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GLOBAL HEALTHCARE & BIOMEDICAL INTELLIGENCE

MLJC EXCLUSIVE | NATURE WATCH

WHEN RADIATION BECOMES PRECISION

When We Can Finally See What Living Cells Are Doing

A New Window into Living Biology: China-developed RUSH3D-HR Pushes Intravital Imaging Towards the Subcellular–Mesoscale Frontier

Biomedical Imaging | Cell Biology | Immunology | Inflammation | Translational Medicine | AI for Science

Research • Evidence • Medical Interpretation • Strategic Intelligence

EXECUTIVE SUMMARY

Medical progress is not always defined by a new drug, a new surgical technique, or a new therapeutic molecule.

Sometimes, the breakthrough is more fundamental:

Science learns to see something that it could not previously see.

On **15 July 2026**, *Nature Biotechnology* published an open-access study describing **RUSH3D-HR**, a high-numerical-aperture confocal volumetric mesoscope designed to capture subcellular dynamics across a mesoscale field of view in living mammals.

The system was developed by a multidisciplinary Chinese research team including **Zhi Lu, Jiamin Wu and Qionghai Dai**, with collaborators including Wei Wang and others.



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The significance is not simply that the microscope has higher resolution.

The deeper significance is that it attempts to bridge a longstanding gap between:

subcellular detail

and

large-scale cellular behaviour in living tissue.

RUSH3D-HR reports approximately **390 nm lateral resolution and 700 nm axial resolution** across a volume of **$2.7 \times 2.0 \times 0.04 \text{ mm}^3$** , at up to **five volumes per second**, with reported data throughput of approximately **70 billion voxels per second**.

For biomedical research, that changes an important question:

Instead of asking only where a cell is, can we begin to observe what thousands of cells are doing — and how their behaviour changes over time?

That is where MLJC believes the strategic significance begins.



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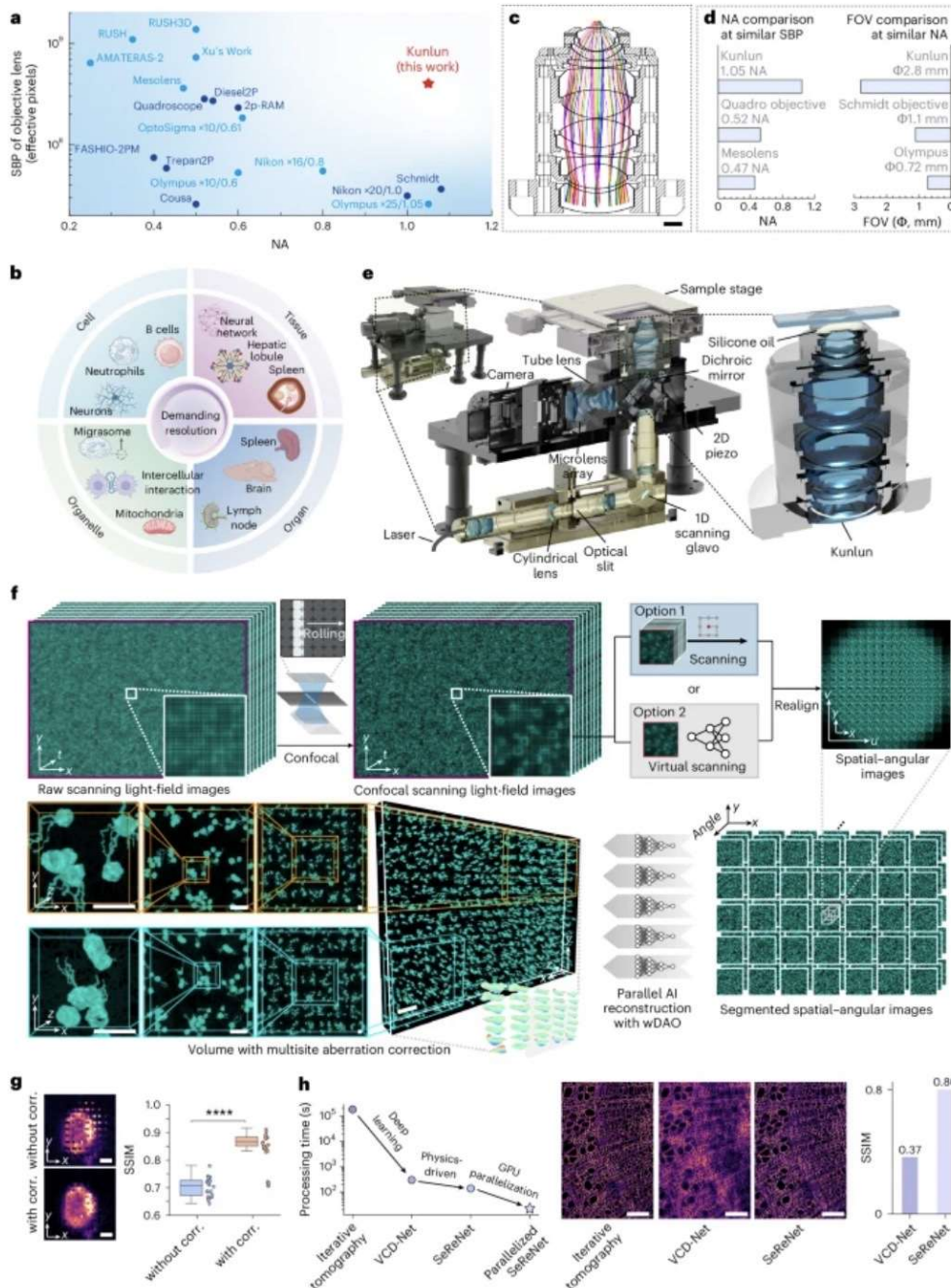
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Fig. 1: Principle of RUSH3D-HR.





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01 | THE BREAKTHROUGH IS NOT JUST A MICROSCOPE

Living biology is dynamic.

Cells migrate.

Cells communicate.

Cells divide.

Cells change shape.

Immune cells form transient clusters.

Cells interact with surrounding tissue.

Organelles change their behaviour.

These processes occur simultaneously across different spatial and temporal scales.

The difficulty for microscopy has always been a fundamental engineering trade-off:

Higher resolution

usually means a smaller field of view.

Larger field of view

usually means reduced resolution.

Higher imaging speed

can increase phototoxicity and data burden.

Longer observation

can introduce photobleaching, motion artefacts and biological disturbance.

Nature Biotechnology describes these trade-offs as a major systems-engineering challenge for high-NA mesoscale imaging.

RUSH3D-HR is an attempt to address these constraints simultaneously.



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02 | WHAT DOES RUSH3D-HR ACTUALLY ACHIEVE?

The reported system combines several technological components rather than relying on a single optical innovation.

High-NA objective

The researchers developed a custom objective named **Kunlun**, reaching NA **1.05** over a field of view of approximately **2.8 mm**.

Digital adaptive optics

Wave-optics digital adaptive optics are used to correct spatially varying optical aberrations.

Confocal scanning light-field imaging

This enables high-speed volumetric acquisition while improving optical sectioning and reducing unwanted background.

Parallelised AI processing

The imaging system generates enormous quantities of data.

The researchers therefore developed a deep-learning pipeline for:

- denoising
- motion-artifact correction
- multisite aberration correction
- 3D reconstruction

The paper reports processing improvements of more than **1,000-fold** for its reconstruction approach compared with conventional deconvolution algorithms in the relevant benchmark.

This is important.



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The future of biomedical imaging is no longer simply:

Optics.

It is increasingly:

Optics + computation + AI + biology.

03 | THE NUMBERS THAT MATTER

Parameter	Reported performance
Numerical aperture	1.05
Lateral resolution	~390 nm
Axial resolution	~700 nm
Imaging volume	$2.7 \times 2.0 \times 0.04 \text{ mm}^3$
Volumetric imaging speed	Up to 5 volumes/s
Data throughput	~70 billion voxels/s
Effective axial range	~40 μm
Long-term imaging demonstrated	>3 hours
Maximum monitored neutrophil population	>6,000



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The Nature study reports that the system maintained approximately 390-nm lateral and 700-nm axial resolution across the stated mesoscale field of view, while enabling prolonged intravital imaging with low phototoxicity.

One experiment demonstrated continuous imaging for more than three hours, producing more than **450 trillion voxels**.

These numbers should not be interpreted as clinical performance specifications.

They describe a **research imaging platform**.

That distinction matters.

04 | WHAT DID THE RESEARCHERS ACTUALLY SEE?

This is where the paper becomes more than an engineering achievement.

The researchers demonstrated RUSH3D-HR in several biological settings.

Wound healing

In mouse skin, the system tracked large populations of immune cells during wound repair.

The study followed thousands of neutrophils over extended periods and observed coordinated long-distance migration towards the wound.

One reported dataset tracked approximately **19,992 neutrophils** whose trajectories lasted longer than ten minutes over a 400-minute observation period.

The researchers were able to observe not merely cell location, but also differences in cellular morphology and migration behaviour.



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Acute liver failure

In an acetaminophen-induced mouse model of acute liver failure, the researchers observed:

neutrophil–macrophage interactions

and increased:

migrasome generation

and

neutrophil motility.

The significance is methodological as much as biological.

Rare immune events can be difficult to capture using conventional approaches because they may occur infrequently.

A larger and faster observation window increases the probability of seeing them.

05 | MORE THAN 6,000 NEUTROPHILS

One of the study's most striking demonstrations involved the mouse spleen during lipopolysaccharide-induced inflammation.

The researchers monitored more than:

6,000 neutrophils

over hours of observation.

They identified transient, emergent **neutrophil swarming behaviour** distributed across the spleen.

This matters because inflammation is not simply a collection of independent cellular events.



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It can become:

collective cellular behaviour.

That introduces an important conceptual shift.

From:

Cell

to

Cell–Cell Interaction

to

Cellular Population

to

Tissue Behaviour

to

Organ-Level Response

RUSH3D-HR provides an experimental platform for studying that continuum in vivo.

06 | A PARTICULARLY INTERESTING FINDING: ELECTROACUPUNCTURE

The study also investigated electroacupuncture stimulation at **ST36** in the inflammatory mouse model.

The researchers reported suppression of the observed neutrophil swarming behaviour following ST36 electroacupuncture and interpreted the findings as evidence of peripheral immunomodulation.



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This is scientifically interesting.

But MLJC believes an important distinction must be maintained.

What the study demonstrates:

A mechanistic observation in an **animal model**.

What it does not demonstrate:

That electroacupuncture has been clinically proven to treat inflammatory diseases in humans.

Therefore, MLJC would not describe this study as:

“Nature proves acupuncture treats inflammation.”

That would exceed the evidence.

The more accurate interpretation is:

The imaging platform enabled direct observation of an immune-cell behavioural response associated with peripheral electrical stimulation in a preclinical model.

That is already scientifically valuable.

And it preserves the integrity of the evidence.



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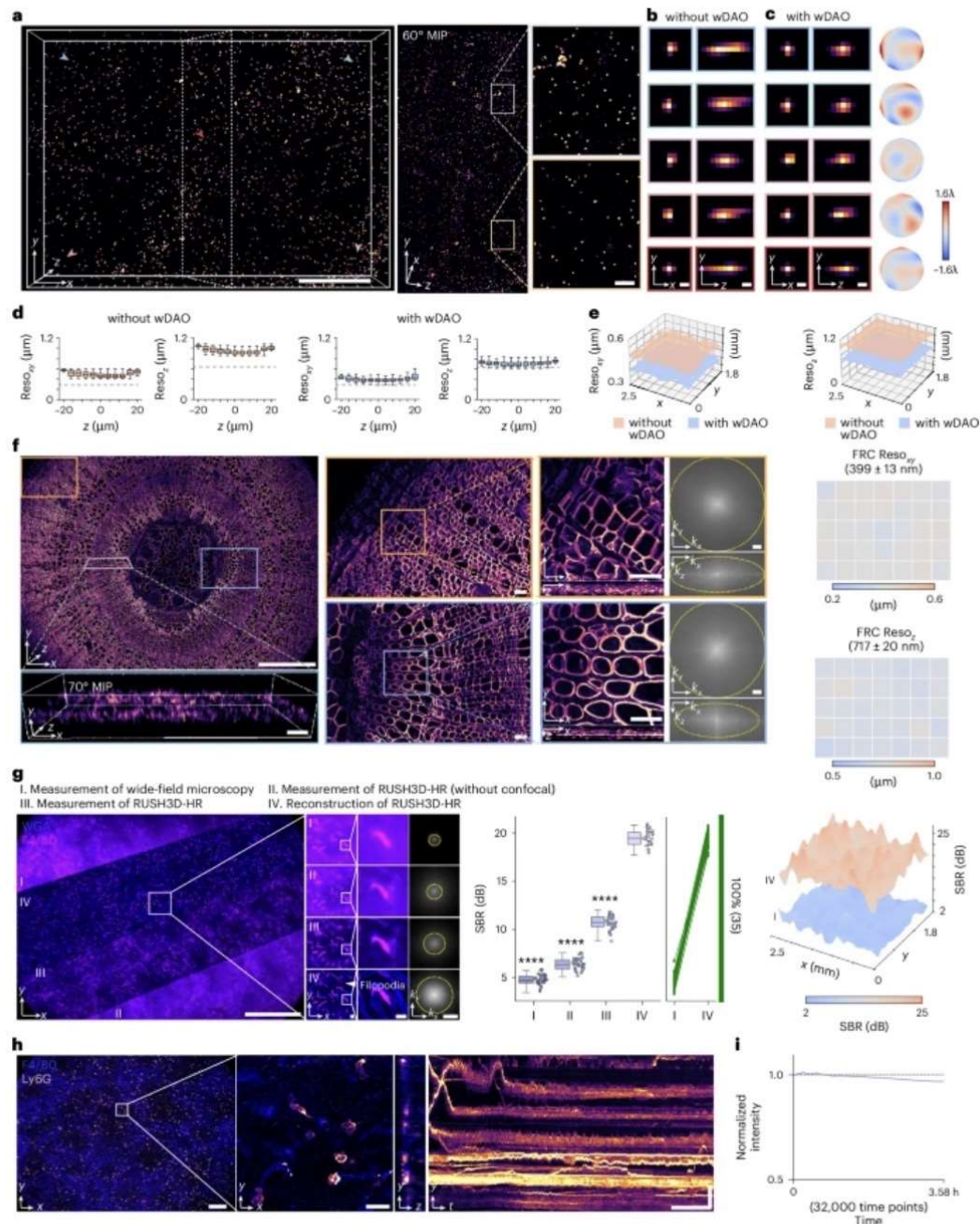
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Fig. 2: Characterization of RUSH3D-HR.



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07 | THE QUESTION MLJC BELIEVES MATTERS MOST

The traditional biomedical question is often:

Which cell is abnormal?

But increasingly, biology may require a different question:

What are the cells doing to one another?

Disease is rarely a single-cell event.

It can involve:

cellular communication

→

immune recruitment

→

collective migration

→

tissue remodelling

→

organ dysfunction

RUSH3D-HR provides an opportunity to investigate these processes dynamically rather than reconstructing them only from static snapshots.

That is a potentially important shift in biomedical research.



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08 | FROM OBSERVATION TO QUANTITATIVE BIOMARKERS

This is one of the areas MLJC believes deserves the greatest future attention.

The paper suggests that neutrophil swarming behaviour can function as a **mesoscale biomarker of inflammation** in the experimental model.

This raises a much larger question:

Can cellular behaviour become a measurable biomarker?

Instead of measuring only:

- blood markers
- protein concentrations
- histology
- gene expression
- imaging endpoints

future biomedical research could potentially quantify:

cell velocity

cell morphology

cellular clustering

migration trajectories

cell–cell interactions

collective behaviour

and potentially:

dynamic cellular states.



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This would represent a move from:

Static Biomarkers

towards

Dynamic Cellular Biomarkers

The concept remains an area for further research.

But it is an important direction.



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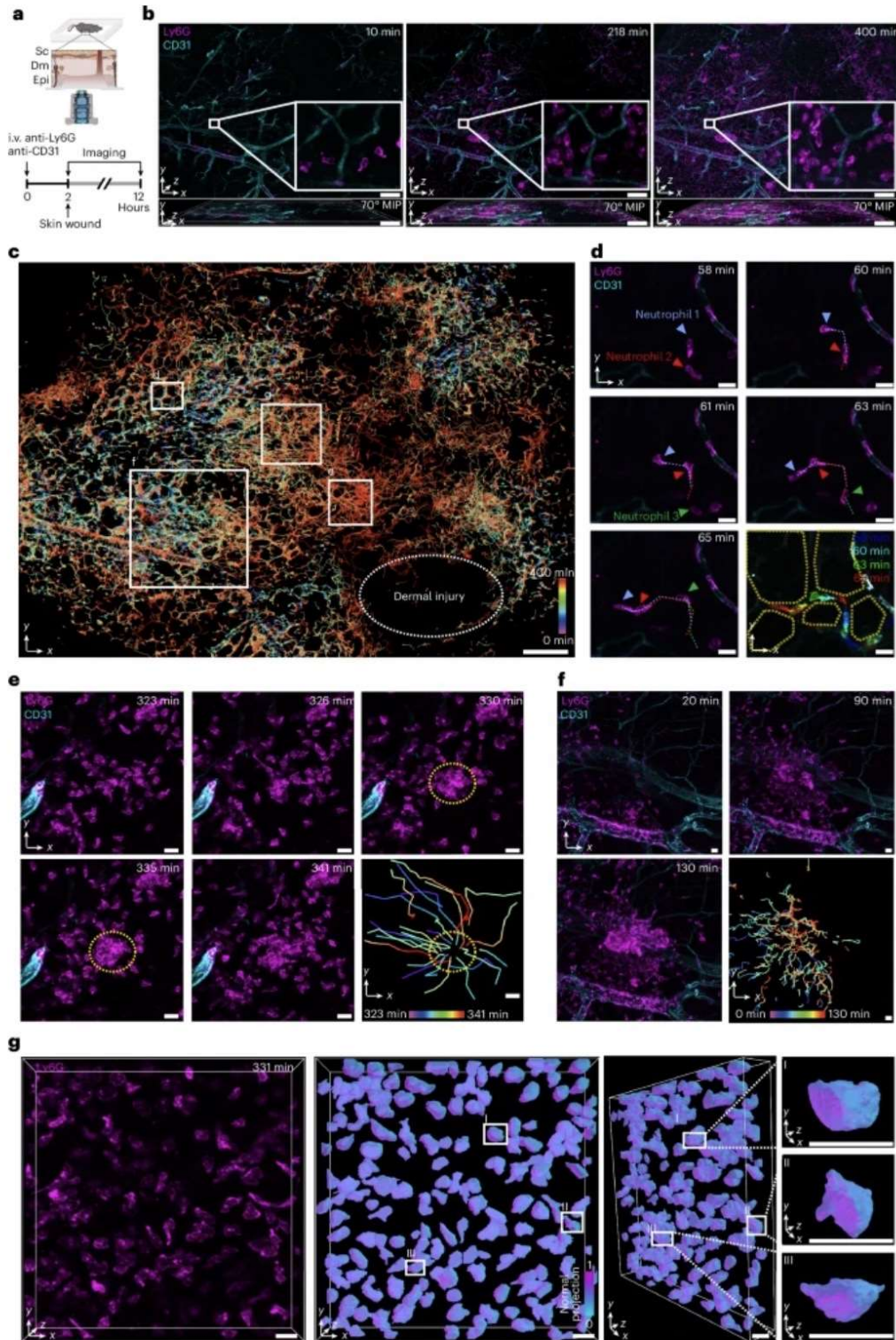


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09 | WHY THIS COULD MATTER FOR DRUG DISCOVERY

MLJC sees another potential implication.

Drug development frequently asks:

Did the treatment work?

But high-resolution intravital imaging can potentially add another question:

What happened inside the living tissue after treatment was administered?

For example:

Did immune cells reach the target?

Did cellular recruitment increase or decrease?

Did inflammatory clusters disappear?

Did cell–cell interactions change?

Did the tissue microenvironment respond before conventional endpoints became measurable?

These questions could eventually contribute to:

Mechanism-of-action studies

Drug-response profiling

Target validation

Preclinical efficacy assessment

Therapeutic biomarker development

However, this should be described as **potential research application**, not as an established clinical capability.



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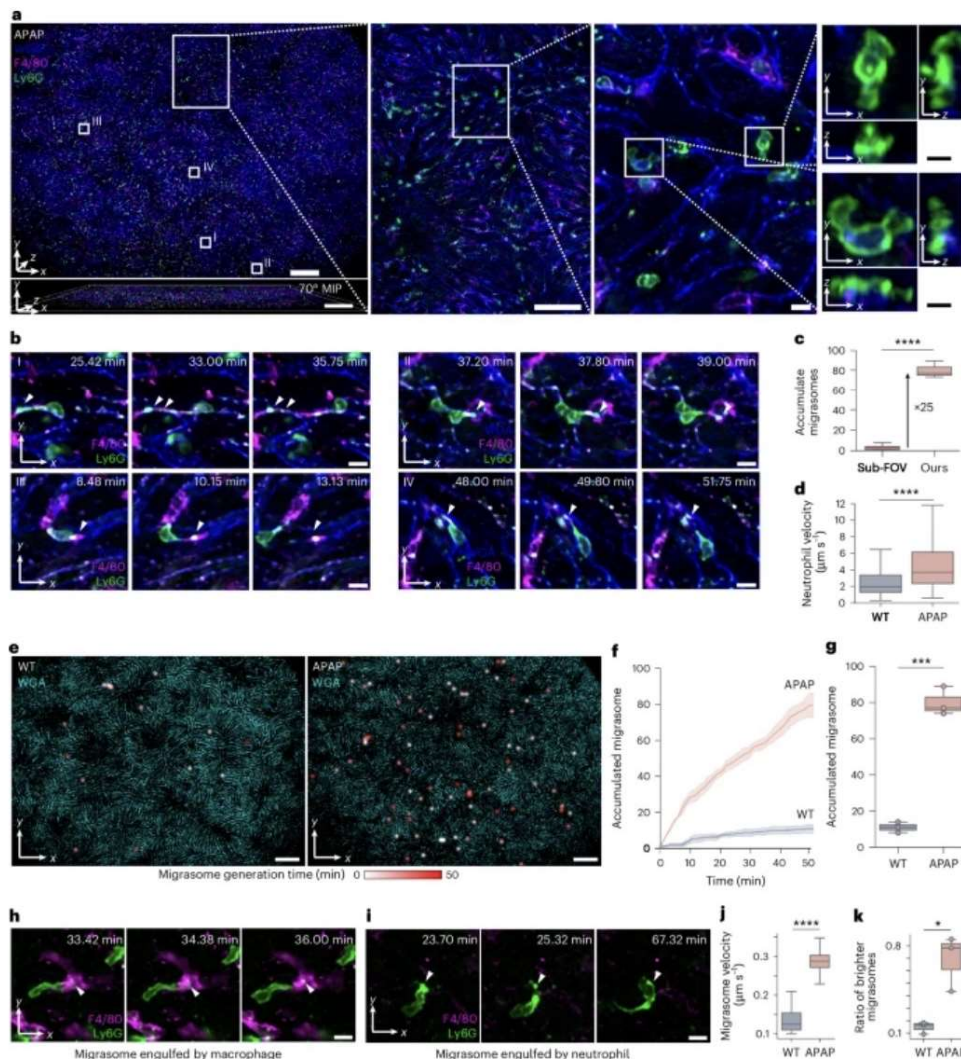


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The Nature paper itself positions the technology primarily as a research platform with applications in cell biology, immunology and pathology.

Fig. 4: Quantitative investigation of migrasome functions during liver failure at the mesoscale.



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10 | THE NEXT FRONTIER: SEE → MEASURE → UNDERSTAND → PREDICT

MLJC sees a broader trajectory.

Stage I — SEE

Observe biological events that were previously invisible.

Stage II — MEASURE

Convert cellular behaviour into quantitative data.

Stage III — UNDERSTAND

Identify relationships between cellular behaviour and disease progression.

Stage IV — PREDICT

Use computational models and AI to predict biological responses.

The current technology is most clearly positioned within:

SEE → MEASURE

But it may help establish the data foundation required for the later stages.

11 | AI IS NOT THE STORY — DATA IS

There is a temptation to describe every modern biomedical breakthrough as an “AI breakthrough”.

MLJC would take a different view.

AI is important here because the imaging system generates extraordinary amounts of data.



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At approximately:

70 billion voxels per second

human processing alone is not a realistic solution.

AI therefore becomes part of the infrastructure required to turn raw optical information into interpretable biological information.

The deeper architecture is:

Optics



Imaging



Massive biological data



AI reconstruction



Cell tracking



Quantitative analysis



Biological interpretation

This is closer to the emerging concept of:

AI for Science

than conventional “AI in healthcare”.



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12 | WHY MLJC CONSIDERS THIS A SYSTEM-LEVEL INNOVATION

A single impressive specification would not be enough.

The significance of RUSH3D-HR comes from the integration of:

High-NA optics

Large field of view

Adaptive optics

Fast volumetric imaging

Low phototoxicity

Deep-learning reconstruction

Intravital biological validation

That is:

SYSTEM ENGINEERING

rather than a single-component improvement.

This distinction matters when evaluating advanced biomedical technology.

13 | MLJC'S FIVE QUESTIONS FOR THE NEXT DECADE

Question 01

Can this technology be extended to deeper and more complex biological environments?

Question 02

Can similar capabilities eventually be translated into human clinical research?



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Question 03

Can dynamic cellular behaviour become a validated quantitative biomarker?

Question 04

Can AI discover biological patterns that researchers cannot identify manually?

Question 05

Can real-time cellular observation eventually improve drug development and precision medicine?

None of these questions has been completely answered.

That is precisely why the research is important.

14 | FROM A MICROSCOPE TO BIOMEDICAL OBSERVATION INFRASTRUCTURE

MLJC believes the long-term value may extend beyond the instrument itself.

If technologies of this class continue to mature, they could become part of a broader:

Biomedical Observation Infrastructure

connecting:

Advanced Imaging

Computational Biology

AI

Immunology

Pathology

Drug Discovery



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Precision Medicine

and eventually:

Clinical Translation

The strategic question therefore changes from:

How powerful is this microscope?

to:

What new biological knowledge becomes possible because this microscope exists?

That is the more important question.

15 | MLJC EVIDENCE ASSESSMENT

Category	Assessment
Journal	Nature Biotechnology
Publication date	15 July 2026
Article status	Open Access
Technology	RUSH3D-HR
Numerical aperture	NA 1.05
Lateral resolution	~390 nm
Axial resolution	~700 nm



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Imaging volume	$2.7 \times 2.0 \times 0.04 \text{ mm}^3$
Volumetric speed	Up to 5 volumes/s
Data throughput	~70 billion voxels/s
Demonstrated long-term imaging	>3 hours
Biological models	Mouse preclinical models
Major applications	Wound healing, acute liver failure, inflammation
Clinical status	Research / preclinical imaging platform
Human therapeutic evidence	Not established by this study

The primary source is the *Nature Biotechnology* article itself.

16 | MLJC'S SCIENTIFIC BOUNDARY

This technology should **not** currently be described as:

- ✗ an approved clinical diagnostic device
- ✗ a routine hospital imaging system
- ✗ a proven cancer treatment
- ✗ a human therapeutic technology
- ✗ proof that AI can independently diagnose disease

Its appropriate description is:

An advanced preclinical biomedical imaging platform for high-resolution, mesoscale intravital observation.



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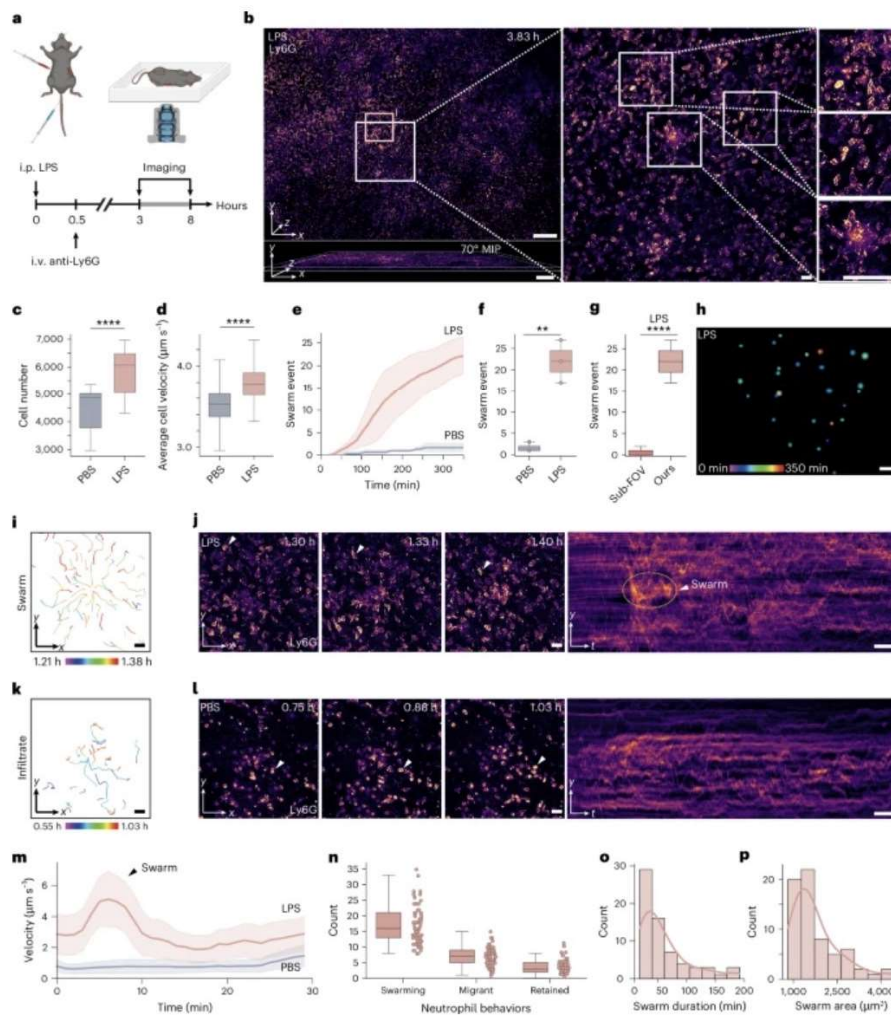
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That distinction is not a limitation of the story.

It is what makes the story credible.

Fig. 5: Large-scale transient swarming behaviors of neutrophils during inflammation in mouse spleens.



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17 | MLJC'S APPRECIATION

MLJC believes the work deserves recognition not simply because it was developed in China.

It deserves recognition because the research addresses a genuine and difficult scientific-engineering problem.

The team has brought together:

optical engineering

computational imaging

AI

cell biology

immunology

and

intravital research

within a single experimental platform.

That is a meaningful example of multidisciplinary scientific engineering.

The most important achievement may therefore not be one particular resolution number.

It may be the ability to connect:

SUBCELLULAR

with

CELLULAR

with



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MESOSCALE

with

ORGAN-LEVEL BIOLOGY

in the living state.

18 | THE MLJC PRINCIPLE

Science deserves respect because of evidence.

Not because of headlines.

Not because of nationality.

Not because of commercial interest.

Not because something sounds revolutionary.

Our principle is simple:

Report what has been demonstrated.

Distinguish what is promising from what is proven.

Respect what remains unknown.

In medicine, this distinction is particularly important.

A preclinical discovery should remain a preclinical discovery until clinical evidence supports something more.

An experimental mechanism should remain an experimental mechanism until it is independently validated.

And scientific optimism should never become medical exaggeration.



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19 | MLJC'S CONCLUSION

The deepest significance of RUSH3D-HR may not be that researchers have built a more powerful microscope.

It may be that biomedical science is moving towards a different way of understanding disease.

From:

Where is the cell?

to:

What is the cell doing?

From:

What happened?

to:

How did it happen?

And eventually:

Can we predict what will happen next?

The journey is:

SEE → MEASURE → UNDERSTAND → PREDICT

RUSH3D-HR does not represent the end of that journey.

It represents another step toward it.

A new window has opened into living biology.

The scientific question now is not merely:

How much more can we see?



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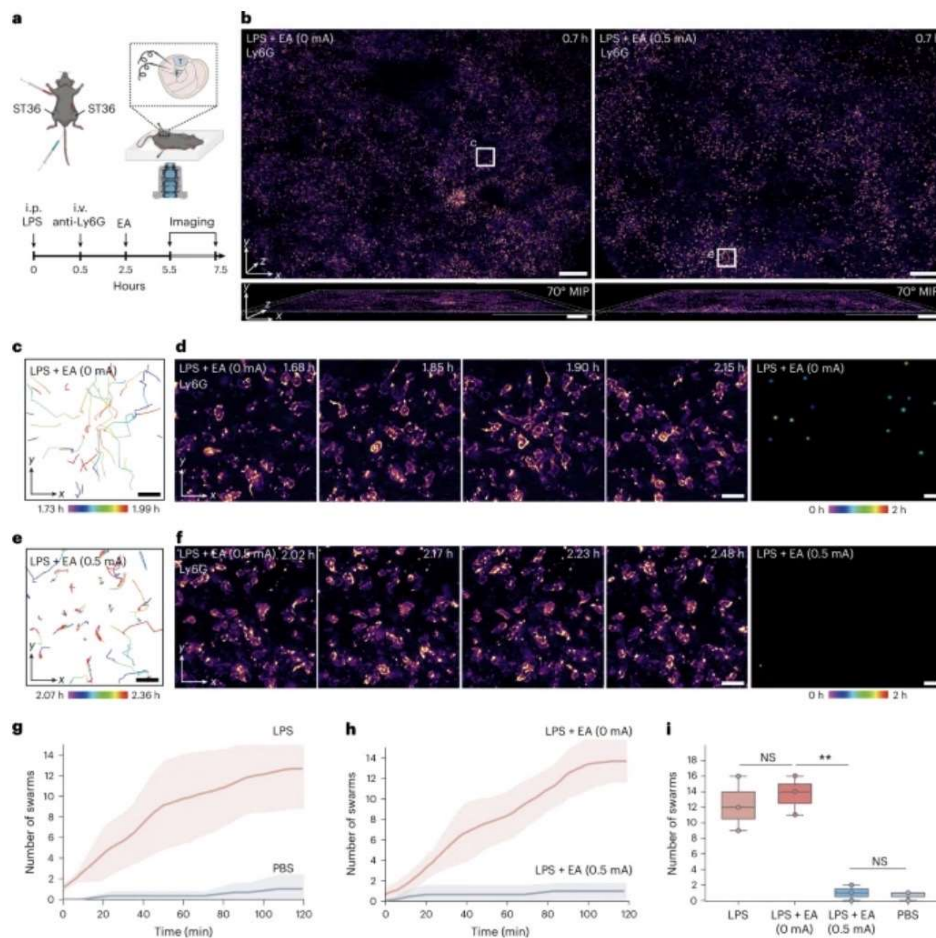
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It is:

What will we learn once we can see life at this scale, in motion, over time?

That is the question MLJC believes deserves the world's attention.

Fig. 6: EA at ST36 attenuates early-stage inflammation in mouse spleen validated by the mesoscale biomarker.



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MLJC | JY HCG

全球医疗与生物医学战略情报

MLJC 独家 | Nature Biotechnology 深度研究报告

当我们终于能够看见生命正在发生什么

中国科研团队突破活体亚细胞成像尺度：RUSH3D-HR 如何打开医学观察的新窗口

Intravital Imaging | Biomedical Imaging | Cell Biology |
Immunology | Precision Medicine | AI for Science

Research • Evidence • Clinical Translation • Strategic
Intelligence

一、MLJC 导读

医学真正的进步，有时候并不是创造一种新的药物。

而是：

让科学家第一次能够看见过去无法看见的东西。

2026 年 7 月 15 日，国际权威期刊 Nature Biotechnology 正式发表了一项来自中国科研团队的重要研究：

High numerical aperture confocal volumetric mesoscope reveals
mesoscale subcellular dynamics in vivo

论文介绍了一套名为：

RUSH3D-HR



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的高数值孔径共焦体积介观显微成像系统。

研究团队由清华大学戴琼海、吴嘉敏团队与华中科技大学同济医学院附属同济医院王伟团队等合作完成。论文同时涉及复旦大学及相关科研与产业机构。

这项研究最值得关注的地方，不只是“显微镜看得更清楚”。

真正重要的是：

它开始让科学家在活体内，同时观察“大范围细胞群体”与“细胞内部亚细胞结构”的动态变化。

这意味着我们正在从：

看见一个细胞

进一步走向：

看见成千上万个细胞如何共同运动、相互作用，以及如何参与疾病过程。

二、为什么这件事情重要？

生命并不是静止的。

人体内数以百万计的细胞不断：

移动

交流

聚集

分离



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吞噬

攻击

修复

死亡

并形成复杂的群体行为。

特别是在：

炎症

感染

创伤修复

肿瘤

免疫反应

器官衰竭

等疾病过程中，真正决定疾病发展方向的，往往并不是单独一个细胞。

而是：

大量细胞之间如何相互作用。

问题在于，过去的成像技术通常必须在：

分辨率

与

观察范围

之间作出牺牲。



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看得非常清楚的时候，通常只能看很小的区域。

看得很大的时候，又很难同时看到亚细胞层面的细节。

而 RUSH3D-HR 的意义，正是在于尝试突破这一长期存在的技术矛盾。

三、这不是“显微镜升级”

MLJC 更愿意把它理解成：

医学观察能力的一次扩展。

传统显微成像可以理解为：

看得很清楚，但看得不够大。

介观成像可以：

看得很大，但细节不足。

而 RUSH3D-HR 尝试建立第三种能力：

在毫米级空间范围内，同时保留亚细胞级别的观察能力。

论文报告：

横向分辨率

约 390 nm

轴向分辨率

约 700 nm

单次成像体积

$2.7 \times 2.0 \times 0.04 \text{ mm}^3$



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成像速度

最高约 5 volumes/second

数据吞吐

约 70 billion voxels/second

并且维持较低的光毒性。

这些参数不是简单的“硬件升级”，而是多个光学、计算和工程技术共同作用的结果。

四、RUSH3D-HR 究竟做了什么？

这套系统并不是依靠单一技术实现突破。

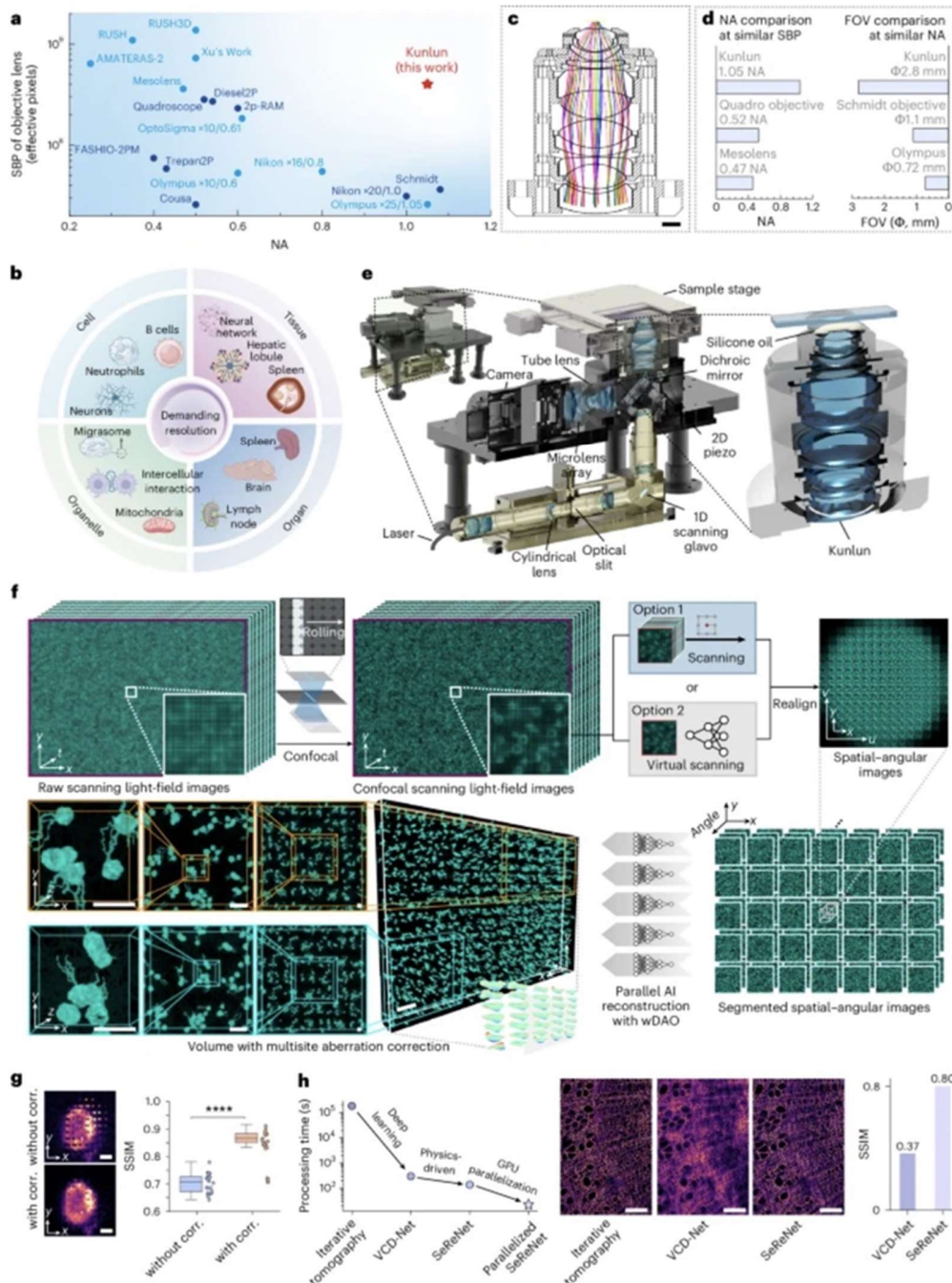
它结合了多个关键技术模块。



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Fig. 1: Principle of RUSH3D-HR.





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01 | High-NA Optics

研究团队开发了：

Kunlun high-NA objective

数值孔径：

NA 1.05

高数值孔径意味着更强的光学解析能力，但同时也会带来更严重的像差、景深和光毒性问题。

因此，单纯提高 NA 并不能解决问题。

02 | Digital Adaptive Optics

研究团队加入：

数字自适应光学校正

用于处理高 NA 光学系统对像差高度敏感的问题。

换句话说：

不是只把镜头做得更强，而是让系统能够不断修正光学误差。

03 | Confocal Scanning Light-field Imaging

系统进一步结合：

共聚焦扫描光场显微成像

让大范围三维成像能够保持较高速度，同时降低不必要的光照。



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04 | Deep Learning

这里还有一个非常重要的部分：

AI 并不是为了“替代显微镜”。

而是参与：

去噪

像差校正

运动伪影修正

三维重建

等数据处理过程。

研究团队建立了并行化深度学习处理流程，用来处理每秒约 700 亿像素的数据规模。

这代表：

现代生物医学成像正在从“光学问题”变成“光学 + 计算问题”。

五、真正令人惊叹的不是 390 纳米

390 nm 当然重要。

但从 MLJC 的角度：



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真正重要的是三个数字同时出现：

390 nm

×

millimetre-scale field of view

×

5 volumes per second

也就是说：

研究人员不只是看见更小的结构，而是能够在更大的活体空间里，以更高速度持续观察这些结构如何变化。

这改变的是：

TIME + SPACE + SCALE

三个维度。

过去可能是：

一个细胞

现在：

数千个细胞

过去可能是：

一个瞬间

现在：

数小时动态观察

过去可能是：

局部结构



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现在：

毫米尺度的细胞群体行为

六、研究人员真正“看见”了什么？

论文并不是停留在技术参数。

研究团队把 RUSH3D-HR 应用于多个活体研究场景，包括：

伤口修复

观察细胞进行长距离集体迁移。

急性肝衰竭

观察：

中性粒细胞

与

巨噬细胞

之间的亚细胞层面相互作用。

脾脏炎症

研究团队连续数小时观察超过：

6,000 个中性粒细胞

并发现炎症条件下存在短暂出现的：

Neutrophil Swarming

即：



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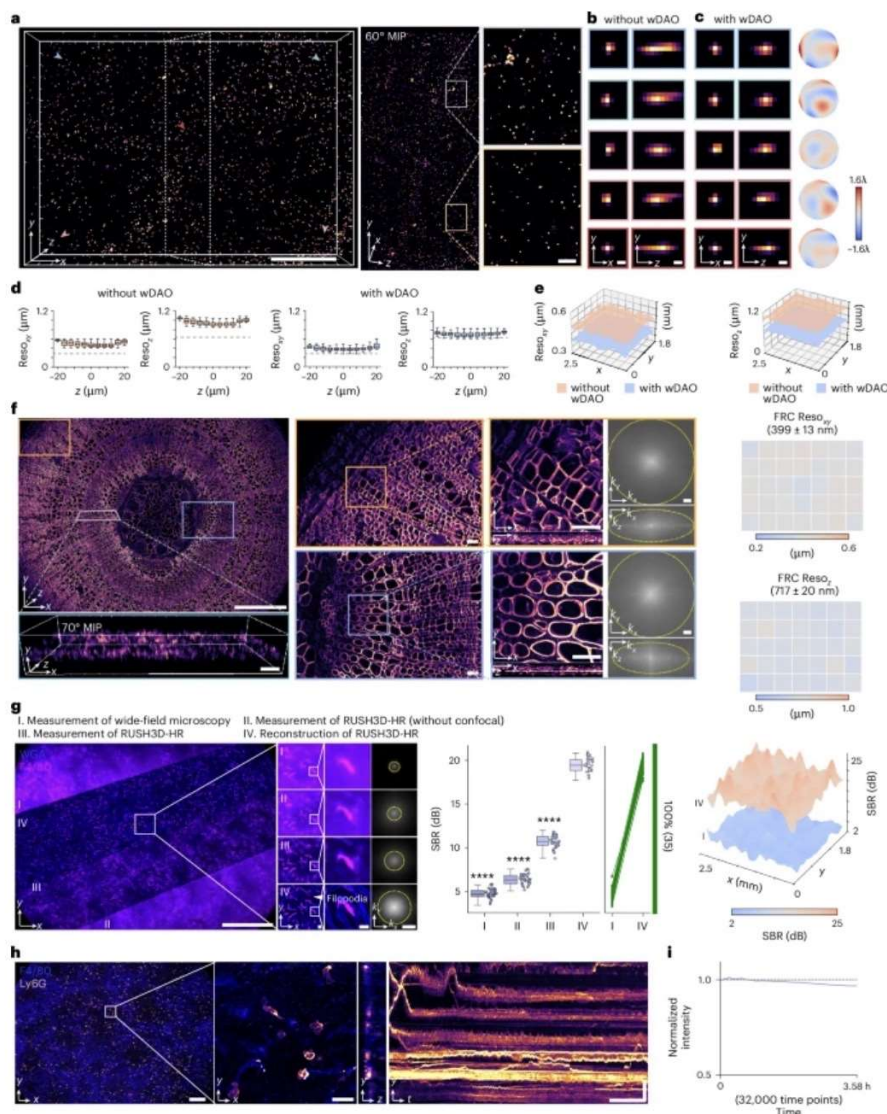
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中性粒细胞群体性聚集 / “蜂群式”运动行为。

这种行为此前很难在活体中以如此大规模、长时间和亚细胞分辨率同时观察。

Fig. 2: Characterization of RUSH3D-HR.



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七、这可能改变我们理解疾病的方式

过去我们往往问：

哪个细胞出了问题？

未来可能需要问：

这些细胞之间发生了什么？

这是两个完全不同的问题。

疾病可能并不是单个细胞的问题。

而可能是：

Cell



Cell - Cell Interaction



Cellular Network



Tissue Microenvironment



Organ-Level Response

最终形成疾病。



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RUSH3D-HR 的价值之一，就是尝试连接：

SUBCELLULAR

亚细胞



CELLULAR

细胞



MESOSCALE

介观



ORGAN

器官

之间过去相对割裂的观察尺度。

论文作者也将其定位为连接单细胞内部微观动态与器官层面功能的重要平台。

八、MLJC 特别关注：它可能改变“药物研发”

这是我们认为最值得国际医疗产业进一步关注的部分。

传统药物研发往往依赖：

病理指标



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分子指标

血液指标

组织切片

终点疗效

但是，如果未来能够直接观察：

药物进入组织以后，细胞群体在几分钟、几十分钟甚至数小时内发生了什么？

那么药物研发可能获得一种新的观察维度。

例如：

免疫细胞是否真正到达目标位置？

肿瘤微环境如何变化？

炎症反应什么时候开始？

哪些细胞首先响应？

细胞之间是否形成新的群体行为？

这些问题过去往往只能通过不同时间点的实验进行推断。

而实时活体成像可能逐渐让部分过程：

从“推测”变成“观察”。

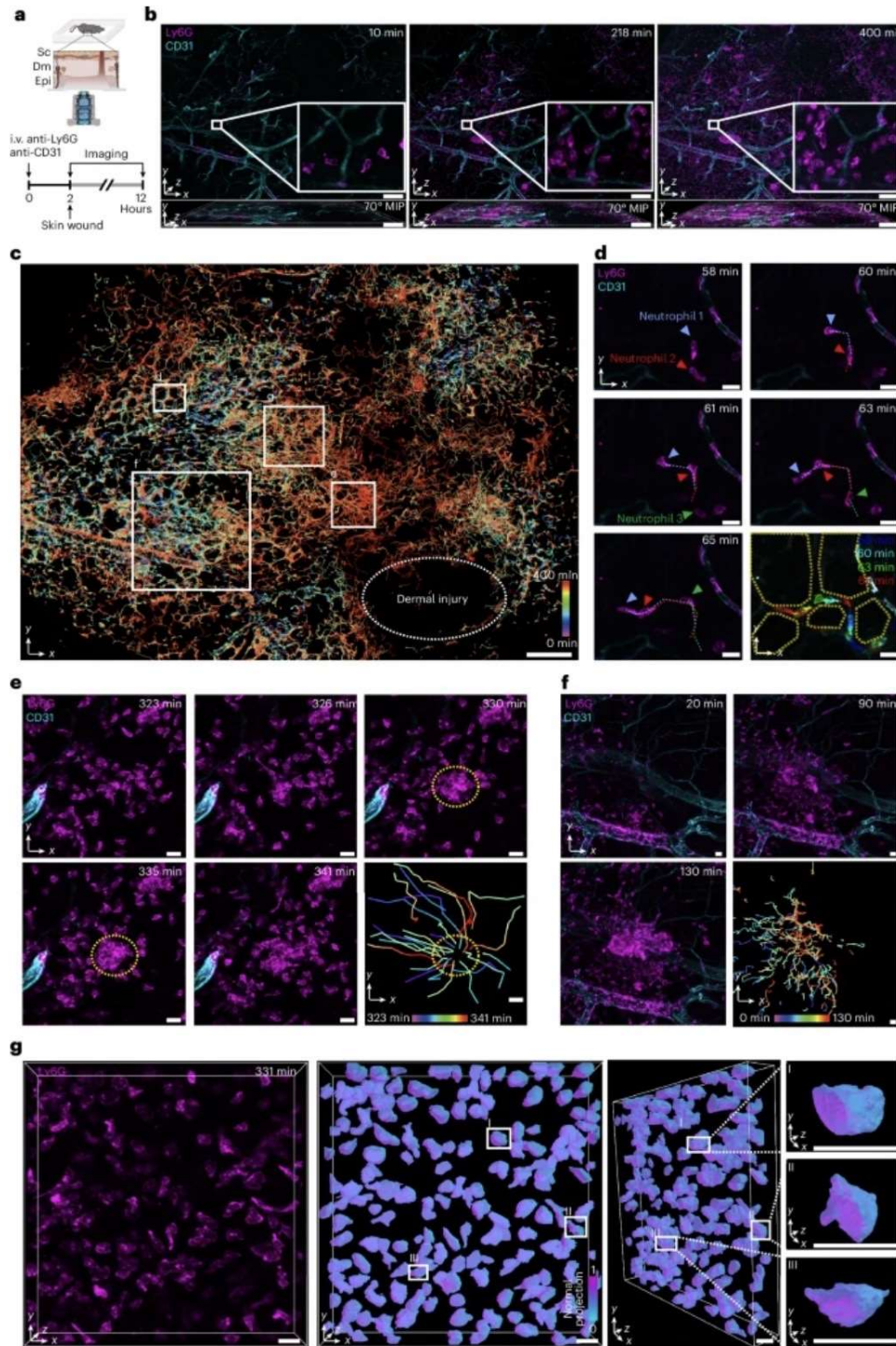
当然，这并不意味着 RUSH3D-HR 已经成为临床诊断设备。

这是两个完全不同的阶段。



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九、MLJC 的一个重要问题

如果未来我们能够：

实时观察数千甚至数万个细胞如何响应疾病与治疗，

那么下一个问题自然出现：

Can we turn cellular behaviour into a measurable clinical biomarker?

细胞群体行为能不能成为新的疾病生物标志物？

例如论文已经展示：

中性粒细胞群体行为可以作为一种介观尺度炎症生物标志物，用于评估外周干预的抗炎效果。研究中观察到这种指标可以在数小时尺度上出现变化。

这意味着未来值得研究：

Cellular behaviour → Quantitative biomarker

即：

从“看见细胞”走向“测量细胞行为”。

这一步可能比显微镜本身更加重要。



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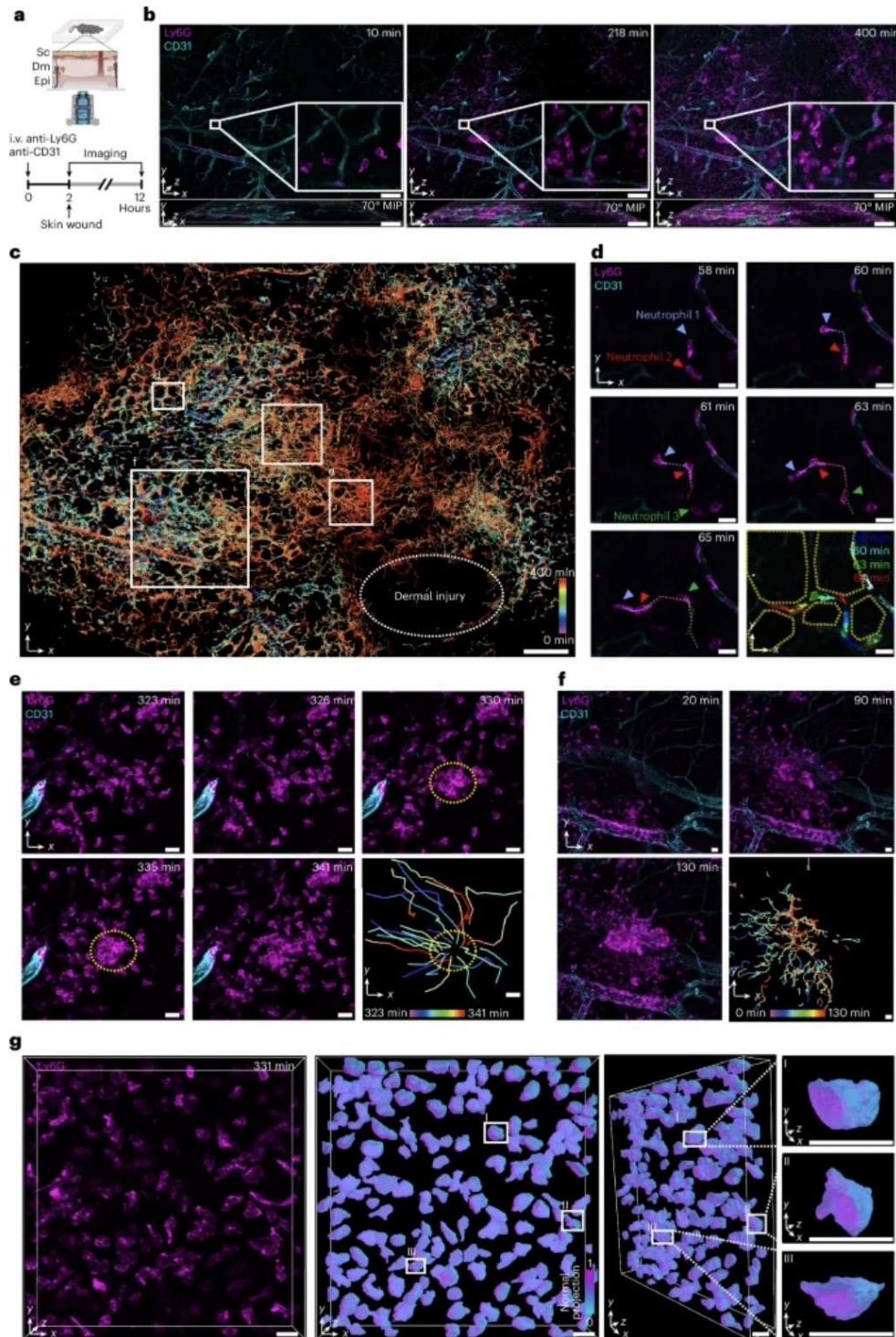


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十、关于针灸研究：应该如何严谨理解？

这里尤其需要避免媒体化表达。

论文确实使用 RUSH3D-HR 观察了小鼠脾脏炎症模型中的中性粒细胞群体行为，并研究了 ST36（足三里）电针刺激对这一炎症行为的影响。研究报告该刺激抑制了观察到的中性粒细胞蜂群式行为。

但这应该理解为：

动物模型中的机制研究证据。

不能直接转换成：

✗ “Nature 证明针灸可以治疗炎症。”

也不能转换成：

✗ “电针已经被证明适用于所有人体炎症疾病。”

MLJC 认为，这种区分非常重要。

真正专业的医学报道不是把一个动物实验扩大成临床结论。

而是：

让动物研究告诉我们，它真正发现了什么。

十一、这项研究为什么值得赞赏？

MLJC 愿意明确表达赞赏。

不是因为“这是中国科研”。

而是因为这项研究解决的是一个长期存在的基础科学与工程问题：



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Resolution

分辨率

Field of View

观察范围

Speed

速度

Phototoxicity

光毒性

Data Processing

数据处理

这些因素彼此牵制。

团队不是简单地提高其中一个指标，而是通过：

光学设计

自适应光学

共聚焦光场成像

高速体积采集

深度学习计算

建立完整系统。

这才是值得肯定的地方。

它不是一项孤立的技术。



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而是一个：

SYSTEM-LEVEL INNOVATION

十二、MLJC 更深一层的判断

过去的医学成像更多回答：

Where is the cell?

细胞在哪里？

下一阶段可能回答：

What is the cell doing?

细胞正在做什么？

再下一阶段：

Why is the cell doing it?

为什么会这样做？

最终：

Can we predict what it will do next?

我们能不能预测它下一步会做什么？

这将形成：

SEE → MEASURE → UNDERSTAND → PREDICT

而 RUSH3D-HR 更像是处在：

SEE → MEASURE



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这个关键阶段。

它还不是最终答案。

但它正在扩大科学家能够观察到的“证据边界”。

十三、MLJC 提出的五个未来问题

Question 01

能否进一步实现更深层器官成像？

Question 02

能否在人类组织或临床环境中实现类似观察？

Question 03

能否把细胞群体行为转化为可靠的数字生物标志物？

Question 04

AI 能否从海量细胞动态中识别过去无法人工发现的疾病模式？

Question 05

能否最终把这种成像技术真正连接到药物研发、疾病诊断及精准治疗？

这些问题目前没有全部答案。

但这恰恰是科研最值得继续的地方。

十四、从科研仪器，到未来医疗基础设施

MLJC 认为，如果这一方向持续成熟，它的价值可能远远超过：

一台显微镜。



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未来它可能成为一种：

Biomedical Observation Infrastructure

生物医学观察基础设施。

因为医学的一个核心问题永远是：

如果我们不能准确观察疾病发生的过程，就很难真正理解疾病。

而如果能够：

观察

→

量化

→

建模

→

预测

→

干预

那么医学将逐渐从：

Endpoint Medicine

走向：

Dynamic Medicine

即：



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从观察结果，走向观察过程。

十五、MLJC | JY HCG Evidence Assessment

项目	MLJC 评估
论文发表	Nature Biotechnology
发表日期	15 July 2026
论文状态	Open Access
DOI	10.1038/s41587-026-03231-z
核心系统	RUSH3D-HR
数值孔径	NA 1.05
横向分辨率	约 390 nm
轴向分辨率	约 700 nm
成像体积	$2.7 \times 2.0 \times 0.04 \text{ mm}^3$
速度	5 volumes/s
数据吞吐	70 billion voxels/s



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长时间观察	超过 3 小时的连续 3D 活体成像实验
研究对象	活体动物模型
观察领域	伤口修复、急性肝衰竭、脾脏炎症等
临床状态	研究/临床前科研工具，并非获批临床诊疗设备

上述论文信息及性能指标均可由 *Nature Biotechnology* 原始论文及 PubMed 记录核实。

十六、MLJC 的科学边界

我们特别强调：

这不是：

- ✗ 一项已经获得临床批准的诊断技术
- ✗ 一台普通医院已经广泛使用的医学设备
- ✗ 已经证明能够治疗疾病的医疗器械
- ✗ “AI 可以直接看懂人体疾病”

它目前更准确的定位是：

Advanced Preclinical Biomedical Imaging Platform

先进的临床前生物学医学成像平台。



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它的意义在于：

帮助研究人员获得过去难以获得的活体动态证据。

十七、MLJC | JY HCG 的观点

我们对这项研究的评价，不应该只是：

“中国又取得了一项世界领先技术。”

这样的表达太简单。

我们更愿意说：

这是一项值得国际生物医学界持续观察的系统性成像创新。

它的重要性来自三个层面：

第一层 | Scientific

扩大活体生物学能够被观察和测量的范围。

第二层 | Medical

为免疫、炎症、组织修复和疾病机制研究提供新的观察工具。

第三层 | Strategic

推动：

Advanced Imaging

AI

Biomedical Research

Drug Discovery

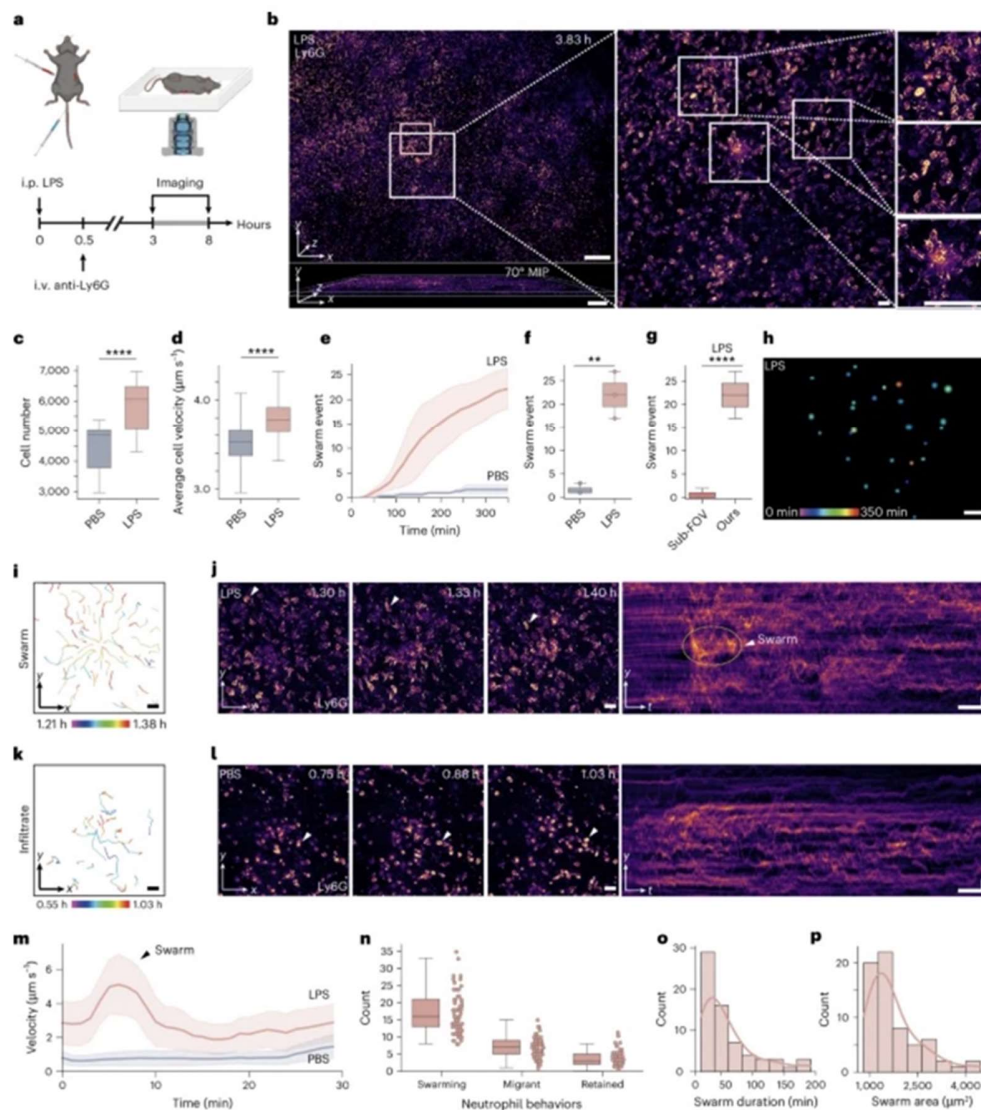
之间进一步融合。



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Fig. 5: Large-scale transient swarming behaviors of neutrophils during inflammation in mouse spleens.





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十八、MLJC 的赞赏

科学值得赞赏，不因为它来自哪里。

而因为它：

解决了问题。

提供了证据。

打开了新的可能。

对于参与这项研究的科学家、工程师、医学团队及合作机构，MLJC 给予充分尊重。

特别值得肯定的是：

他们没有试图用一个简单指标解决一个复杂问题，而是建立了一套从光学、成像、计算到生物医学验证的完整系统。

这也是中国科研正在出现的一种值得国际社会关注的变化：

从单点技术突破，走向系统工程能力。

十九、MLJC 的“儒家式科学观”

我们愿意把这一点作为 MLJC | JY HCG 医疗科技报告长期坚持的原则。

知之为知之，不知为不知。

知道已经证明的，就如实报道。

不知道的，就明确说不知道。



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尚未进入临床的，不把它写成临床治疗。

动物实验，不冒充人体证据。

科研突破，不制造医疗神话。

因为：

医疗的终点不是流量。

而是生命。

所以：

见新而不惑，见成而不夸，见未成而不妄。

这应该成为 MLJC | JY HCG 对未来医疗科技报道最基本的态度。

二十、MLJC FINAL VIEW

这项研究真正改变的，可能不是显微镜。

而是：

我们能够知道多少。

过去：

我们看到细胞。

今天：

我们开始看到细胞群体如何运动。

过去：

我们研究疾病的结果。



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现在：

我们开始观察疾病发生的过程。

未来：

我们或许能够通过大量真实的动态数据：

理解疾病



建立生物标志物



预测疾病



评价治疗



最终实现更加精准的干预。

因此，RUSH3D-HR 今天还不是临床医学的终点。

甚至不是成熟医疗产品的终点。

它更像是打开了一扇门：

A WINDOW INTO LIVING BIOLOGY

一扇通往活体生命动态世界的新窗口。

而 MLJC 所关注的，正是这扇窗口打开之后：

我们下一步究竟能够看见什么。



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Fig. 6: EA at ST36 attenuates early-stage inflammation in mouse spleen validated by the mesoscale biomarker.

