.cn/zh-cn/product/cell-analysis/real-time-cell-metabolic-analysis/xf-software/seahorse-wave-pro-software-2007523>



Intuitive and easy-to-use software: Data Acquisition and Analysis (网页版)

<https://seahorseanalytics.agilent.com/Account/Login?ReturnUrl=%2F>



Agilent Cell Reference Publication Database



<https://www.agilent.com/search/?N=4294836537>

Home > Search

Refine Results

SEARCH View per page: 20 1 - 20 of 6451 results

+ Industry

+ Research Area

+ Cell Type

+ Cell Line

+ Analysis Platform

+ Assay

+ Species

+ Language

+ Publication Date

Agilent Cell Analysis Publication Database

The Agilent Cell Analysis Publication Library provides an easy way to search scientific publications that reference and/or cite Agilent products. Search publications by research area, cell type, cell line, instrument, assay, or author. The resulting publications can be reviewed with links to the abstract, in the Quick View, or be exported in MS Excel format and reviewed offline at a later time. (Click on the Download Results button to compile the results)
For Research Use Only. Not for use in diagnostic procedures.

Download Results

Publication

PM2.5 triggered apoptosis in lung epithelial cells through the mitochondrial apoptotic way mediated by a ROS-DRP1-mitochondrial fission axis

Journal: J Hazard Mater / Publication Date: October 5, 2020 / Author: Liu X, et al.

Quick View Supporting Products

Publication

Acute and long-term metabolic consequences of early developmental Bisphenol A exposure in zebrafish (Danio rerio)

Journal: Chemosphere / Publication Date: October 1, 2020 / Author: Martinez R, et al.

Quick View Supporting Products

For Research Use Only. Not for use in diagnostic procedures.

<https://www.agilent.com/en/products/cell-analysis/how-to-run-an-assay>

How to run an assay

XF Assay Learning Center


Analyzer:
Seahorse XFe96

1. Gather materials
2. Prepare for assay
3. Set up assay
4. Run assay
5. Analyze results
6. Beyond the basics

Seahorse XF Assay Learning Center

Select your XF Instrument Type

XFe96



Procedures, techniques & resources for a successful XFe96 Assay

This learning center is designed to introduce you to the Seahorse XF assay workflow, with a focus on procedures and techniques to ensure optimal XF assay performance and results. As you read through each section, the procedures refer to using the Agilent Seahorse XF Real Time ATP Rate Assay to perform initial cell characterization. The techniques described apply to all Seahorse XF Assays, such as seeding adherent cells, loading injection ports, etc. Only the required consumables will vary according to your XF Analyzer model and XF Assay Kit. Select your XF Analyzer using the drop-down menu, then click a section below to display the relevant content for that step of the XF assay workflow.

Key Success to XF Assay



XF 实验基本流程

Before XF Assay

Day of XF Assay

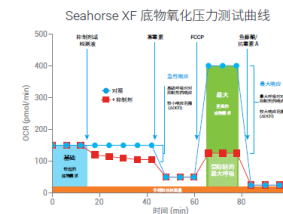
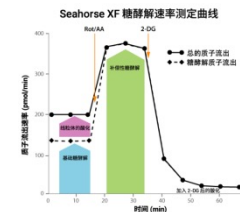
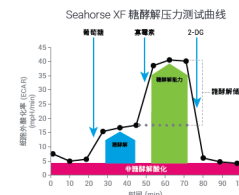
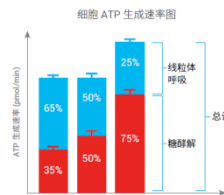
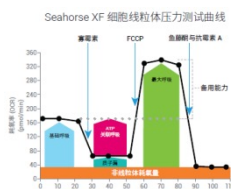
After XF Assay



Fluxpak



Assay Kits



Assay Medium



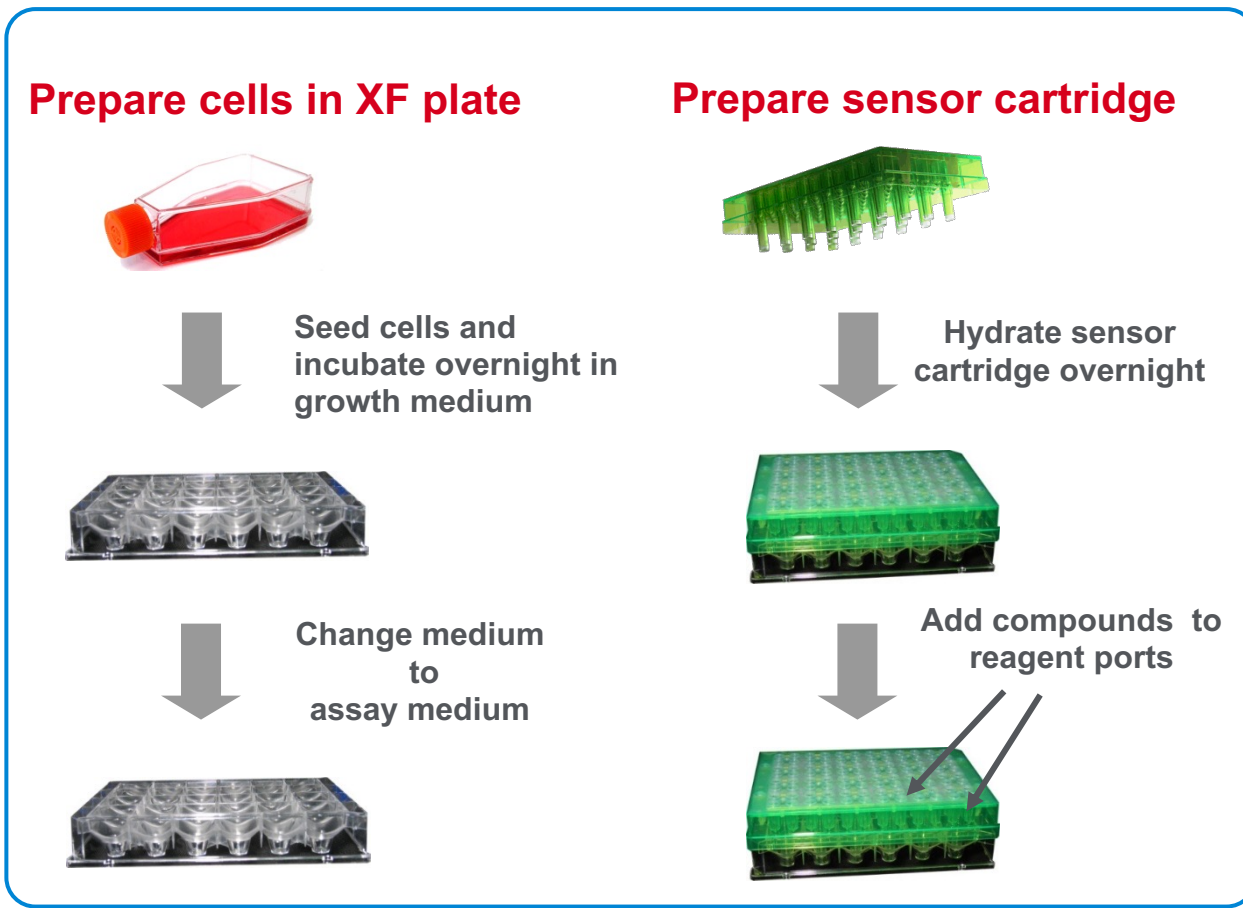
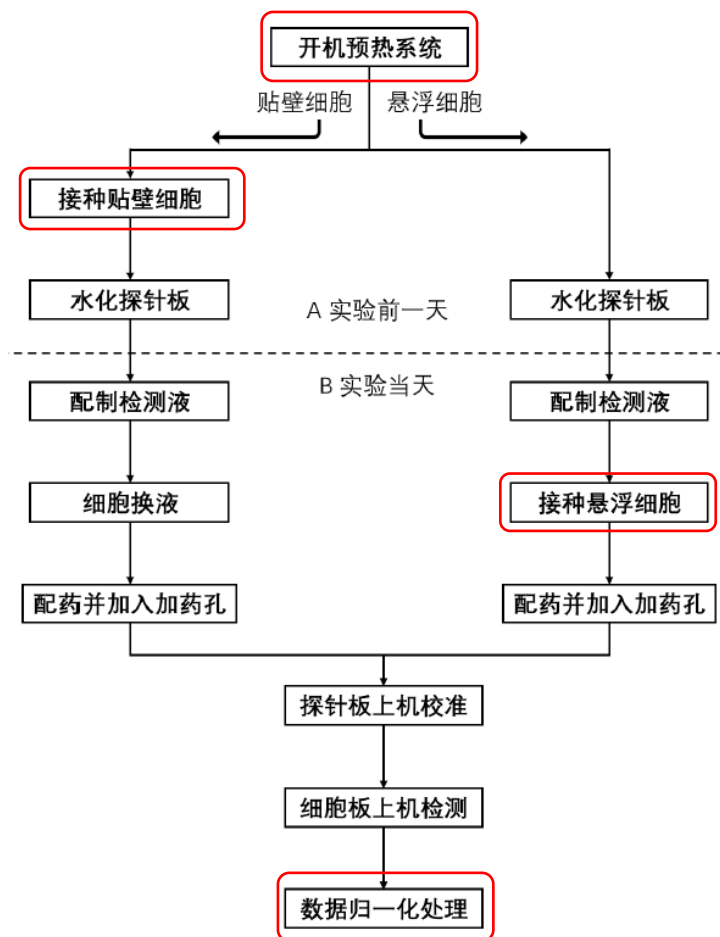
Complete XF media typically includes:

Seahorse XF DMEM, pH 7.4
 Seahorse XF RPMI, pH 7.4

+

- Seahorse XF Glucose
- Seahorse XF aPyruvate
- Seahorse XF Glutamine

XF 实验基本流程





关注细胞形态及生长情况的变化

- 细胞代次
- 污染

在细胞完全汇合之前传代

确保一致的细胞生长环境

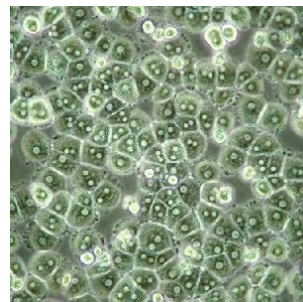
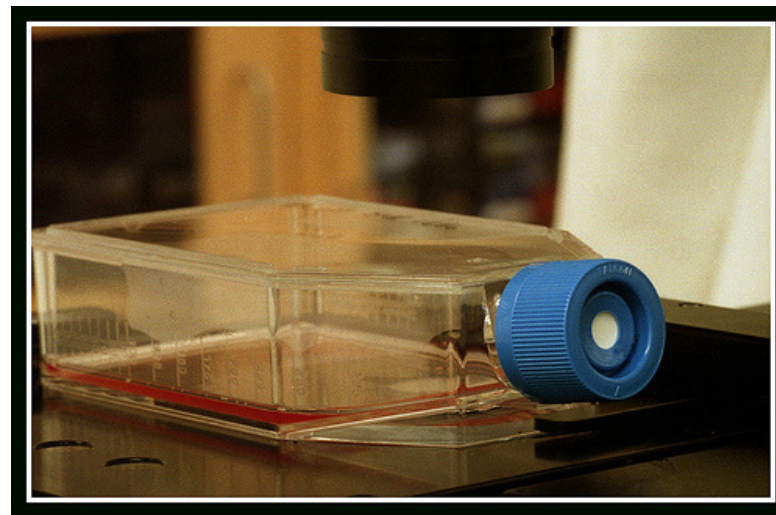
- 血清批次
- 试剂的新鲜度及避光等保存条件

注意培养箱的状态

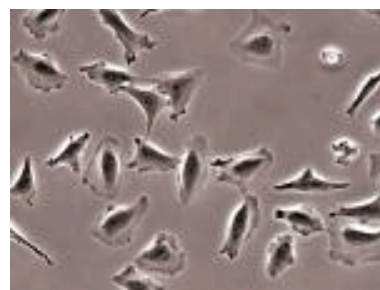
- 湿度
- CO₂

与细胞类型相关的注意因素

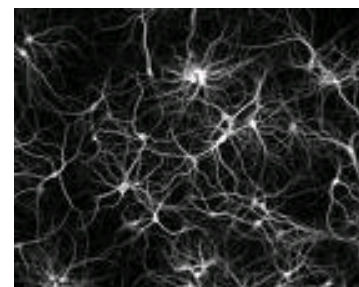
- 细胞接种密度及细胞汇合度
- 细胞培养时间
- 传代细胞或原代细胞
- 增殖细胞或分化细胞
- 细胞培养板表面处coating
- 细胞的特殊生理需求（如：原代皮层神经元）



adipocytes



fibroblast



neurons

Prepare cells in XF plate

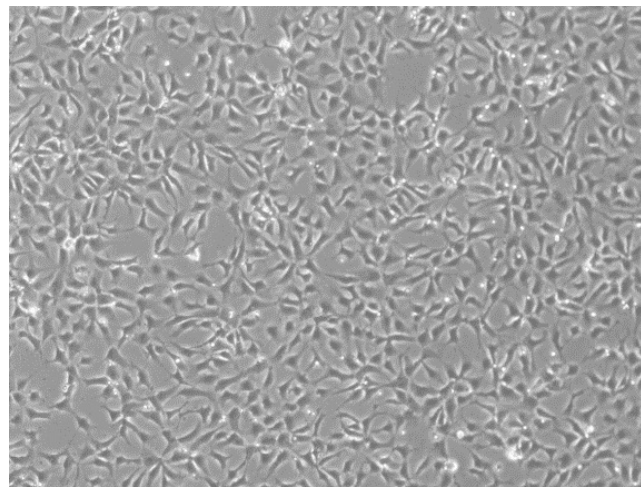


接种细胞并在生长培养基中孵育过夜



细胞接种的关键因素

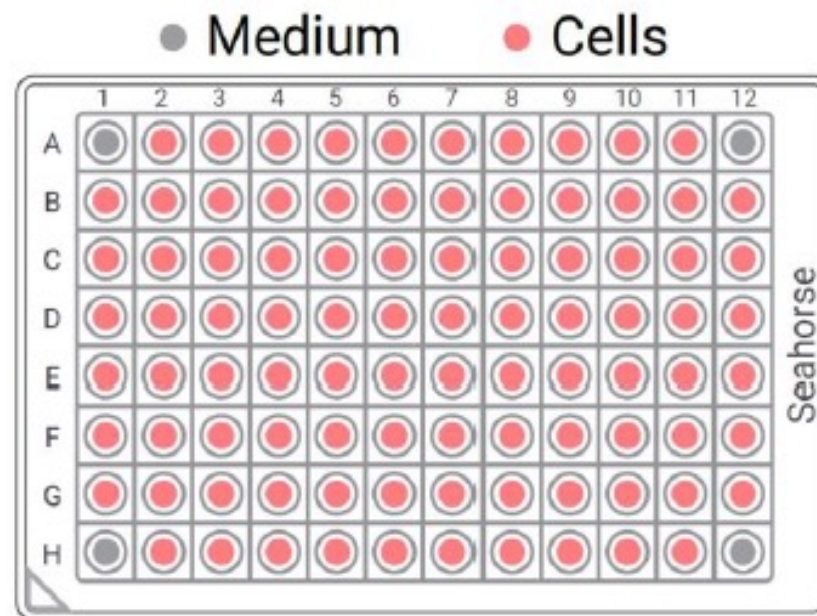
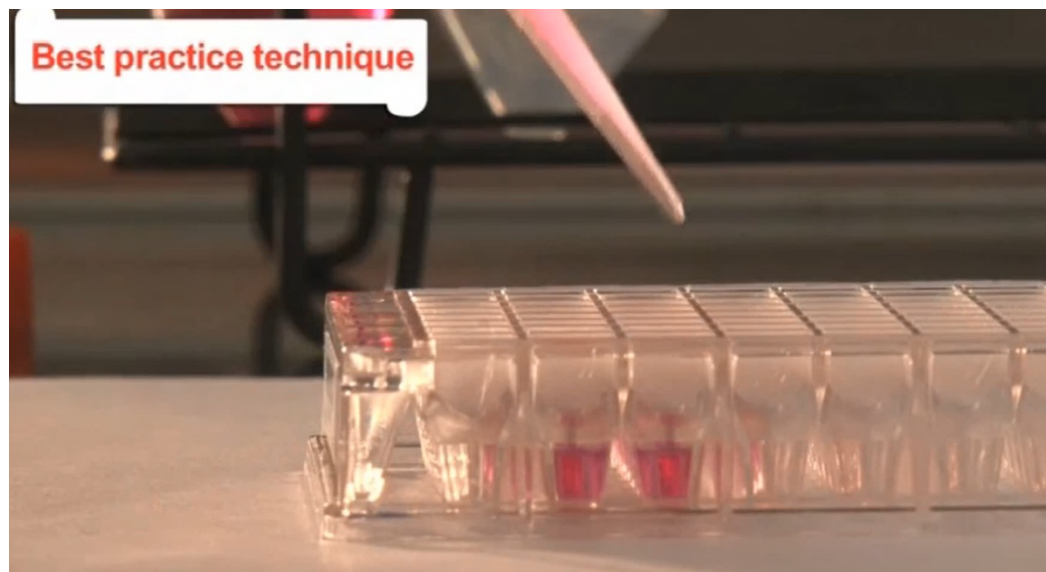
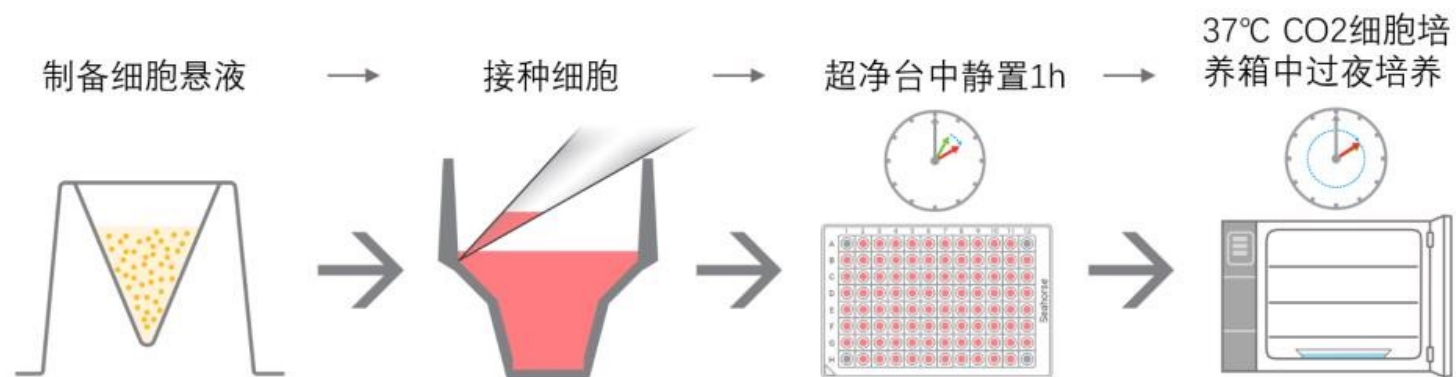
- 一致性
- 单细胞悬浮液是最佳选择
- 考虑细胞附着
- 最小化边缘效应



神经母细胞瘤细胞

接种细胞

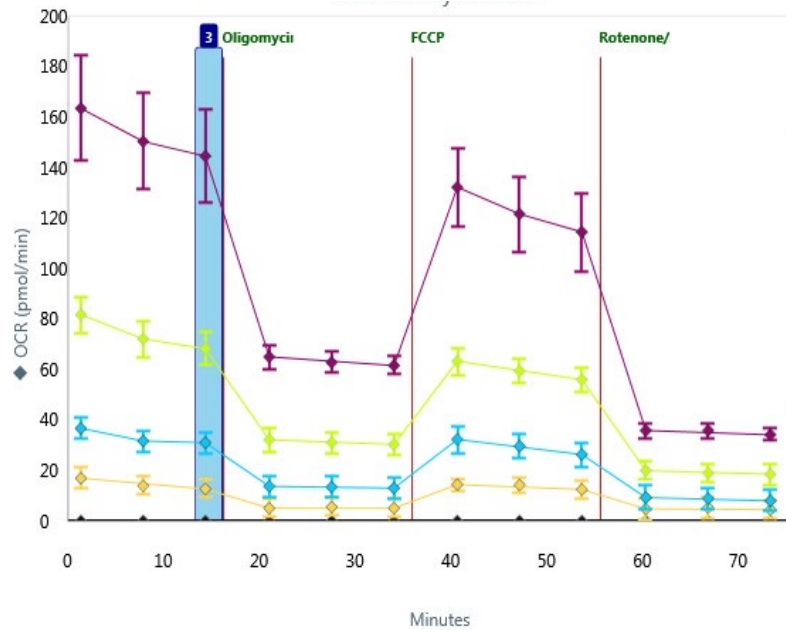
Xfe 96



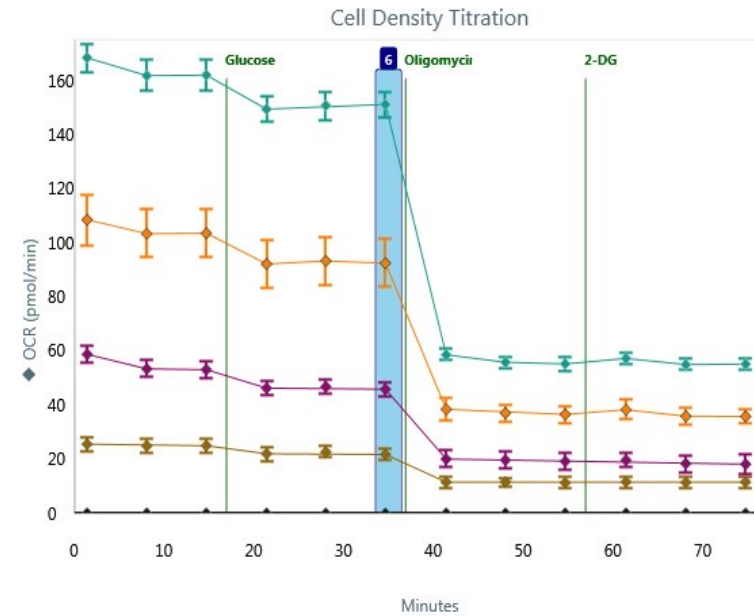
接种细胞前，先在背景校正孔内加入相同体积的生长培养基

使用基础OCR确定最佳细胞密度

Cell Mito Stress Test



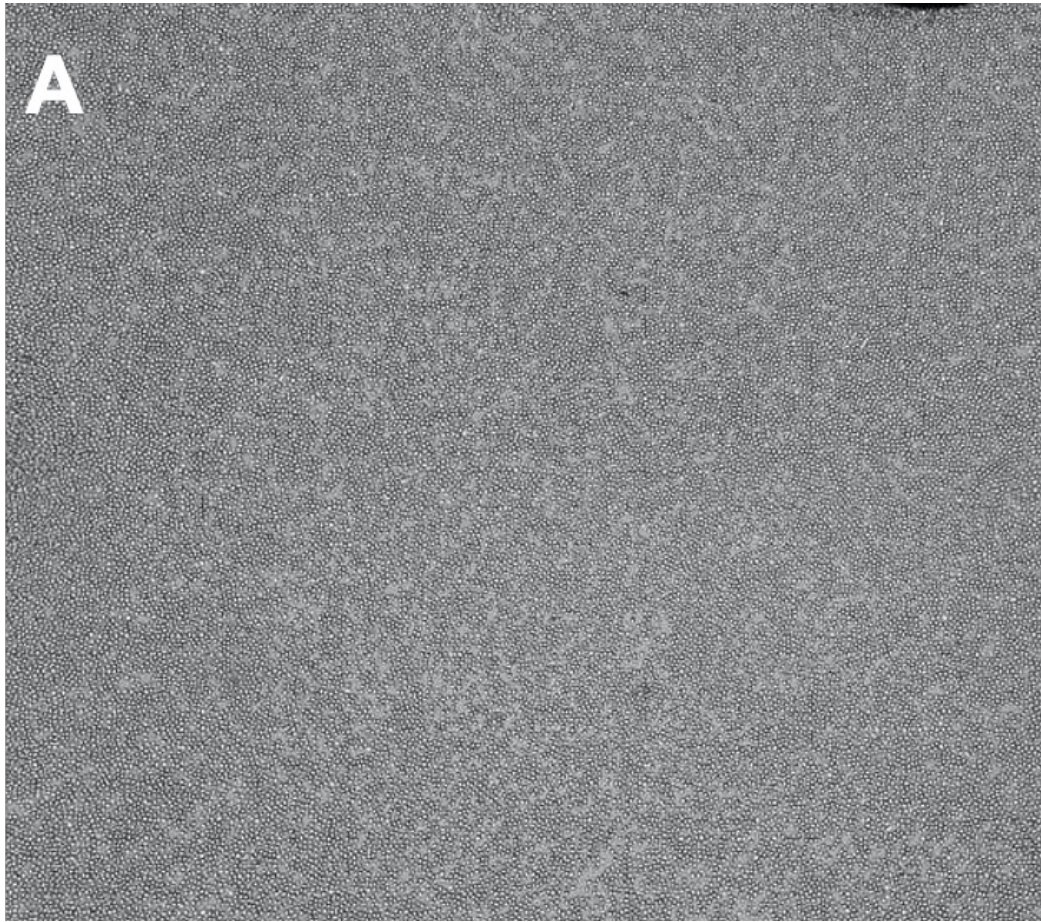
Glycolysis Stress Test



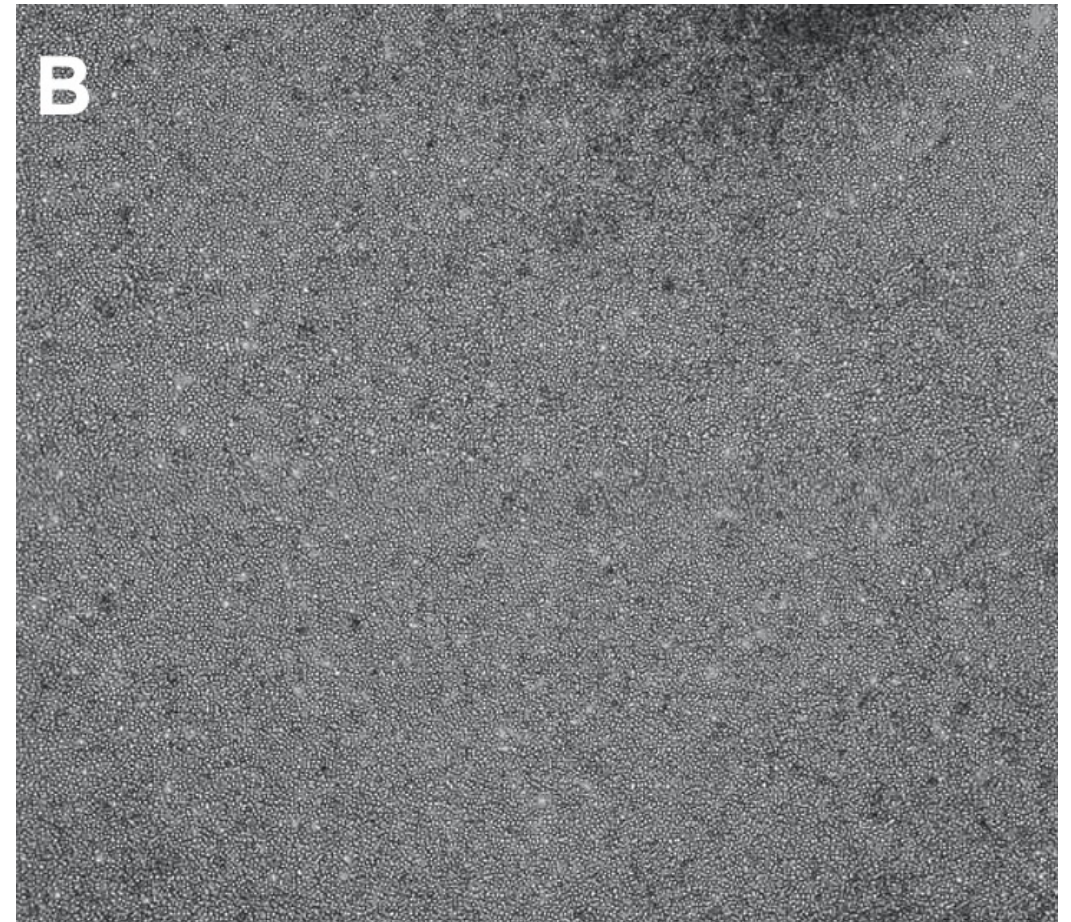
Good signal range – Xfe 96: ~ 20– 160pmol/min

最佳细胞接种密度

最佳细胞接种密度因细胞类型而异。通常，50-90%汇合度的细胞产生的代谢率会在仪器的理想/动态范围内。此外，最佳的细胞接种密度应在细胞孔内形成70-90%汇合度的单层细胞。

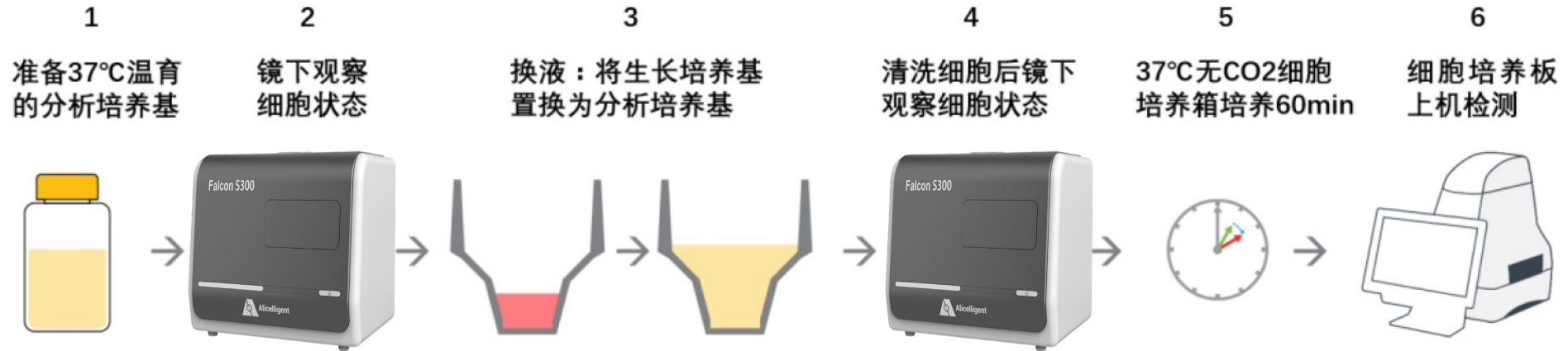
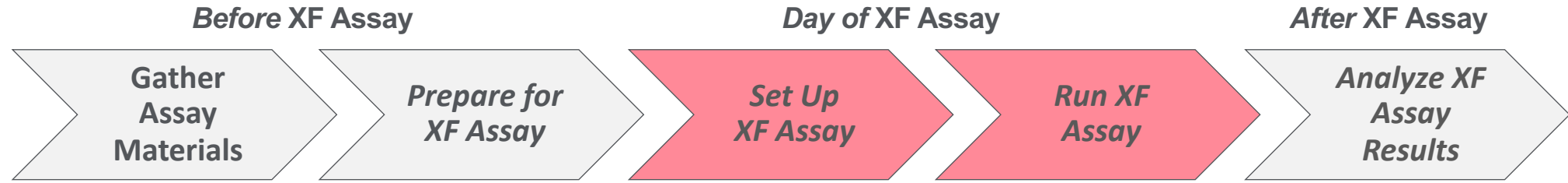


A: image shows low end of optimal cell density, ideal seeding density and distribution.



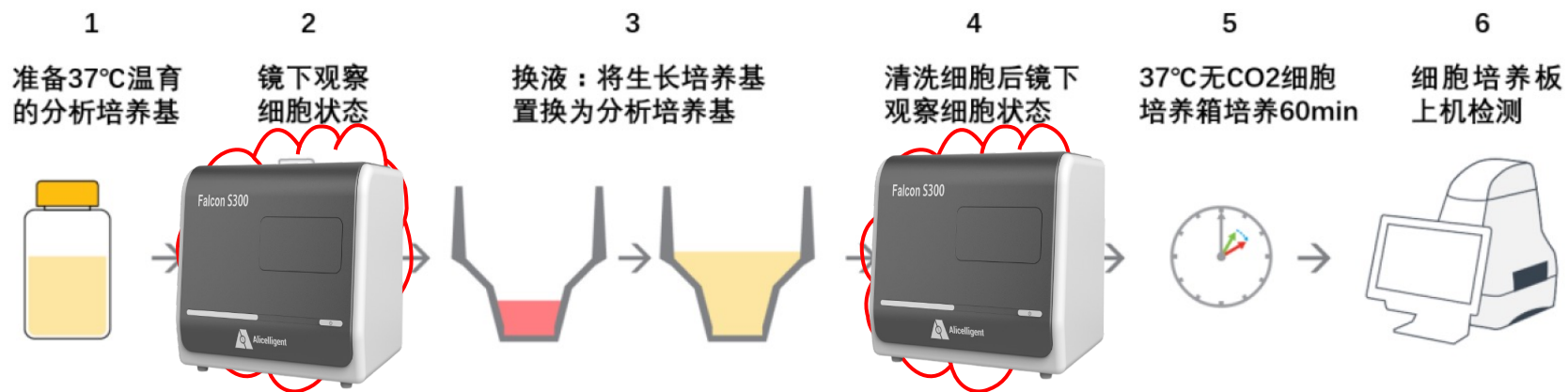
B: image shows high end of optimal seeding density, some cell clusters can be seen.

XF 实验基本流程



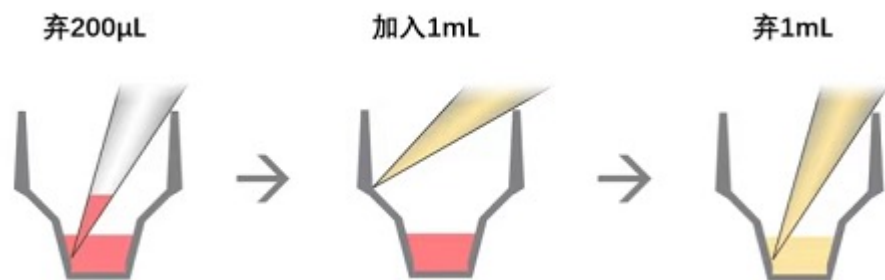
- 务必镜下观察细胞确保满足清洗要求
- 尽量将细胞生长培养基置换干净，至少清洗2次
- 清洗流程遵循试剂盒说明书进行

清洗细胞流程



Xfe 24

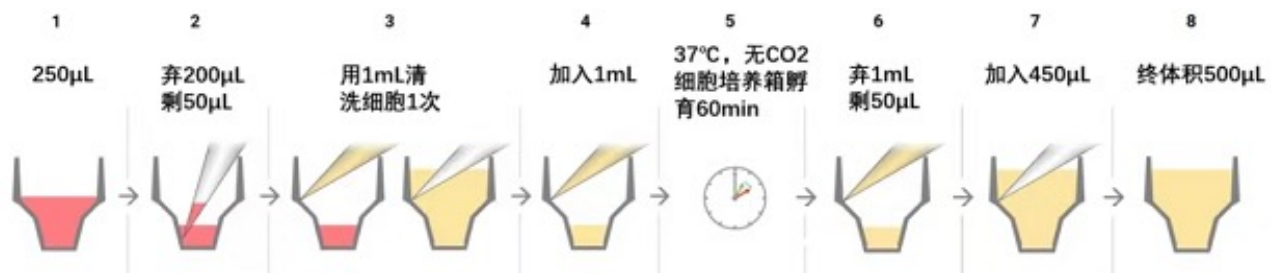
标准换液流程



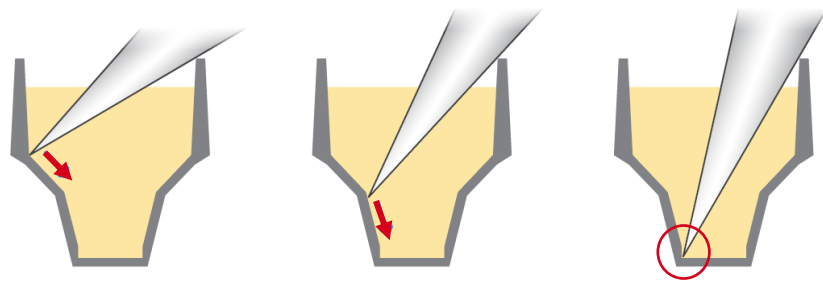
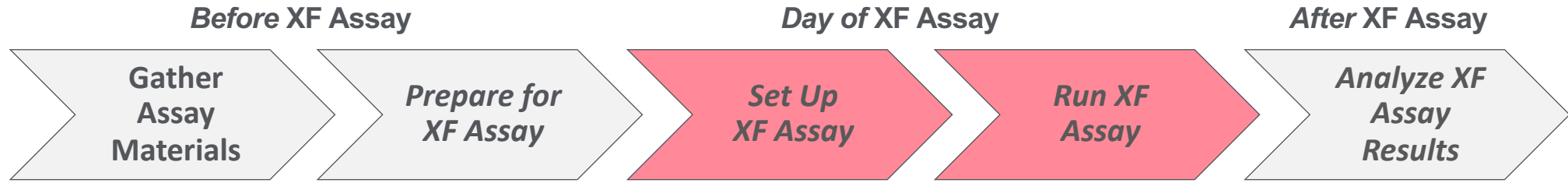
XF Real-Time ATP Rate Assay & XF Glycolytic Rate Assay Workflow

Xfe 24

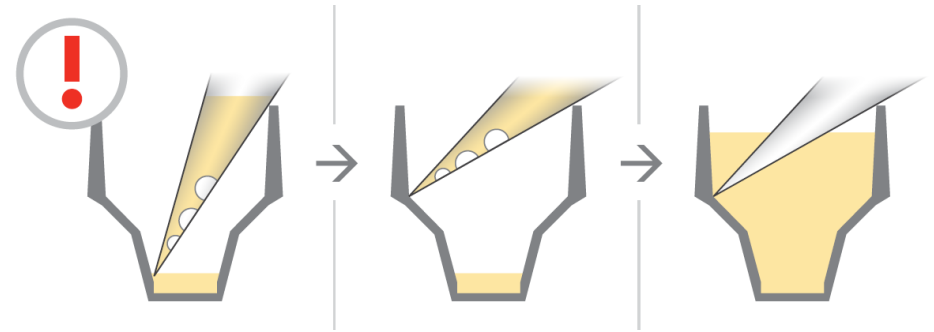
Rate assay
换液流程



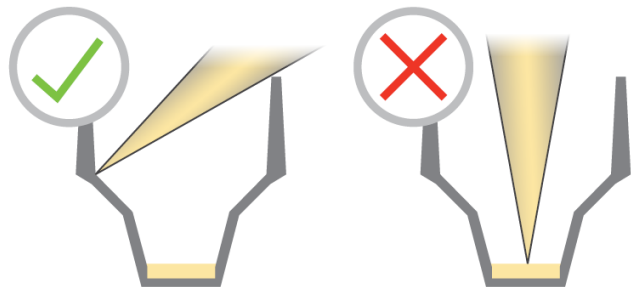
清洗细胞注意事项



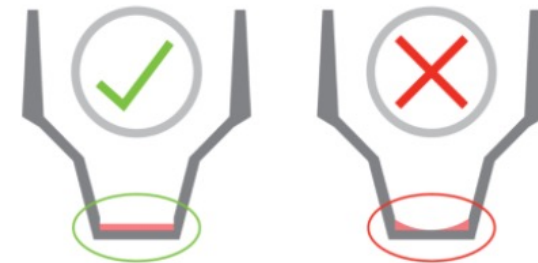
Correct Technique



If bubbles are introduced during the washing/dispensing step



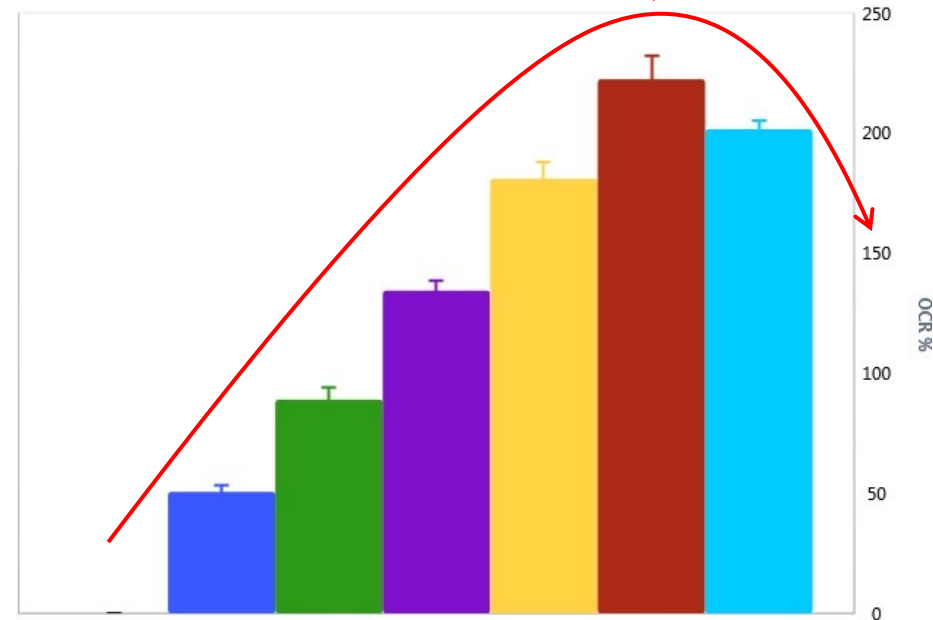
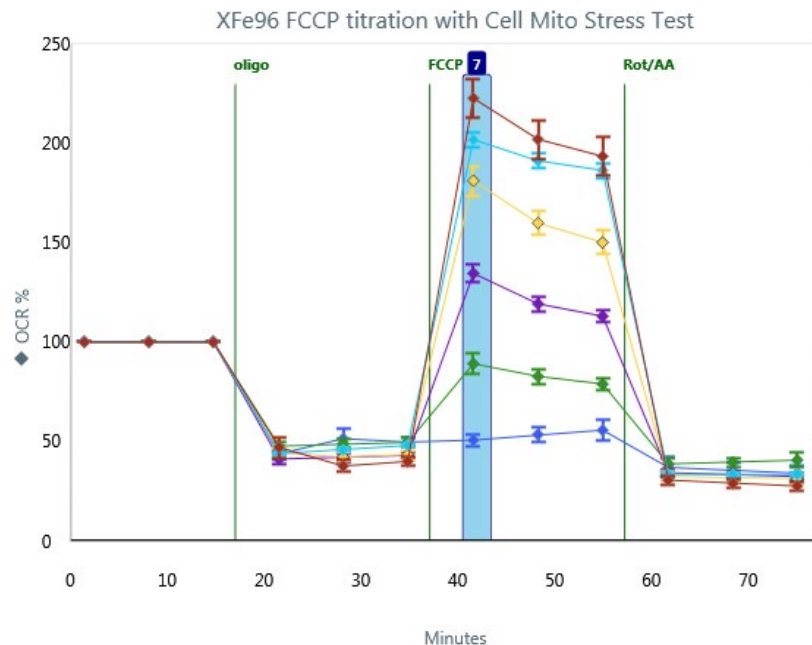
Aspirate and Dispense from the well side, not the center



Ensure the cells are never exposed to air

细胞线粒体压力测试中FCCP浓度优化 (必需)

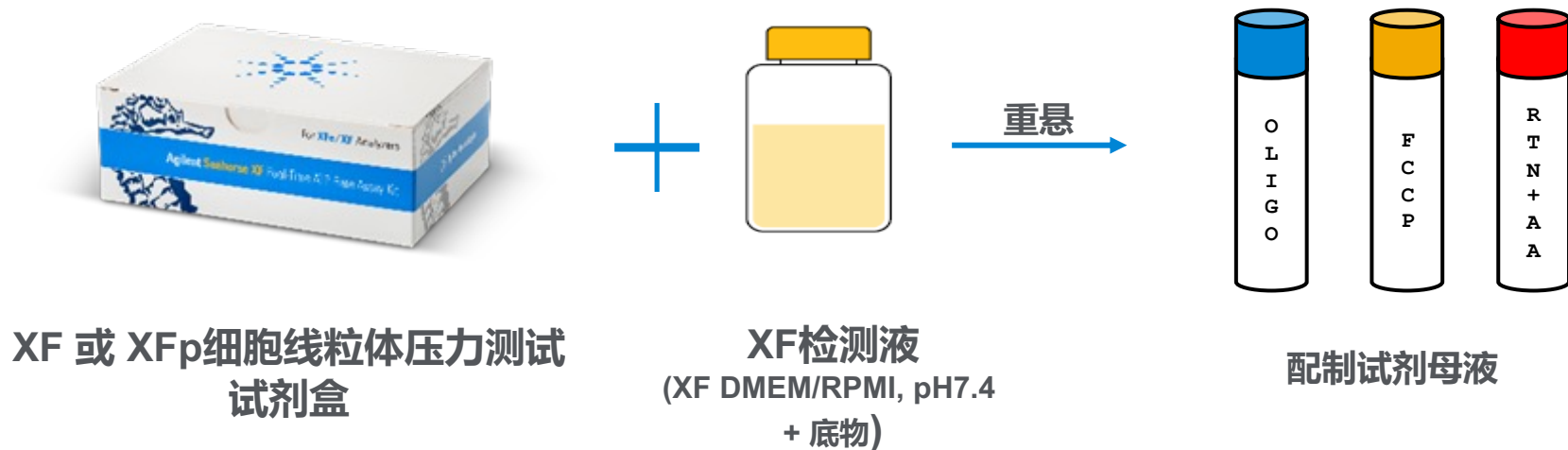
——OCR-FCCP关系务必满足类似的正态分布关系



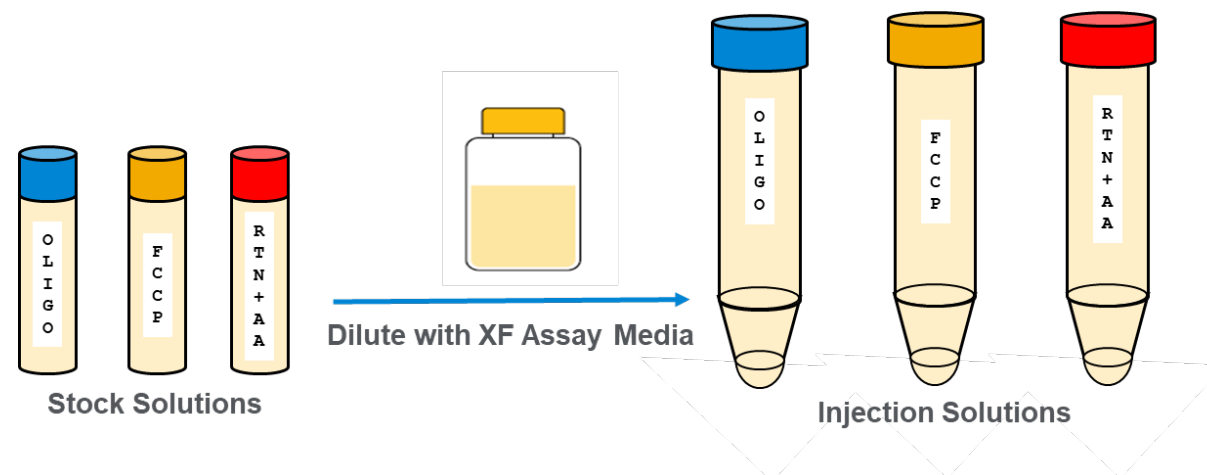
- ✓ Maximal stimulation of OCR is observed
- ✓ The lowest concentration of FCCP that produces maximal stimulation of OCR
- ✓ Ideally the OCR is stable over 3 measurement periods

XF 实验基本流程——准备上机之药物配制

1. 按照kit说明书先
配制试剂母液：



2. 按需将母液稀释
成工作液：



完整的XF 检测液：用于清洗细胞和药物配制

Seahorse XF DMEM, pH 7.4

或

Seahorse XF RPMI, pH 7.4

+

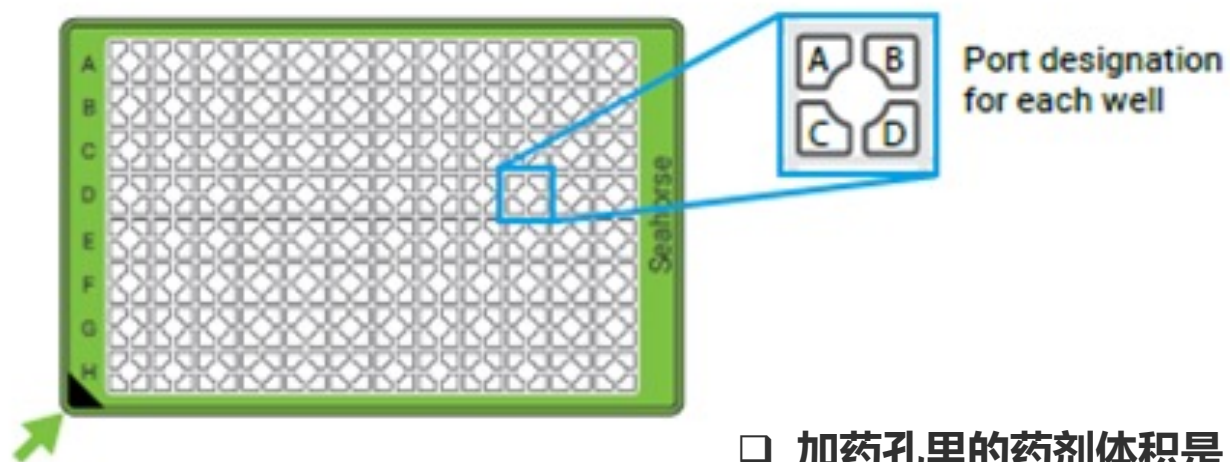
- Seahorse XF 葡萄糖
- Seahorse XF 丙酮酸钠
- Seahorse XF 谷氨酰胺

- ❑ Seahorse实验需要特定的培养基对代谢活性进行准确一致的功能性测量。
- ❑ 安捷伦提供即用的，预添加缓冲成分，预调pH 7.4的培养基，以及相应的底物添加剂，能够简化实验准备，提供一致的实验测量。
- ❑ 检测液中不可添加血清和碳酸氢钠
- ❑ 添加的底物种类和浓度取决于XF实验类型和应用需求

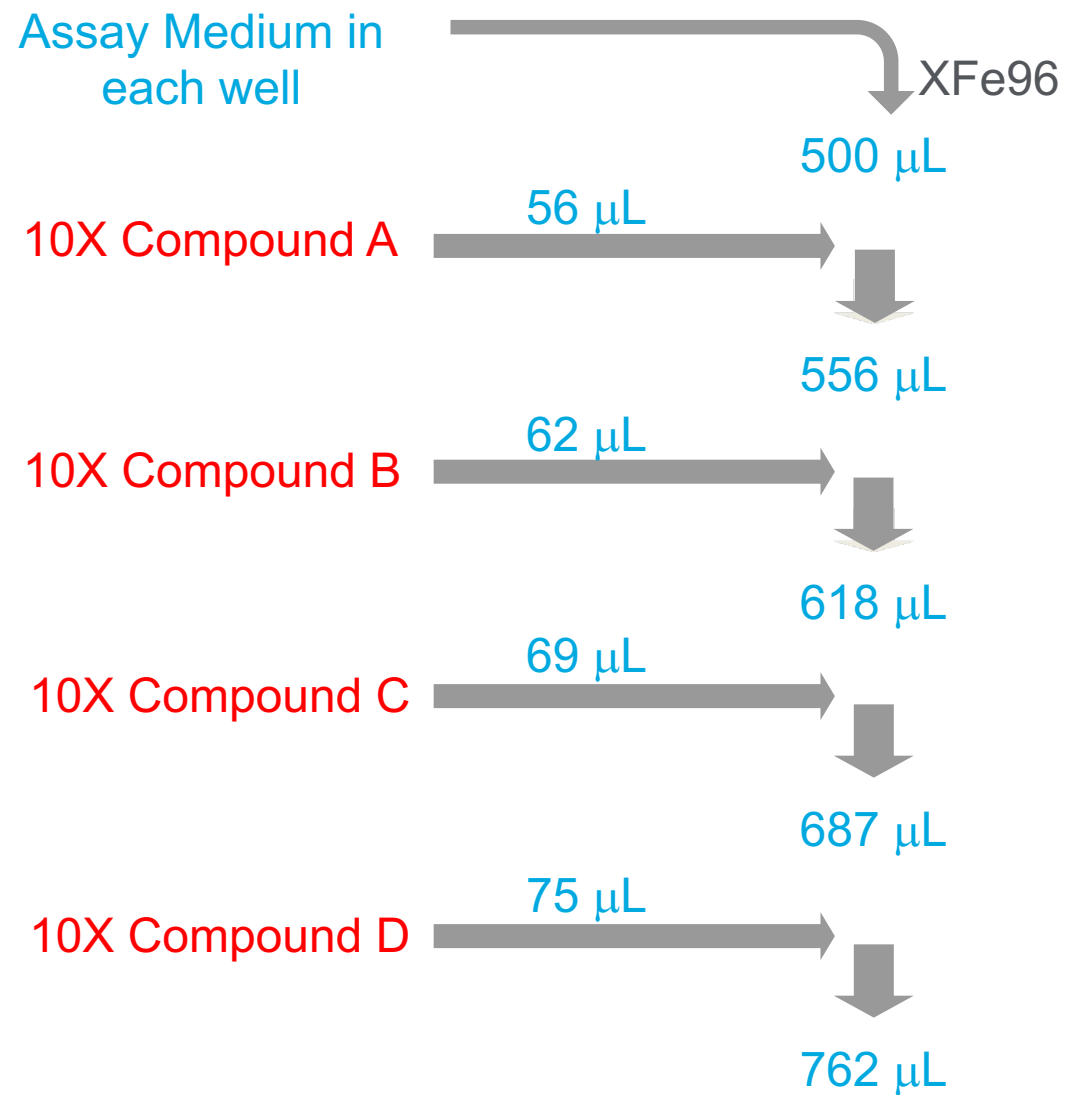
Catalog number	Description	Compatible with
103575-100	Seahorse XF DMEM Medium, pH 7.4, 500 mL	All XF assay kits. All Analyzers except for XF24 Analyzer ¹ .
103576-100	Seahorse XF RPMI Medium, pH 7.4, 500 mL	All XF assay kits. All Analyzer except for XF24 Analyzer ¹ .
103577-100	Seahorse XF 1.0 M Glucose Solution, 50 mL	All XF assay kits. All Analyzers.
103578-100	Seahorse XF 100 mM Pyruvate Solution, 50 mL	All XF assay kits. All Analyzers.
103579-100	Seahorse XF 200 mM Glutamine Solution, 50 mL	All XF assay kits. All Analyzers.



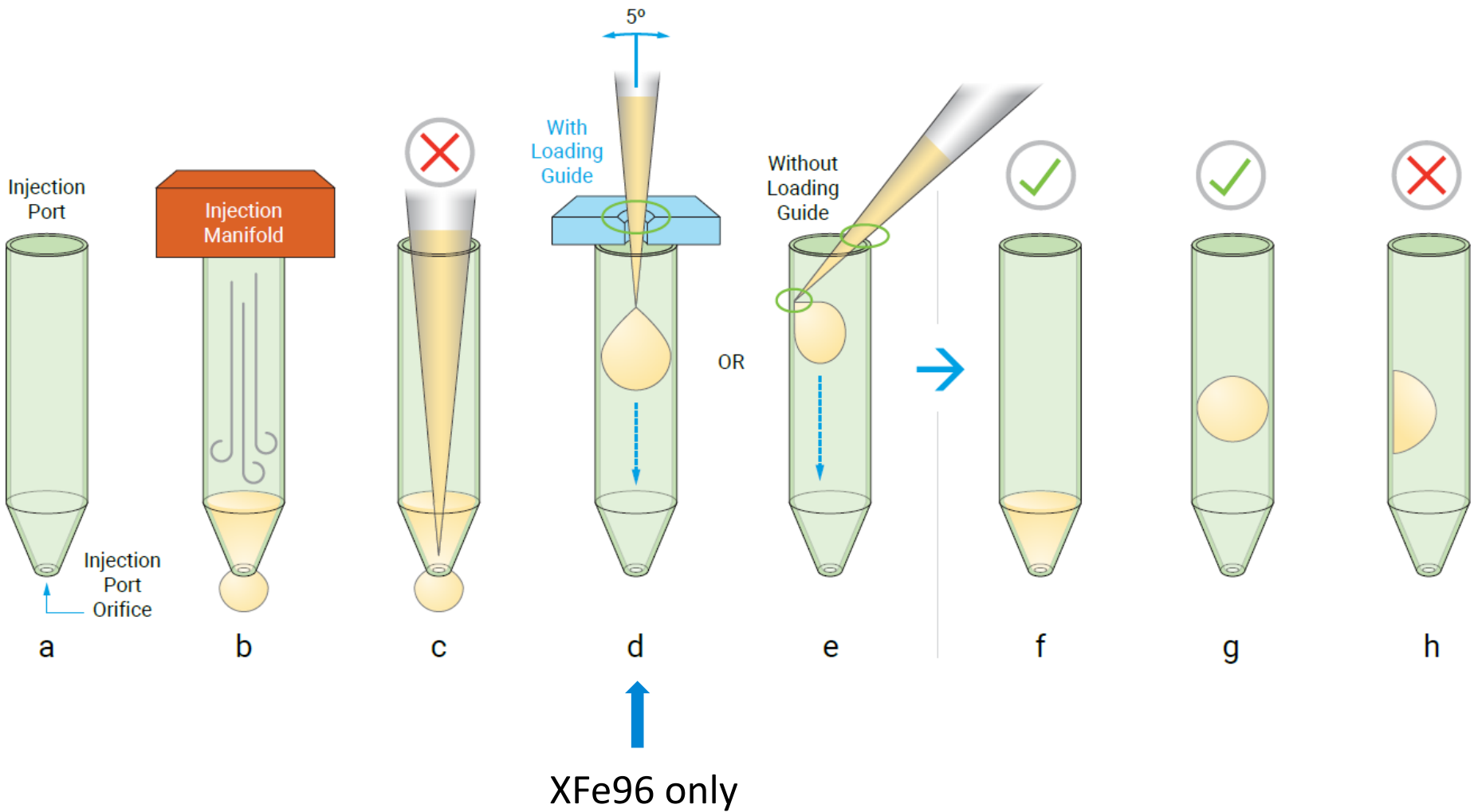
配制实验药物: Constant Stock



- ❑ 加药孔里的药剂体积是基于10倍的药剂终浓度计算而来
- ❑ 加药孔的组合, 加药的顺序以及需要用到的加药孔, 取决于具体的试验设计



加药孔及正确的加药方式



Seahorse试剂耗材订购

北京盘古创新生物科技有限公司简介：

一家专注于为生命科学、分子诊断、药物研发、食品安全、农业科学等领域提供全球最先进的检测设备、检测服务和整体解决方案的高科技企业。

Seahorse细胞能量代谢检测服务

拥有专业化的科研服务平台，面向全国科研用户提供检测服务

 订购专员：

王慧玲 :18701591479

susie.wang@pgbioscience.cn

www.pgbioscience.cn

