

**Photothermal Gold Nano-Rods, Detects and Gets Rid of Cancer SAFELY in Different Animals and Stops Cancer Cell Migration Which Kills 90% of Cancer Patients...**

**EL-SAYED RESEARCH GROUP IN COLLABORATION WITH: DR SHIN GROUP AT EMORY CANCER CENTER in Atlanta, THE RESEARCH GROUP OF DR SALAH SELIM AT CAIRO UNIVERSITY AND THAT OF DR ABDOON OF THE EGYPTION NATIONAL RESEAERCH CENTER IN CAIRO.**

# OUTLINE

- **1. Plasmonic properties of gold metals on the Nanoscale: Strong Scattering or Strong Absorption depends on their size.**
- **2. Using plasmonic enhancement of light scattering in cancer cell detection and strong absorption (which is converted into heat) in cancer photo thermal therapy AND APPLICATIONS IN TREATING DIFFERENT ANIMALS.**
- **3. Results of the Long time testing of the effect of the treatment on the body chemistry in mice, cats and dogs.**
- **4. Experiments show that the GOLD NANORODS photo-thermal treatment, IN ADDITION TO KILLING**

**BULK GOLD IS PRECIOUS BECAUSE IT DOES NOTHING (it does not tarnish i.e. it does not react )**  
**is more precious on the nanoscale**



**Death Mask of Tutankhamun  
~1325 B.C.**



**Tutankhamun's coffin**

# THE GREAT POTENTIAL OF NANO-TECHNOLOGY.

- AS THE SIZE OF ANY MATERIAL DECREASES TO 1-100nm length scale, ITS PROPERTY CHANGES AS ITS SIZE OR SHAPE CHANGES( (the origin of Nanotechnology)..
- THUS EVERY MATERIAL CAN GIVE US MANY NEW MATERIALS EACH WITH DIFFERENT NEW PROPERTIES AS ITS SIZE OR SHAPE IS CHANGED IN THE 1-100 NANOMETERS, MANY WILL HAVE USEFUL PROPERTIES TO START NEW MEDICAL TREATMENT FOR PATIENTS, NEW INDUSTRIES,.....

# WHY NANOMETER AND NOT MICRO- OR PICO-METER???

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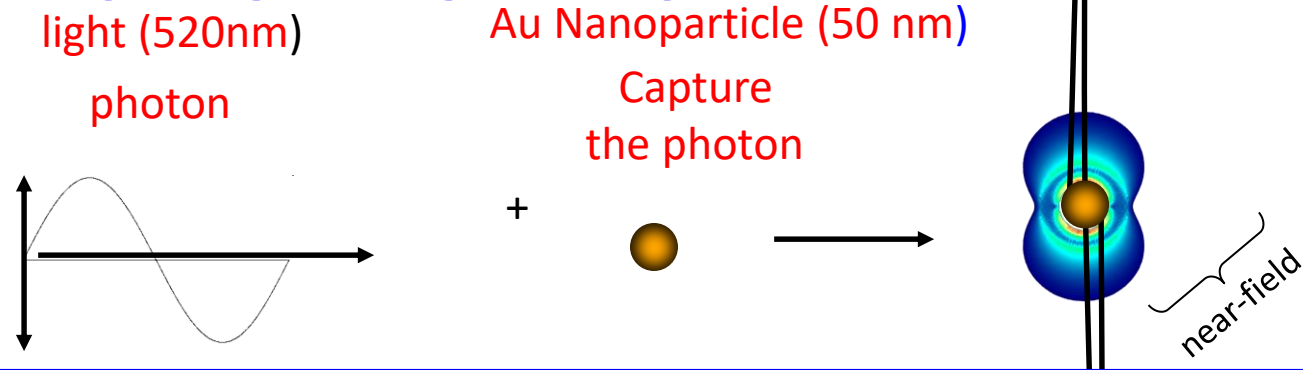
**THE PROPERTY OF EACH MATERIAL:**

“USUALLY BETWEEN 1-100 NANOMETER

IN LENGTH AND DIFFERENT

# Gold nanoparticles Plasmonic Properties

## **CAPTURING THE PHOTON TO INDUCE The Surface Plasmon RESONANCE (SPR) Oscillation with Strong Surface ELECTRO-MAGNETIC Fields?**



**1. The Electromagnetic field of the captured Photon is Enhanced by Thousands of Times on the surface of the nanoparticle as a Result of the Coherent Oscillation Of the Collective Excitation of the Free Conduction Band Electrons in the Metal Cluster.**

**2. THIS Enhances The Rate of their Absorption (sensing) and Scattering (SERS; imaging and thus sensing) Properties.**

**3. The Strongly Absorbed Energy is Rapidly Converted Into Heat That Can Have Useful Photo-Thermal Applications in Different Fields.**

# Some known Facts about Cancer

- In 2009 in the U.S., cancer newly diagnosed in 2.5 million people and killed 560,000
- #1 or #2 cause of death. With lung cancer most dominant followed by prostate for men or breast for women.
- Cancer cells divide rapidly as directed by its unhealthy nucleus.
- Caused either by genes and/or by environmental factors (smoking, drinking TOO MUCH alcohol, eating fatty food)
- Cancer Kills 75 Americans EVERY MINUTE.
- One fourth of dead people in the World died of cancer !!!
- Most can be cured IF DISCOVERED EARLY (Get examined continuously) or if it is treated photothermally with gold
- Nanoparticles as we will show

# THE MANY USEFUL PROPERTIES OF GOLD ON THE NANOSCALE IN MEDICINE

## THE LOCALIZED SURFACE PLASMON RESONANCE OF THE GOLD NANOPARTICLE (LSPR):

1. GREATLY ENHANCES THEIR ABSORPTION and LIGHT SCATTERING PROPERTIES and THE SCATTERING OF the MOLECULAR VIBRATIONS OF MOLECULES NEAR them.
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# PRESENT Cancer treatments

- Options: surgery, radiation therapy, chemotherapy, hormone replacement, biologics
  - Treatment course dependent on cancer type, staging, location, ...
- Surgery is used in 50% of all cancer treatments, rad/chem is tried in 5%\*.
- Surgery efficacy is limited by the capabilities of the surgeon and the location of the cancer.

# **IN-VIVO Cancer DIAGNOSIS AND CANCER THERAPY:**

**1. NEAR IR RADIATION PENETRATES THE HUMAN BODY LONG DISTANCES.**

**2. NANOSPHERES CAN STRONGLY SCATTER VISIBLE RADIATION, THUS IF CONJUGATED TO CANCER CELLS IT CAN BE USED IN CANCER DETECTION.**

**3. NANRODS CAN ALSO ABSORB STRONGLY THE NEAR IR RADIATION (WHICH CAN PENETRATE HUMAN BODY) AND CONVERTS INTO HEAT THAT MELTS THE CANCER CELLS IN THE BODY..**

# PLASMONIC APPLICATIONS IN MEDICINE

- PLASMONIC NANO-MEDICINE: the diagnosis and Photo-Thermal therapy of CANCER (or any other disease)

**1. IN-VITRO PLASMONIC DIAGNOSTICS AND PHOTO-THERMAL THERAPY.**

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**DR IVAN EL-SAYED  
M.D. UCSF**

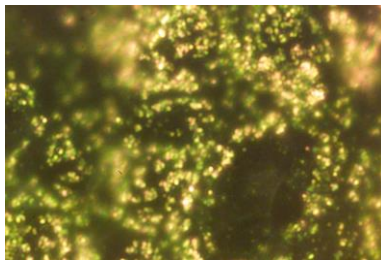
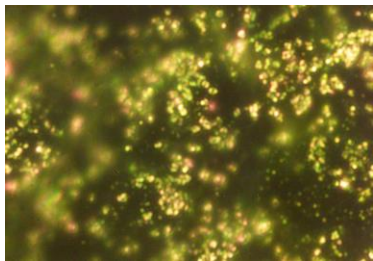


**ERIK DREDEN**

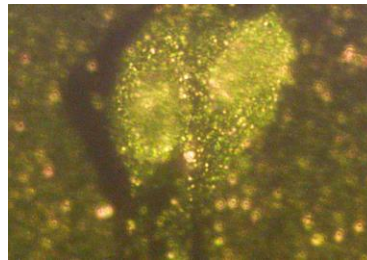
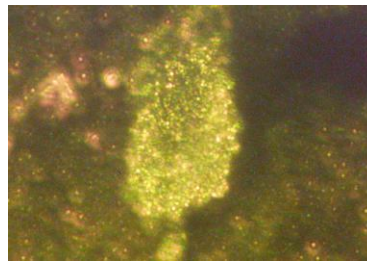


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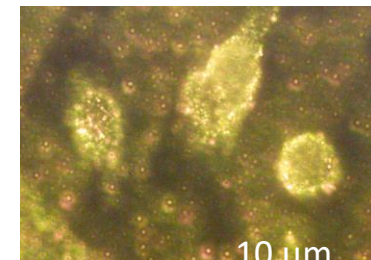
**HaCaT**  
*noncancerous cells*



**HOC**  
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**HSC**  
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**Ivan El-Sayed, Xiaohua Huang, M.A. El-Sayed Nanoletters ,4, 829, 2005.**

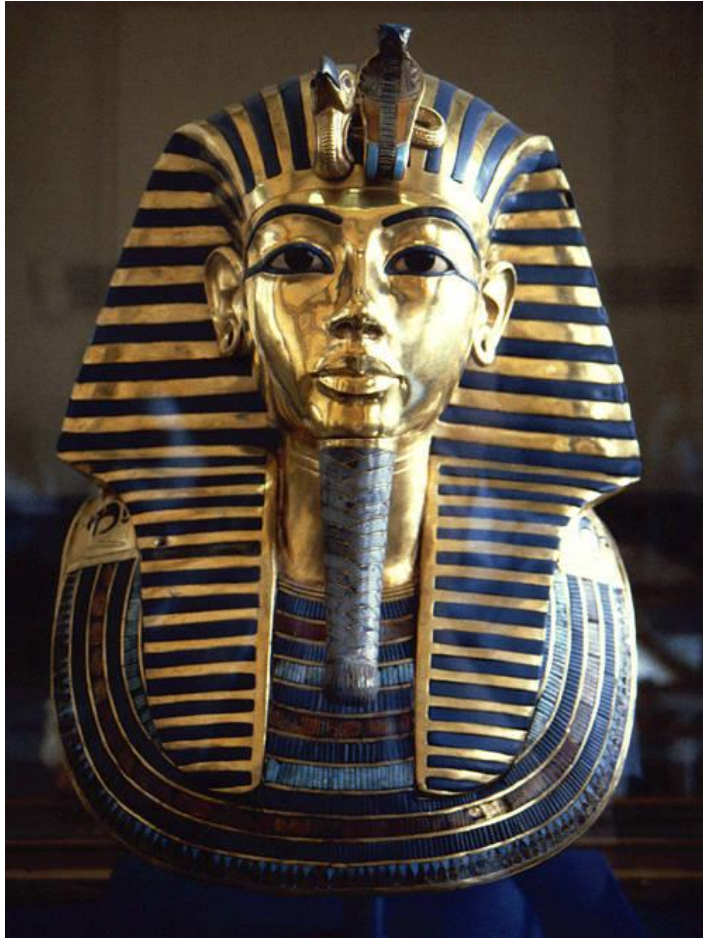
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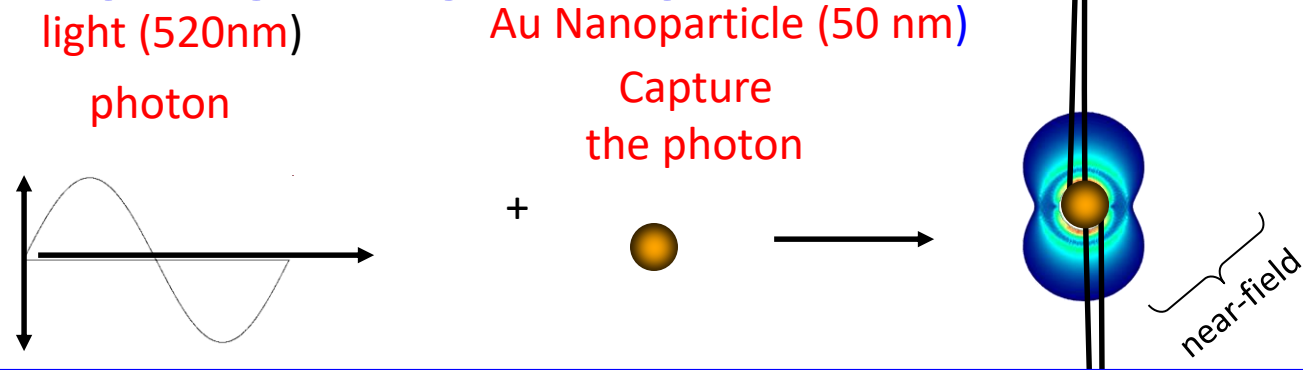
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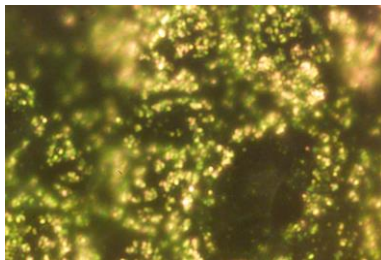
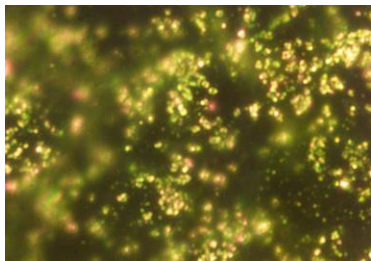


**Xiaohua Huang**

# DETECTION OF ONE CANCER CELL USING Enhanced GOLD NANOPARTICLES LIGHT SCATTERING AND & A SIMPLE LAB MICROSCOPE

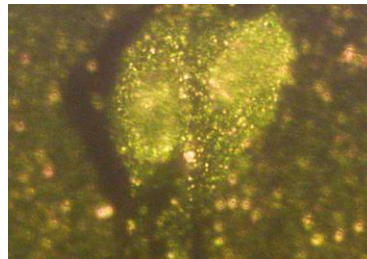
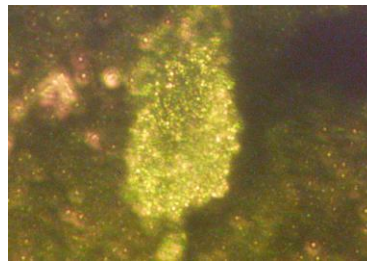
**HaCaT**

*noncancerous cells*



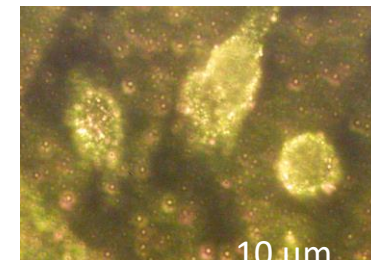
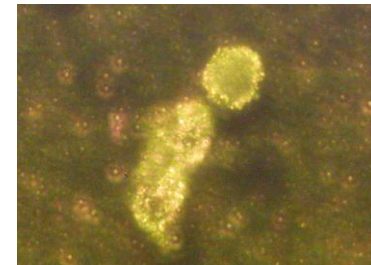
**HOC**

*cancerous cells*



**HSC**

*cancerous cells*



DIFFRACTION UNLIMITED IMAGING

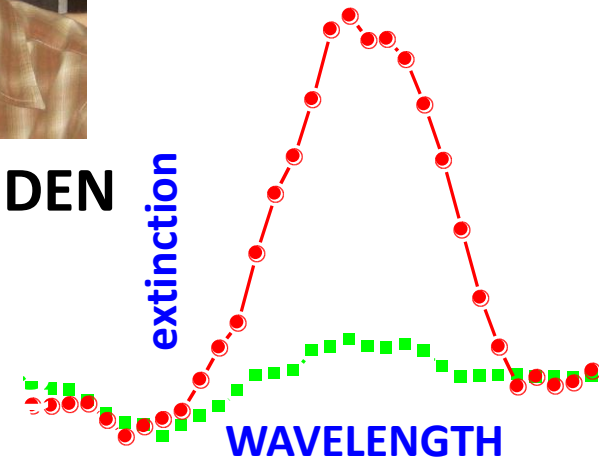
**Ivan El-Sayed, Xiaohua Huang, M.A. El-Sayed Nanoletters ,4, 829, 2005.**



# IN VIVO DETECTION OF CANCER IN ANIMALS USING THE GOLD NANOPARTICLES ENHANCED EXTINCTION PROPERTIES



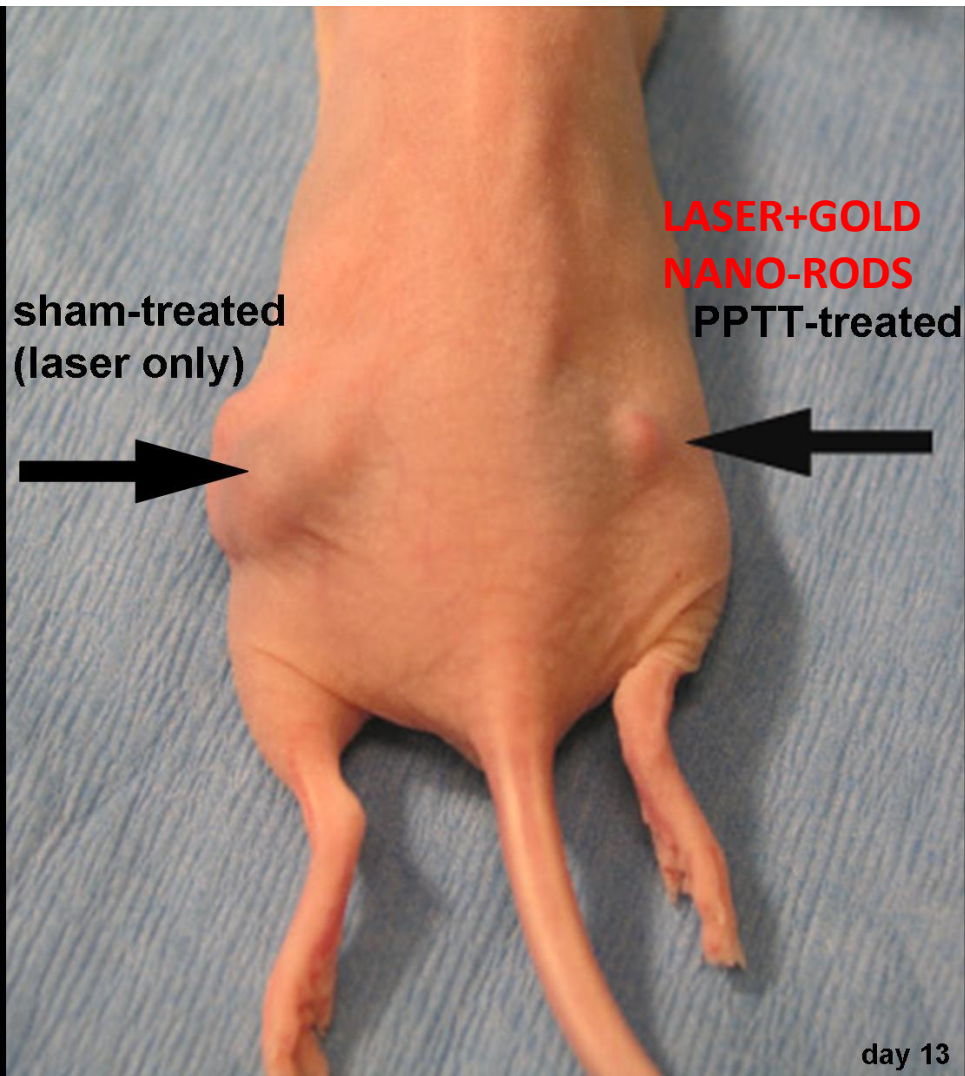
ERIK DREDEN



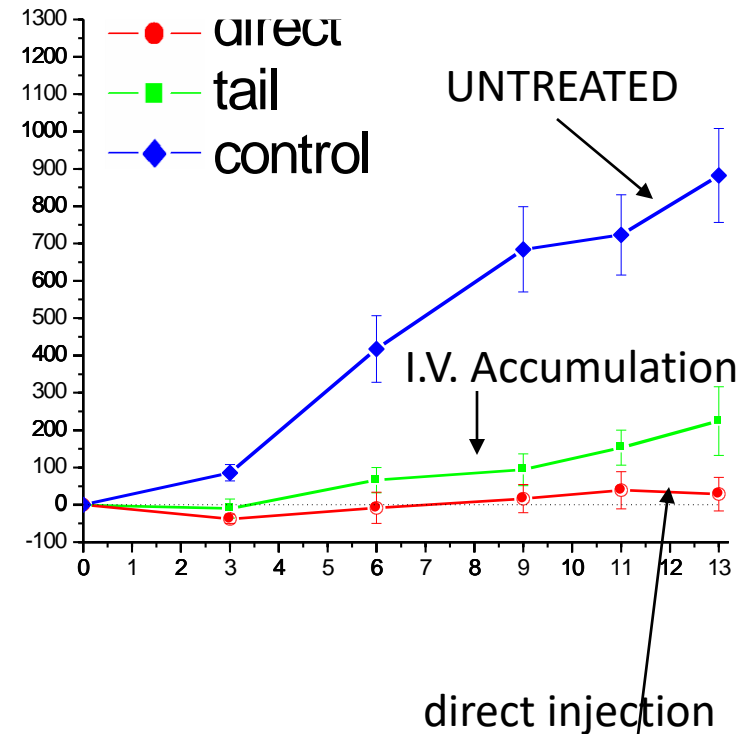
**PICTURES TAKEN WITH A CELL PHONE CAMERA !!!**

Dickerson, E. B.; Dreden, E. C.; Huang, X.; El-Sayed, I. H.; Chu, H.; Pushpanketh, S.; McDonald, J. F.; El-Sayed, M. A. *Cancer Letters* **2008**, 269, 57.

# PHOTO-THERMAL TREATMENT OF MOUSE BODY CANCER

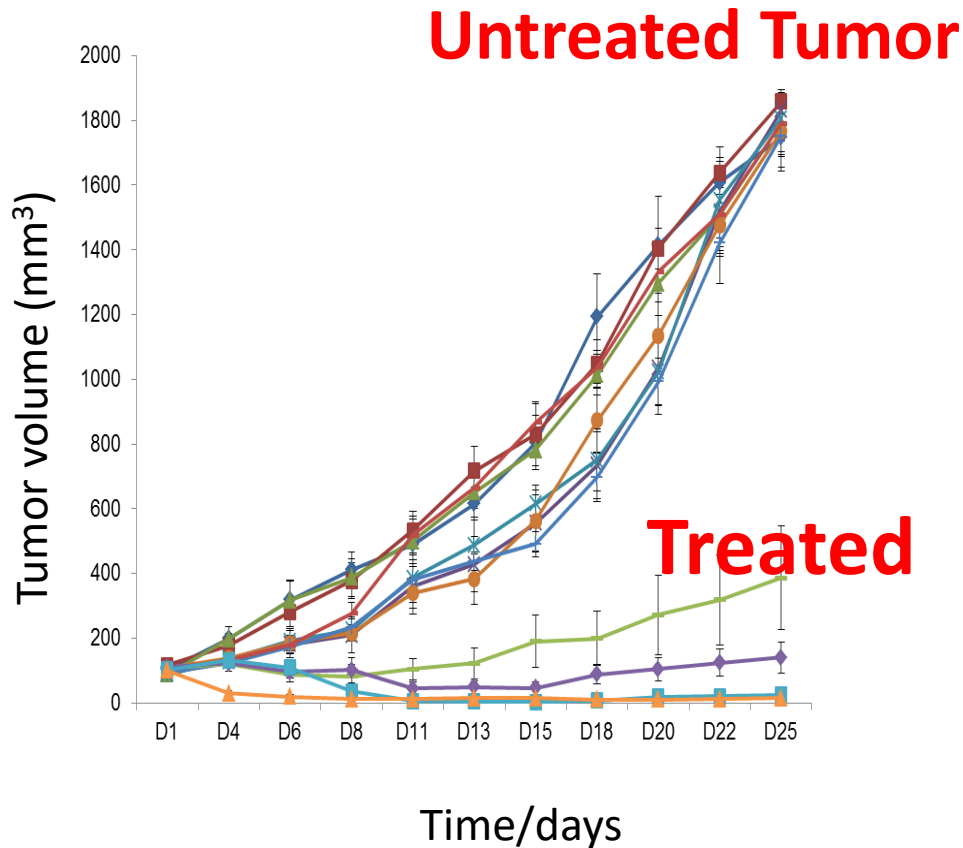


## COMPARISON OF THE GROWTH OF THE TREATED & THE UNTREATED TUMOR



Dickerson, E. B.; Dreaden, E. C.; Huang, X.; El-Sayed, I. H.; Chu, H.; Pushpanketh, S.; McDonald, J. F.; El-Sayed, M. A. *Cancer Letters* 2007, 269, 57.

# Photothermal Efficacy in Treating Head and Neck Cancer in MICE



PPTT not enough exposure (**Continue growing**)



PPTT harsh exposure (**Burning**)



PPTT Gentle exposure (**No burning**)

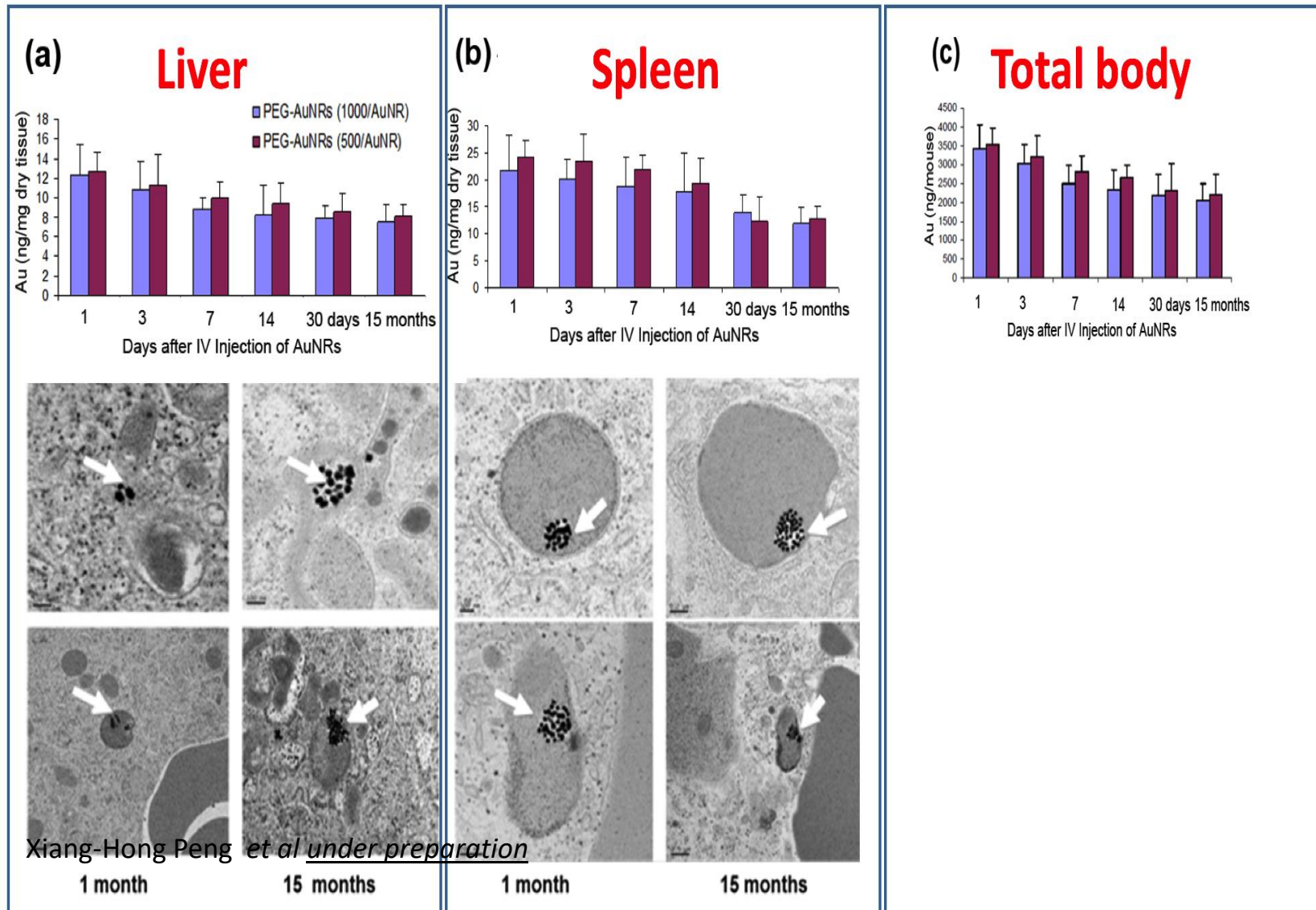


Moustafa R.K.Ali, Rahman Aminur, Dong. Shin , Mostafa El-Sayed,  
THE PROCEEDING OF THE USA NATIONAL ACADEMY OF SCIENCES,  
March 2017.

# LONG TERM TOXICITY OF GOLD PHOTO-THERMAL THERAPY.

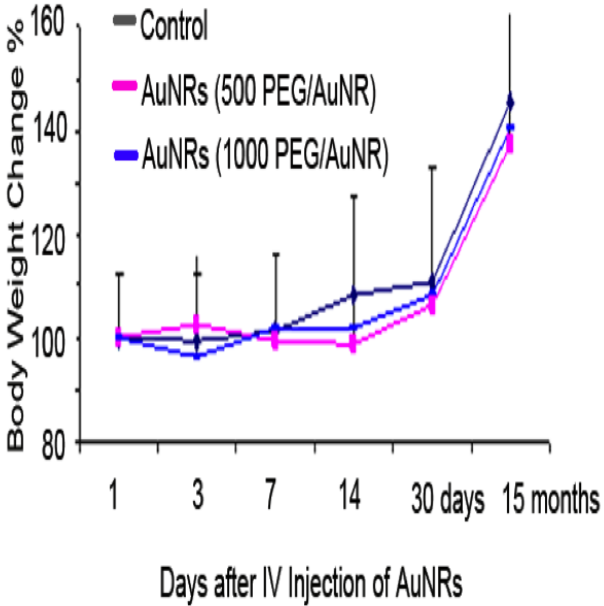
**Moustafa, R. Aminur, (and others) Dong. Shin , Mostafa El-Sayed,  
Proceeding of the USA National Academy of Sciences, Just Appeared.**

# The change IN the Concentration of Au-NANOPARTICLES in Liver, Spleen and The Full Body In 15 month Period in Mice.

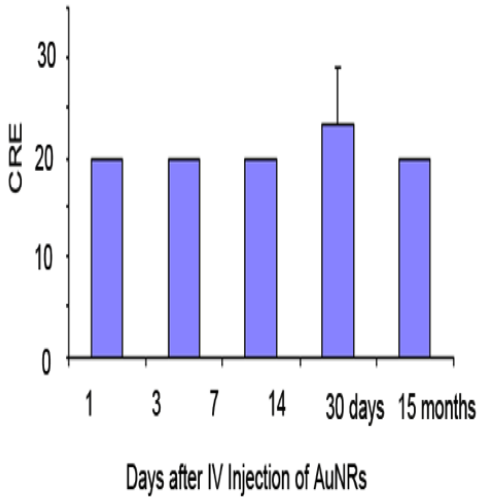


# Change of Body Weight, Kidney and Liver Functions During 15 months (MICE)

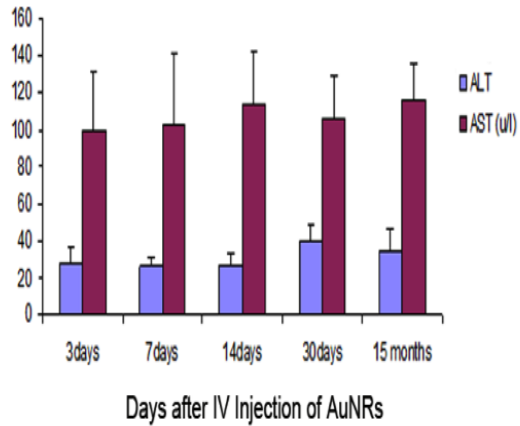
### Body Weight



### Kidney Function



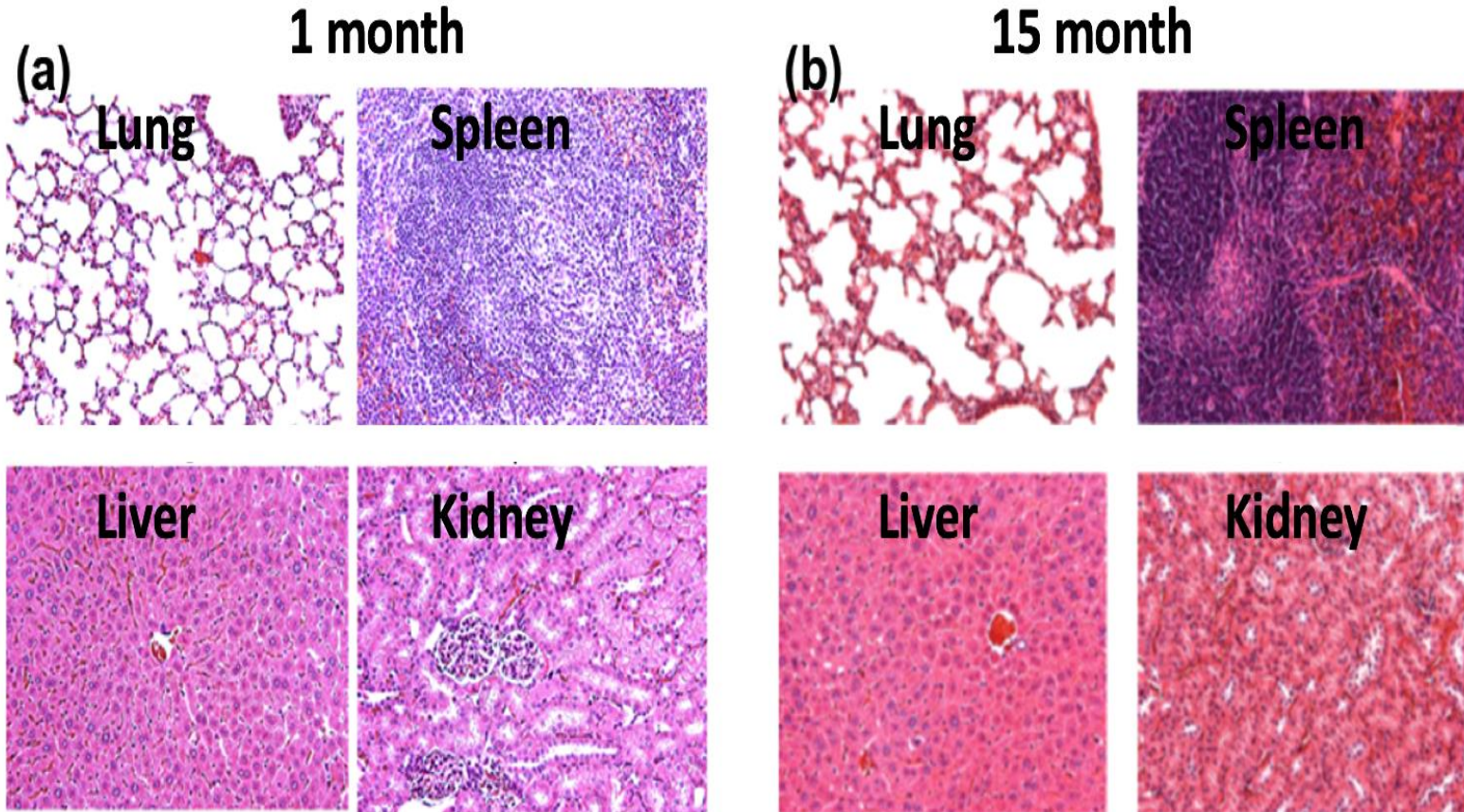
### Liver function



**No obvious long-term toxicity effect over 15 months**

**Moustafa R.K.Ali, Rahman Aminur, (and others) Dong. Shin , Mostafa El-Sayed, PNAS, Just Appeared.**

# Histopathology of Tissues of Different Organs of the Mice From 1 to 15 months.



**No obvious Change in the Tissues over 15 months Period**

Moustafa R.K.Ali, Rahman Aminur,..... Dong. Shin , Mostafa El-Sayed, [PNAS,Just Appeared]

# LARGER ANIMAL TREATMENT



# CAT WITH LARGE MAMMARY GLAND TUMOR COVERING THE WHOLE BREAST



The Egyptian National Research Center, Cairo; Egypt: LEADER IS DR  
ABDOON :*J. Nanomed. Nanotechnol. 2015, 6, 324.*

**THE CAT GOT PREGNANT TWO MONTHS AFTER THE OPERATION AND IS FEEDING HER KITTENS FROM the breast that had the surgery**



**THUS PHOTO-THERMAL THERAPY OF BREAST CANCER USING GOLD NANO-RODS DOES NOT STOP PREGNANCY NOR BREAST FEEDING**

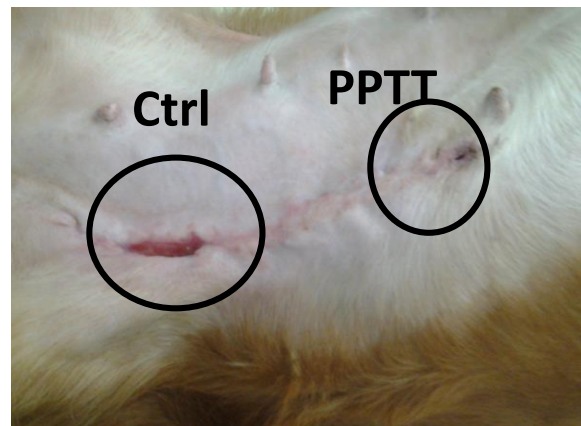
**Dr Abdoon et al, National Research Center, Cairo, Egypt :*J. Nanomed Nanotechnol.* 2015, 6, 324).**

# DIFFERENT TYPES OF CANCER TREATMENTS

**Before treatment**



BELOW: Tumor ON LEFT  
has been treated by  
Surgery. The ONE on  
right by Surgery  
followed by Photo-  
thermal Treatment.

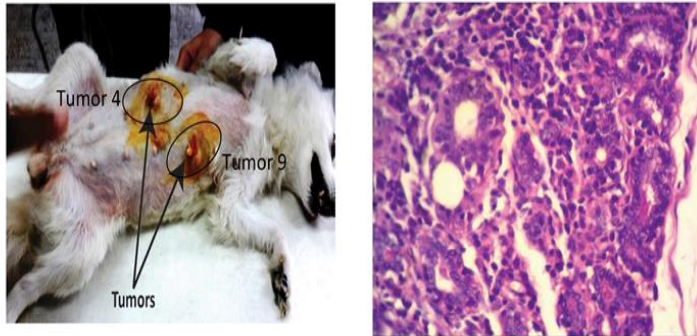


**1 month later, the left half treated by surgery only is ruptured. Retreated Photothermally.**

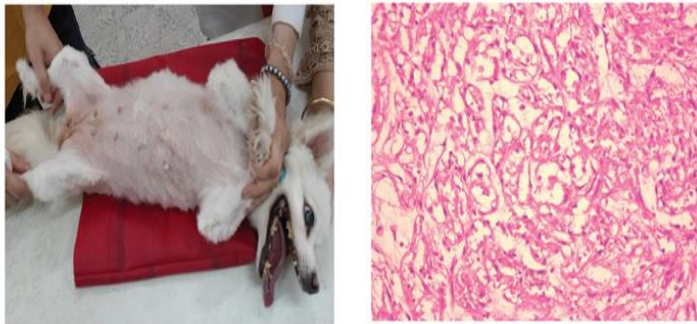
**(Cairo University Team: Dr Salah Selim and his team, Moustafa Ali, And M.A. El-Sayed from Georgia Tech travel to EGYPT or use SKYPE**

# AuNRs Treating Spontaneous Mammary Gland Tumors in Feline and Canine

A) Before treatment



2 weeks after third treatment



1 year after animal treatment



A)

Before treatment



B)

2 weeks after the third treatment



1 year after animal treatment

C)

1 year after the third treatment



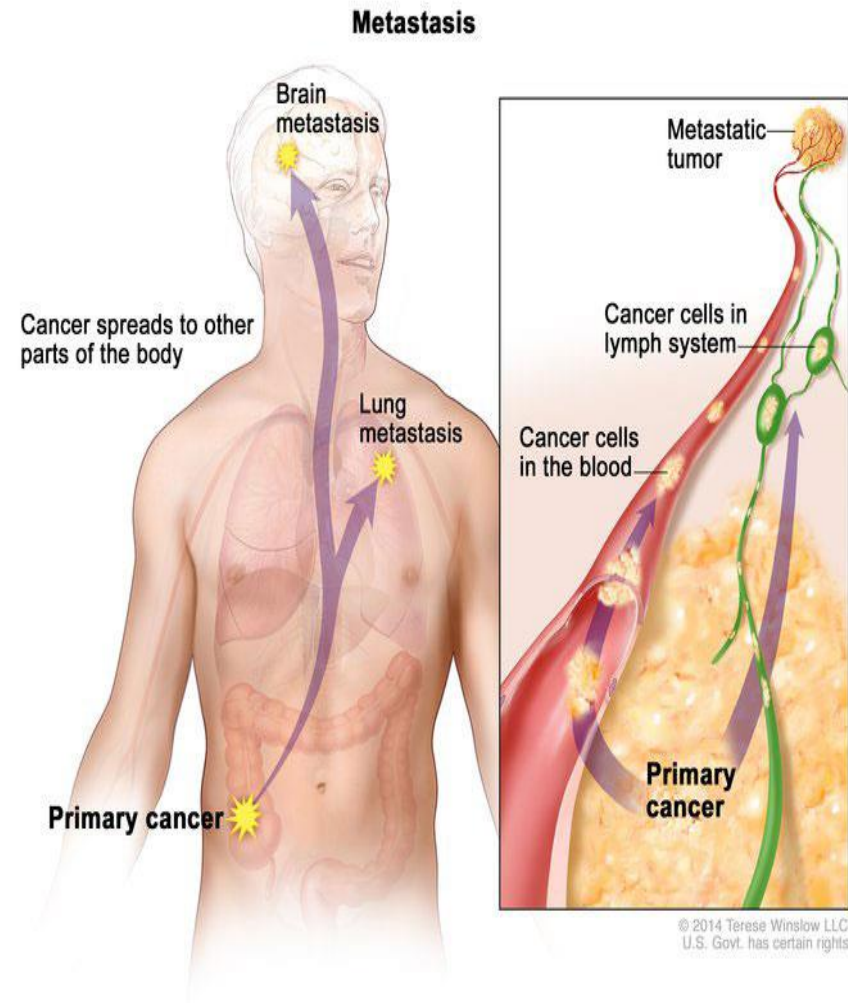
# No Change in Kidney and Liver Functions; before the treatment and 1 year LATER(now we have 3y)

Table 1 blood profile for each case before treatment and after 1 year from their curing  
(T1<3 cm, 3 cm<T2<5 cm, T3>5 cm)

Case No.	Animal Species	Age/year	Tumor Location	Tumor size	Kidney functions						Liver functions					
					Urea (mg/DL)			Creatinine (mg/DL)			GPT(U/L)			GOT(U/L)		
					Before	After 1 year	Normal range	Before	After 1 year	Normal range	Before	After 1 year	Normal range	Before	After 1 year	Normal range
1	Dog Griffon	10	12-left anterior thoracic	T3	15	14.9	5--25	0.82	0.71	0.5-1.6	84	88	5-107	156	135	5-55
2	Dog Griffon	11	9-Right abdominal 4-left caudo-thoracic	T3 T1	28	34	5--25	0.87	0.91	0.5-1.6	49	84.4	5-107	84	61	5-55
3	Dog griffon	7	13-Right abdominal 2-left caudo-thoracic	T3 T1	26	24.2	5--25	1.6	1.1	0.5-1.6	115	117	5-107	142	123	5-55
4	Dog Griffon,	5	8-right cranio-inguinal	T3	27	26.8	5--25	0.96	0.85	0.5-1.6	72	76	5-107	140	96	5-55
5	Dog Griffon,	13.5	7-left cranio-inguinal 5-left cranio-inguinal 3-left inguinal lymph node	T3 T2 T3	15	20	5--25	1.2	1.1	0.5-1.6	76	88	5-107	35	42	5-55
6	Cat shirazy,	11	11- right caudo-inguinal 1- left cranio-thoracic	T2 T1	38.7	35.6	14-36	1.6	1.4	0.6-2.4	56.2	58.4	10-100	34.5	36.2	10-100
7	Cat shirazy,	4	6-left anterior thoracic 10-right post caudo-inguinal	T2 T3	26.4	24.9	14-36	1.8	1.3	0.6-2.4	19	25	10-100	16	14	10-100

# 111. Metastasis (the migration of the cancer cells from its original location to more serious location) is the cause of 90% of Cancer Patient's Death.

**Weigelt, B., Peterse, J. L. & van 't Vee L. J. Breast cancer metastasis: marker and models. Nature Rev. Cancer 5, 591–602 (2005)**  
**<https://www.cancer.gov/types/metastatic-cancer>**



## Past attempts to develop anti-metastasis drugs have not been successful in clinical trials

- Resistance
- Side effects

Weber, G. F. Why Does Cancer Therapy Lack Effective Anti-Metastasis Drugs? *Cancer Lett.* **2013**, 328, 207-11.

Morgillo, F.; Lee, H. Y. Resistance to Epidermal Growth Factor Receptor-Targeted Therapy. *Drug Resist. Updat.* **2005**, 8, 298-310.

Effects of Chemotherapy and Hormonal Therapy for Early Breast Cancer on Recurrence and 15-Year Survival: an Overview of the Randomised Trials. *Lancet (London, England)* **2005**, 365, 1687-717.

# Nanoparticles can inhibit cancer cell migration or metastasis (Recently, observed by different researchers)

Not very biocompatible

- Chor Yong Tay *et al* used nano-ceramics, such as titania, silica, and hydroxyapatite
- Arvizo *et al.* used non-specific targeted gold nanospheres (AuNSs)
- Murphy *et al* used gold nanoparticles (AuNPs)
- Zhou *et al* used gold nanorods (AuNRs) coated with bovine serum albumin (BSA)



Yang, J. A.; Phan, H. T.; Vaidya, S.; Murphy, C. J. Nanovacuums: Nanoparticle Uptake and Differential Cellular Migration on A Carpet of Nanoparticles. *Nano Lett.* **2013**, *13*, 2295-2302.

Arvizo, R. R.; Saha, S.; Wang, E.; Robertson, J. D.; Bhattacharya, R.; Mukherjee, P. Inhibition of Tumor Growth and Metastasis by a Self-Therapeutic Nanoparticle. *Proc. Natl. Acad. Sci. U.S.A.* **2013**, *110*, 6700-6705.

Tay, C. Y.; Cai, P.; Setyawati, M. I.; Fang, W.; Tan, L. P.; Hong, C. H.; Chen, X.; Leong, D. T. Nanoparticles Strengthen Intracellular Tension and Retard Cellular Migration. *Nano Lett.* **2014**, *14*, 83-8.

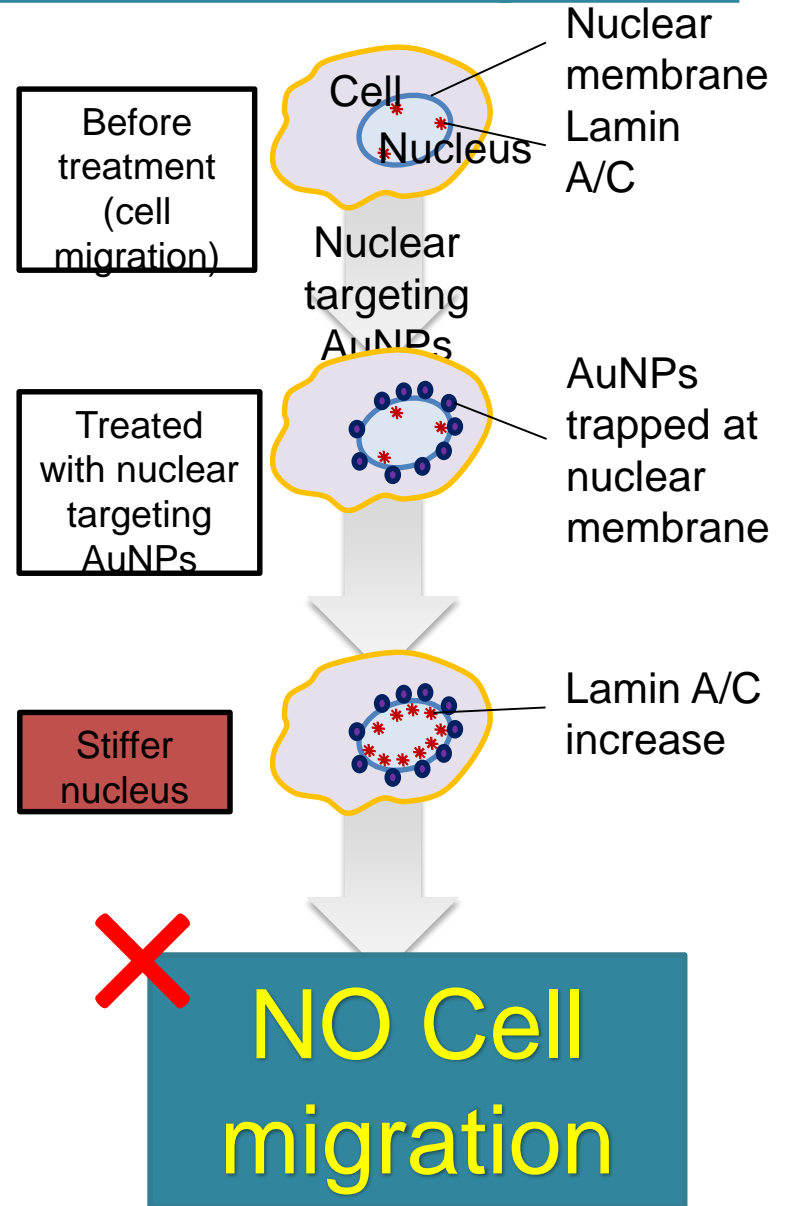


# Gold nanoparticles Inhibit Cancer Cell Migration

## Nuclear targeting AuNPs:

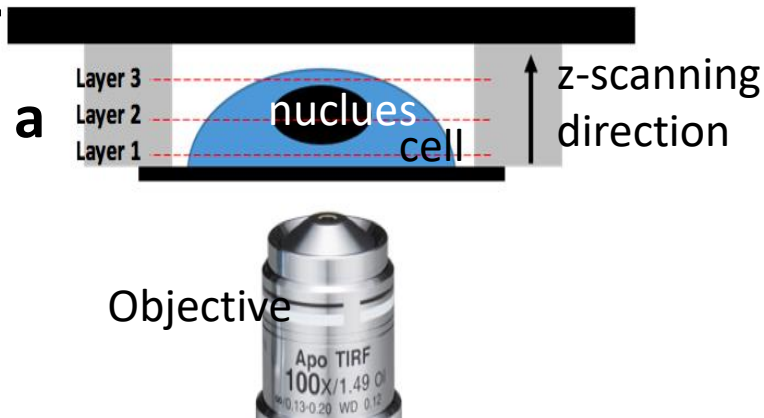
- increase nuclear stiffness
- Increase lamin A/C proteins

Thus inhibit migration

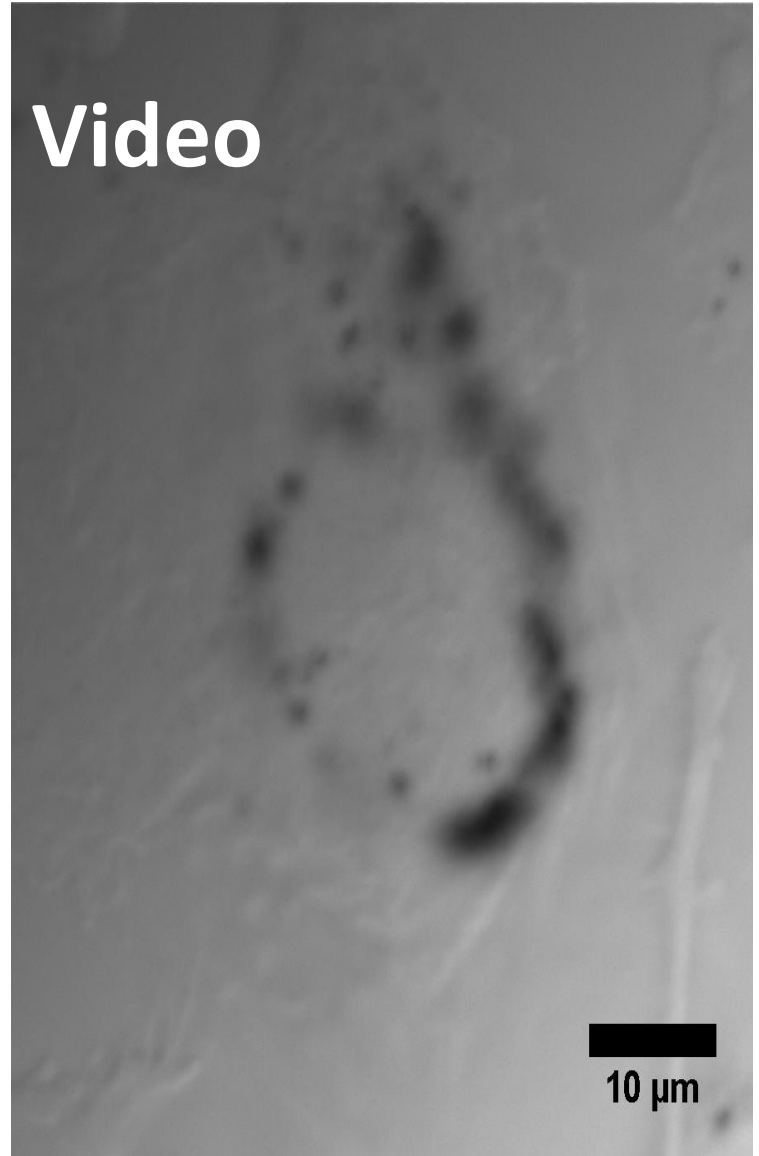


# Gold Nanoparticles Inhibit Cancer Cell Migration

3 dimensional microscope shows the AuNPs are concentrated at the nuclear membrane  
The video shows the z-stack scanning of



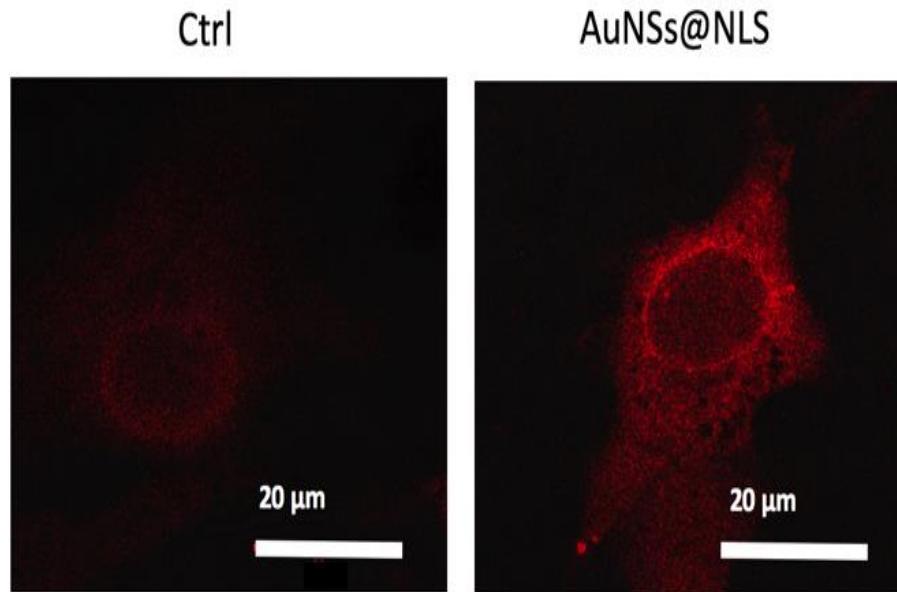
Video



# Gold Nanoparticles Inhibit Cancer Cell Migration

**AuNPs stuck at the nuclear membrane cause increase in lamin A/C protein expression**

**Red fluorescent signal represents  
Large amounts of lamin protein**

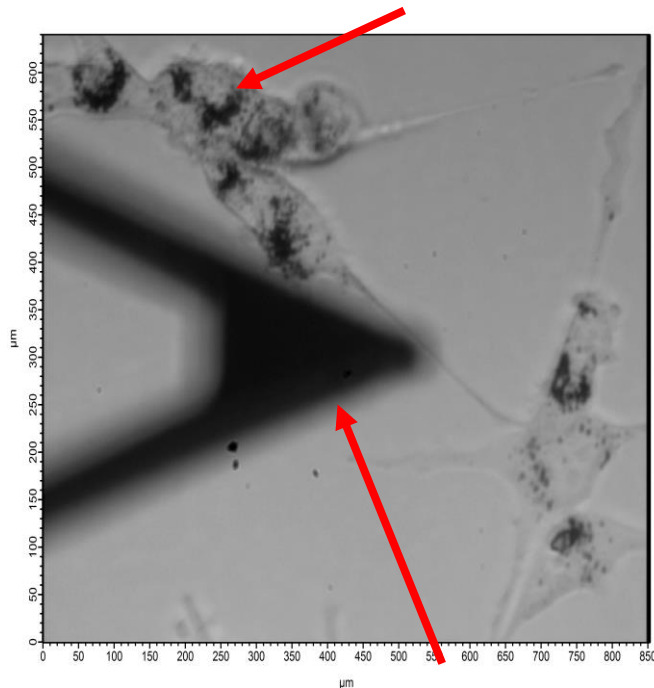


Moustafa R. K. Ali ‡; Yue Wu ‡; Deepraj Ghosh; Brian H. Do; Kuangcai Chen; Michelle R. Dawson; Ning Fang\*; Todd A. Sulchek\*; Mostafa A. El-Sayed\* 2017, **ACS Nano**, DOI: 10.1021/acsnano.6b08345

# Gold Nanoparticles Inhibit Cancer Cell Migration

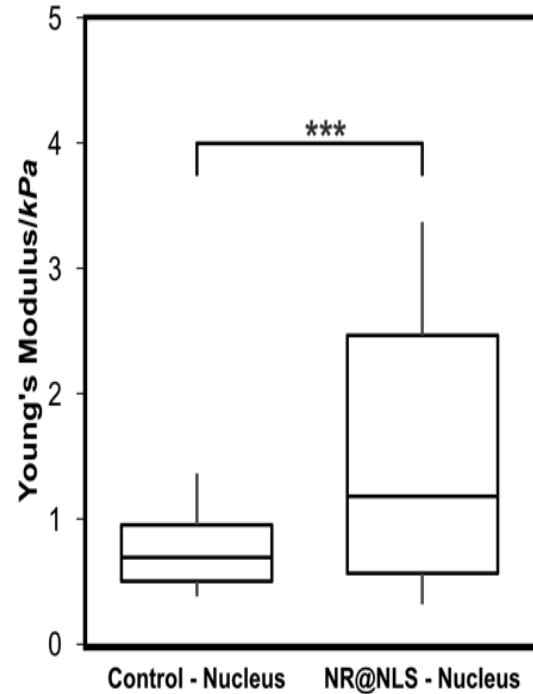
Nuclear stiffness increased by AuNPs detected by atomic force microscope (AFM)

Cells (with AuNPs)



AFM tip to apply force on cell

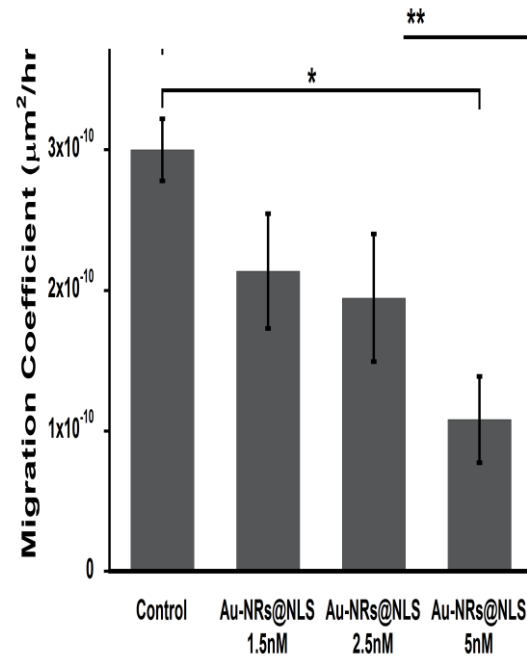
Cell nuclear stiffness increase with AuNPs



Moustafa R. K. Ali ‡; Yue Wu ‡; Deepraj Ghosh; Brian H. Do; Kuangcai Che  
Michelle R. Dawson; Ning Fang\*; Todd A. Sulchek\*; Mostafa A. El-Sayed\*  
2017, ACS Nano, DOI: 10.1021/ACSnano.6b08345

# Gold Nanoparticles Inhibit Cancer Cell Migration

## Migration speed as a function of AuNPs concentration

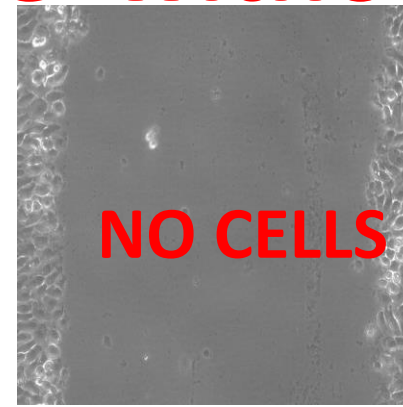
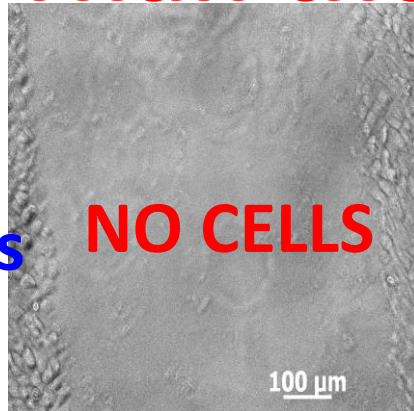


Moustafa R. K. Ali ‡; Yue Wu ‡; Deepraj Ghosh; Brian H. Do; Kuangcai Chen; Michelle R. Dawson; Ning Fang\*; Todd A. Sulchek\*; Mostafa A. El-Sayed\*  
2017, ACS Nano, DOI: 10.1021/acsnano.6b08345

# Cells with GOLD NANORODS move Slower Than those without them

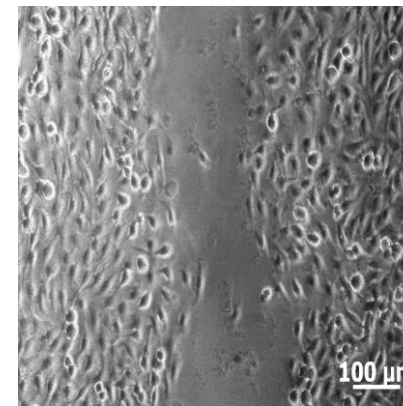
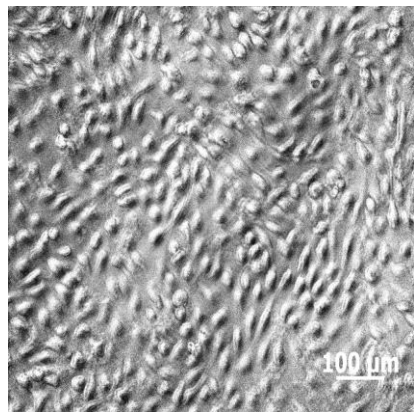
Normal  
Cells on  
The Sides

0 h



Cells with  
AuNRs on  
the sides

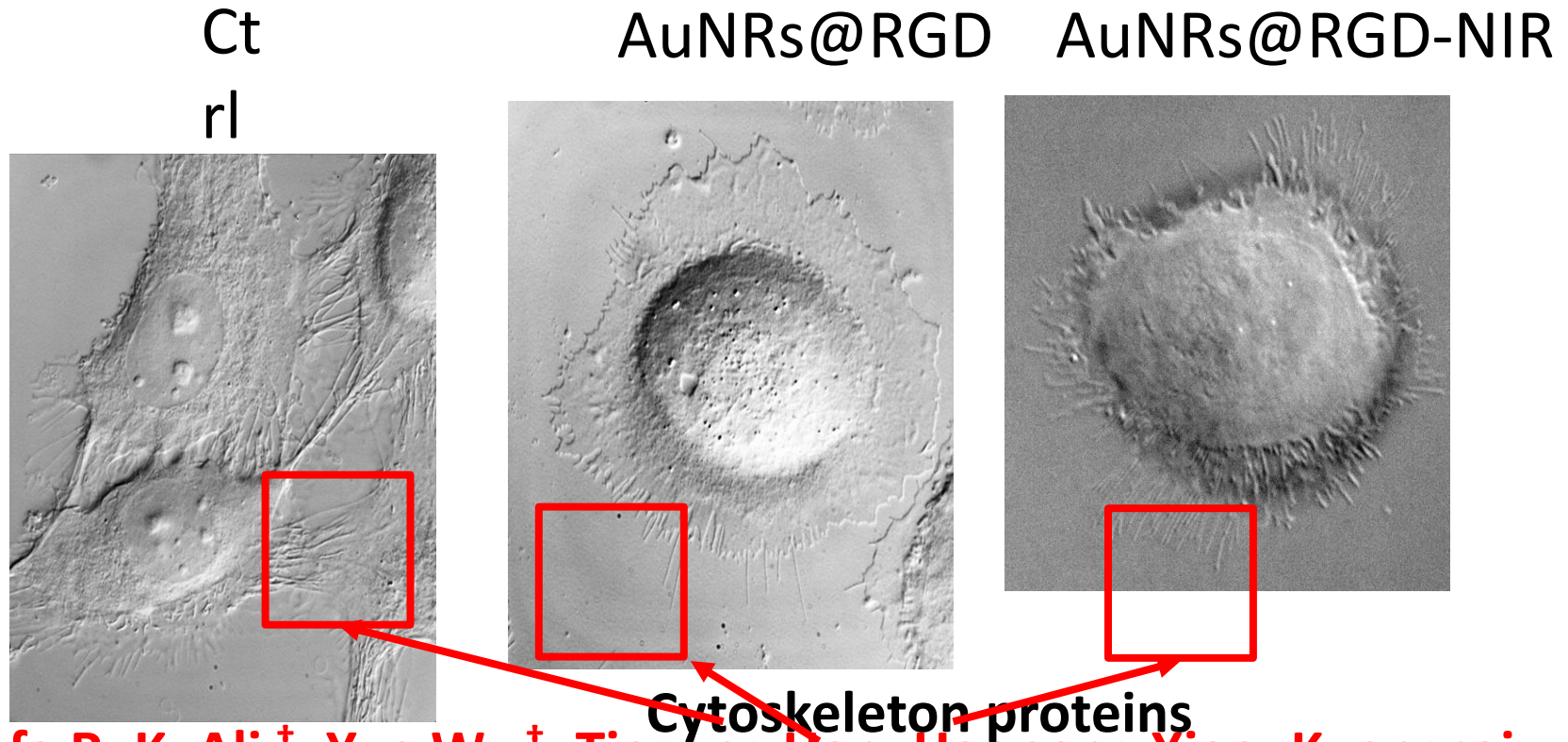
12 h



The cells without Gold Nanoparticles moved faster and filled the empty space in 12 hours. The gold Nanoparticles Slowed Down the cells So they can only fill out part of the empty space.

# Gold Nanoparticles Inhibit Cancer Cell Migration

Gold nanoparticles affect cytoskeleton protein formation  
Cytoskeleton proteins are responsible for cell movement



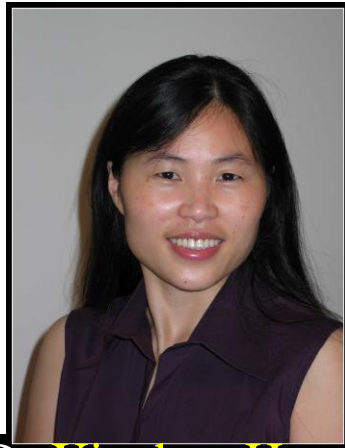
Moustafa R. K. Ali ‡; Yue Wu ‡; Tiegang Han; Haopeng Xiao; Kuangcai;

Ning Fang \*; Ronghu Wu \*; Mostafa A. El-Sayed \*, 2017, PNAS accepted

# CELLS and STUDIES ON DEVELOPPING DETECTION AND TREATMENT METHODS OF CANCER USING GOLD NANOPARTICLES (Georgia Tech)



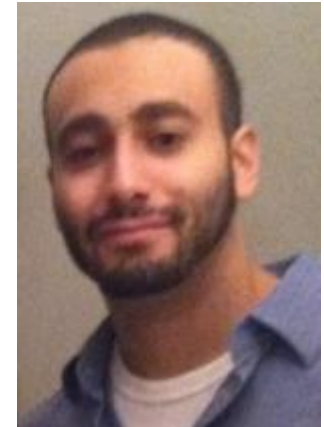
**Dr Ivan El-Sayed.**  
**M.D , UCSF**



**Dr Xiaohua Huang**



**MAGAN  
MAC KEY**



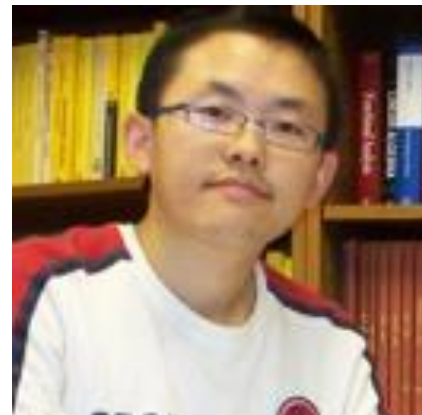
**Mena Aioub**



**Dr Erik C.  
Dreaden**



**Lauren A. Austin**



**BIN KANG**



**MOUSTAFA ALI**



# ANIMAL AND LONG TIME TOXICITY STUDIES

**Moustafa Ali**  
Georgia Tech



**JANE, GT**  
Georgia Tech



**DR Dong Shin**  
EMORY EU. MORY



**Rahman Aminur**  
EMORY



**Dr Abdoon**  
NRC, group  
Cairo MORY



**NRC,**  
group  
NRC



**DR Salah Selim**  
Head of CAIRO U  
group Cairo u



**Haithem Farghaly**  
Emory  
Cairo u



NRC



Thank  
You



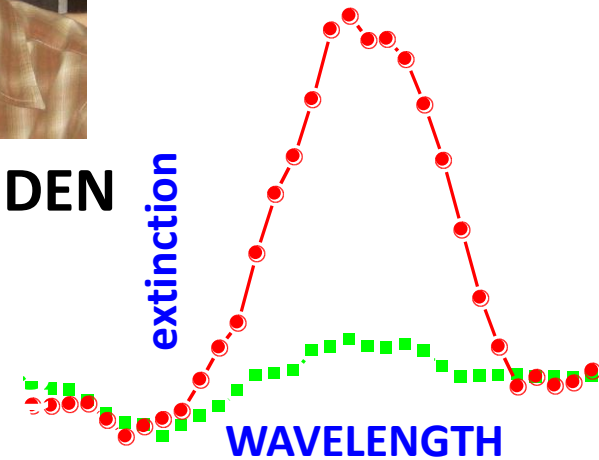
CLOSE



# IN VIVO DETECTION OF CANCER IN ANIMALS USING THE GOLD NANOPARTICLES ENHANCED EXTINCTION PROPERTIES



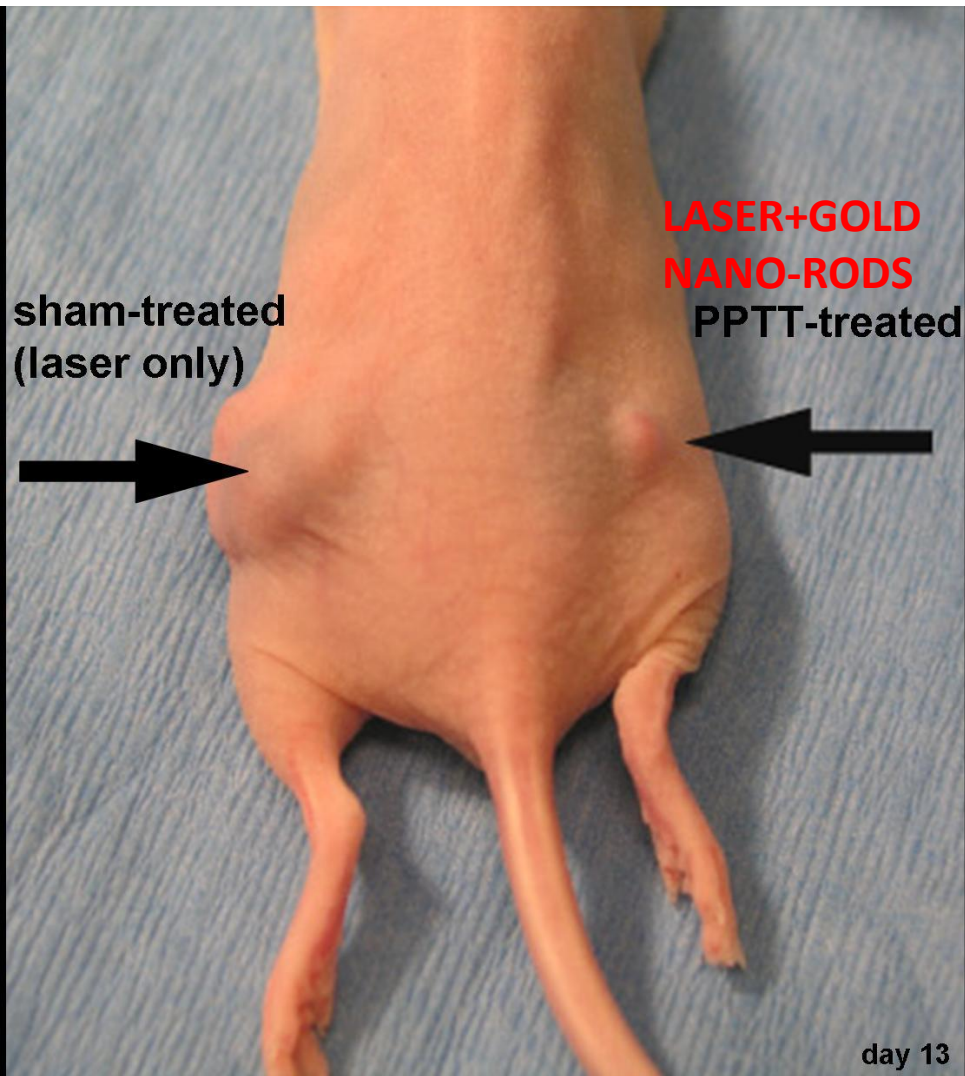
ERIK DREDEN



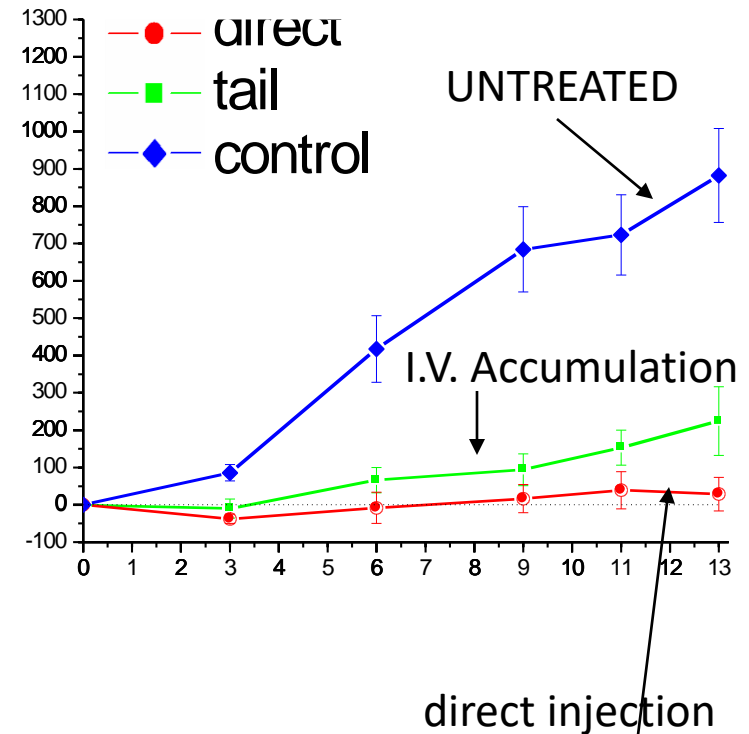
**PICTURES TAKEN WITH A CELL PHONE CAMERA !!!**

Dickerson, E. B.; Dreden, E. C.; Huang, X.; El-Sayed, I. H.; Chu, H.; Pushpanketh, S.; McDonald, J. F.; El-Sayed, M. A. *Cancer Letters* 2008, 269, 57.

# PHOTO-THERMAL TREATMENT OF MOUSE BODY CANCER

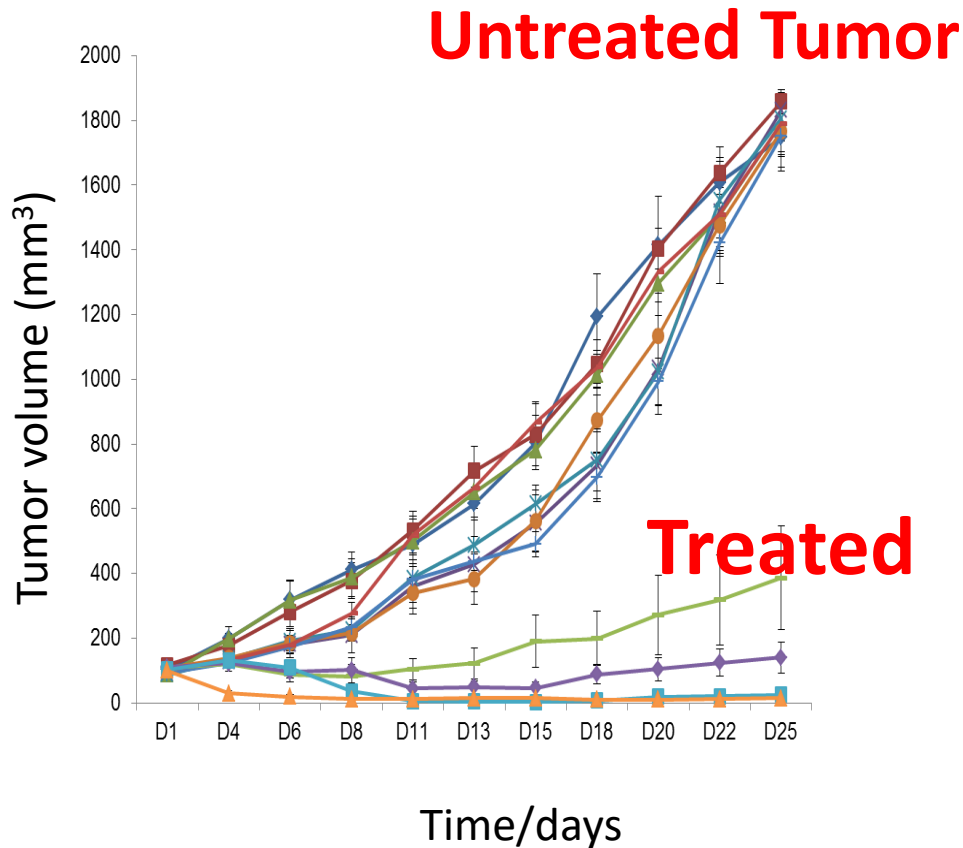


## COMPARISON OF THE GROWTH OF THE TREATED & THE UNTREATED TUMOR



Dickerson, E. B.; Dreaden, E. C.; Huang, X.; El-Sayed, I. H.; Chu, H.; Pushpanketh, S.; McDonald, J. F.; El-Sayed, M. A. *Cancer Letters* 2007, 269, 57.

# Photothermal Efficacy in Treating Head and Neck Cancer in MICE



PPTT not enough exposure (**Continue growing**)



PPTT harsh exposure (**Burning**)



PPTT Gentle exposure (**No burning**)

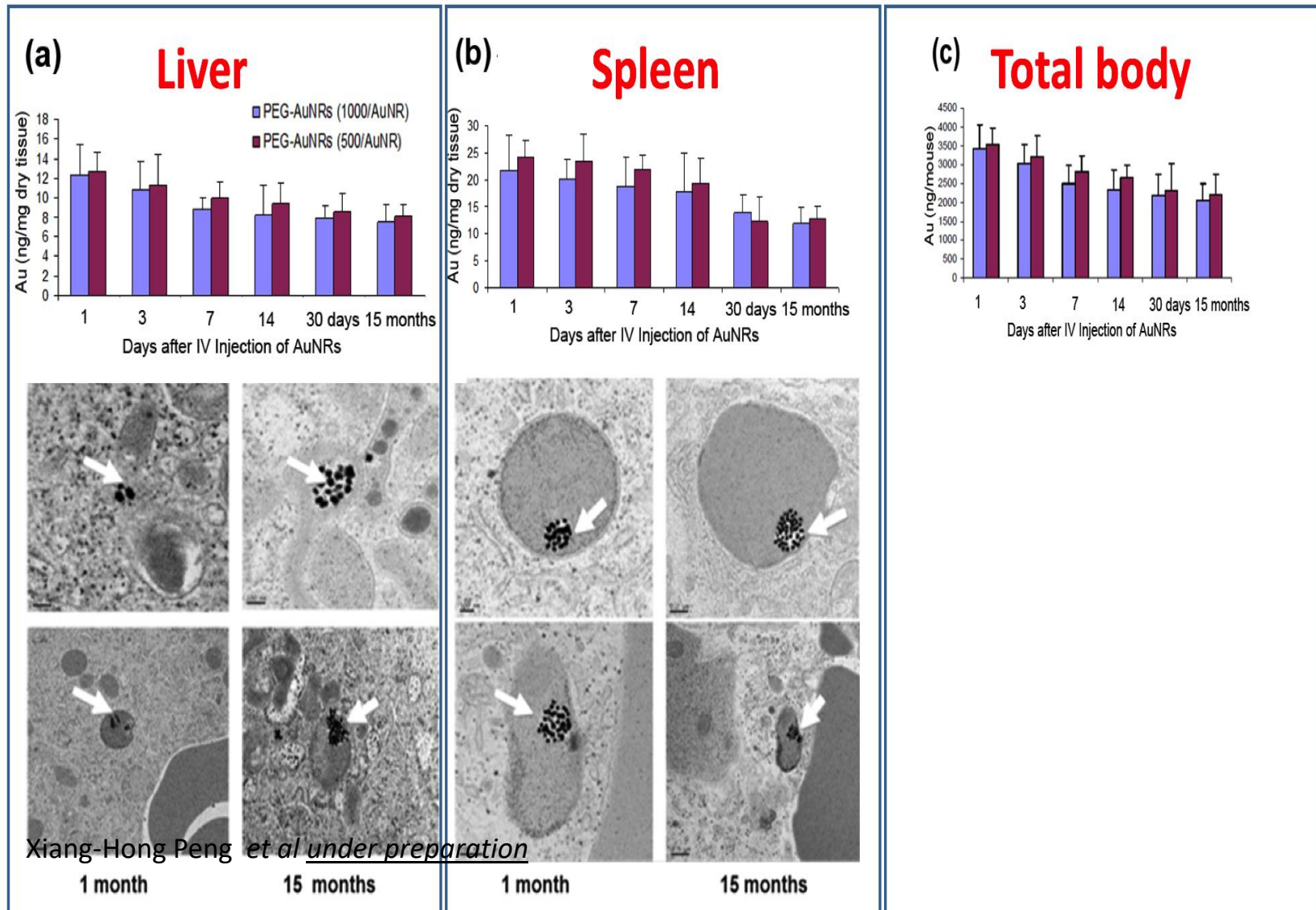


Moustafa R.K.Ali, Rahman Aminur, Dong. Shin , Mostafa El-Sayed,  
THE PROCEEDING OF THE USA NATIONAL ACADEMY OF SCIENCES,  
March 2017.

# II. LONG TERM TOXICITY OF GOLD PHOTO-THERMAL THERAPY

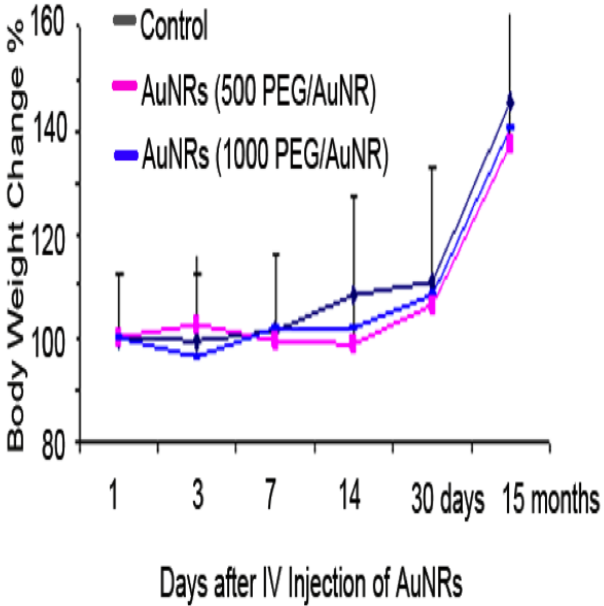
**Moustafa, R. Aminur, (and others) Dong. Shin , Mostafa El-Sayed,  
Proceeding of the USA National Academy of Sciences, Just Appeared.**

# The change IN the Concentration of Au-NANOPARTICLES in Liver, Spleen and The Full Body In 15 month Period in Mice.

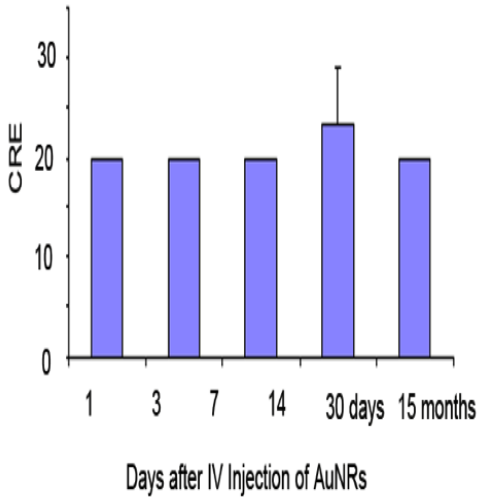


# Change of Body Weight, Kidney and Liver Functions During 15 months (MICE)

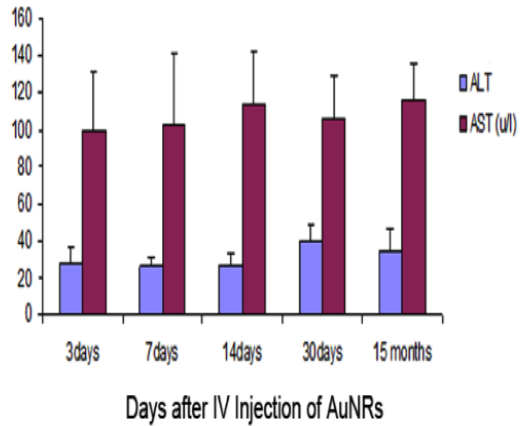
### Body Weight



### Kidney Function



### Liver function

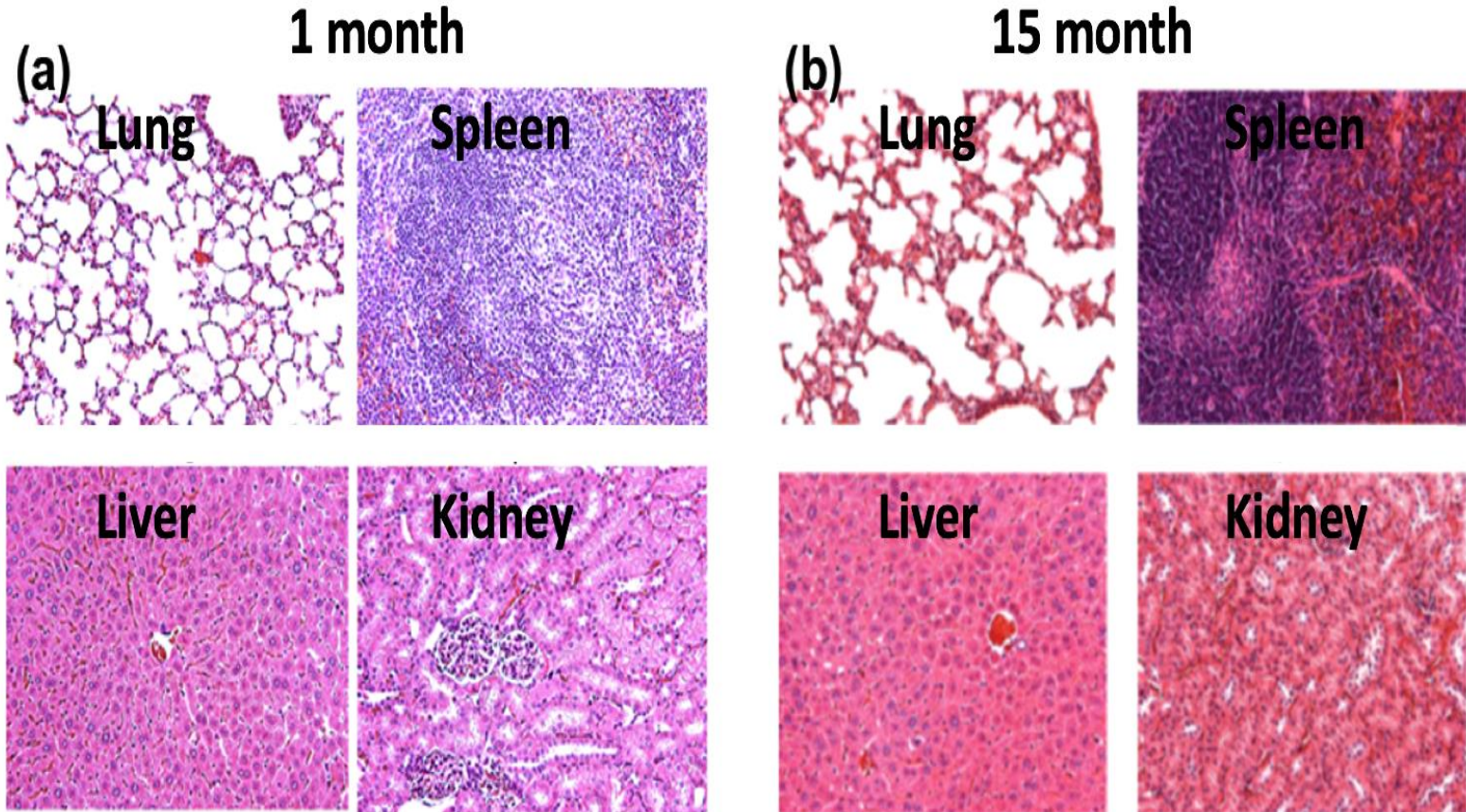


**No obvious long-term toxicity effect over 15 months**

**Moustafa R.K.Ali, Rahman Aminur, (and others) Dong. Shin , Mostafa El-Sayed, PNAS, Just Appeared.**



# Histopathology of Tissues of Different Organs of the Mice From 1 to 15 months.



**No obvious Change in the Tissues over 15 months Period**

Moustafa R.K.Ali, Rahman Aminur,..... Dong. Shin , Mostafa El-Sayed, [PNAS,Just Appeared]

# LARGER ANIMAL TREATMENT

# CAT WITH LARGE MAMMARY GLAND CANCER TUMOR COVERING THE WHOLE BREAST



The Egyptian National Research Center, Cairo; Egypt: LEADER IS DR  
ABDOON :*J. Nanomed. Nanotechnol.* 2015, 6, 324.

**THE CAT GOT PREGNANT TWO MONTHS AFTER THE OPERATION AND IS FEEDING HER KITTENS FROM the breast that had the surgery**



**THUS PHOTO-THERMAL THERAPY OF BREAST CANCER USING GOLD NANO-RODS DOES NOT STOP PREGNANCY NOR BREAST FEEDING**

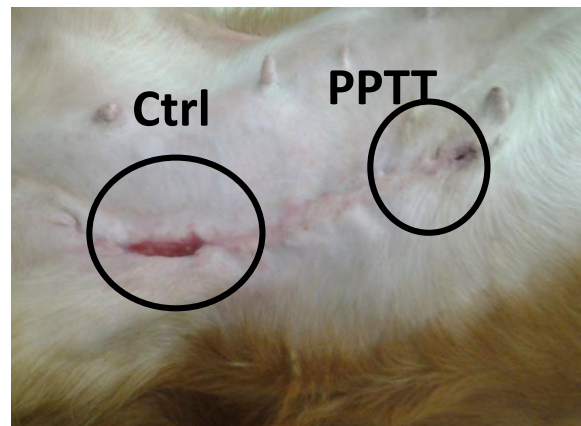
**Dr Abdoon et al, National Research Center, Cairo, Egypt :*J. Nanomed Nanotechnol.* 2015, 6, 324).**

# DIFFERENT TYPES OF CANCER TREATMENTS

**Before treatment**



One tumor has been treated by Surgery(Left). The other by Surgery followed by PPTT( Right)

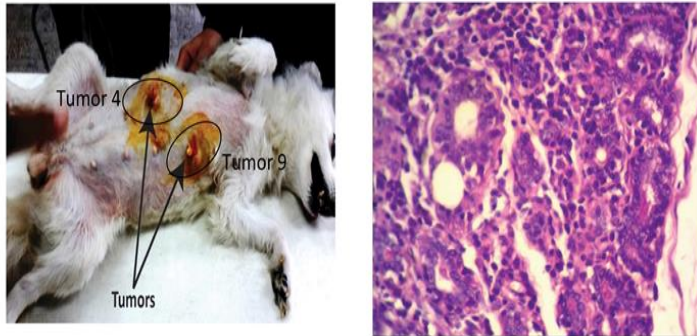


**1 month after, the left half treated by surgery only is ruptured Retreated Photothermally.**

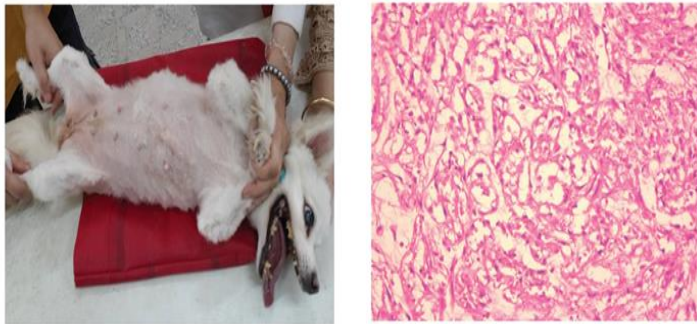
**(Cairo University Team:Dr Salah Selim and his team, Moustafa Ali, And M.A. El-Sayed from Georgia Tech travel to EGYPT or use SKYPE**

# AuNRs Treating Spontaneous Mammary Gland Tumors in Feline and Canine

A) Before treatment



2 weeks after third treatment



1 year after animal treatment



A)

Before treatment



B)

2 weeks after the third treatment



C)

1 year after the third treatment



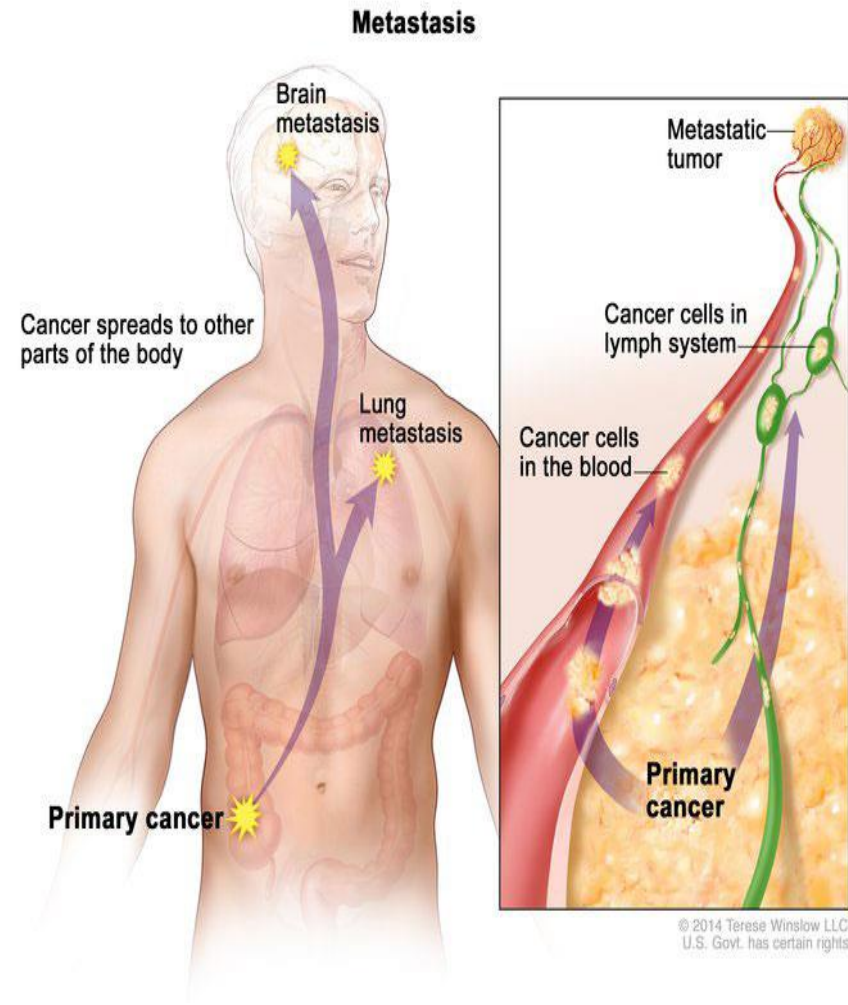
# No Change in Kidney and Liver Functions; before the treatment and 1 year LATER(now we have 3y)

Table 1 blood profile for each case before treatment and after 1 year from their curing  
(T1<3 cm, 3 cm<T2<5 cm, T3>5 cm)

Case No.	Animal Species	Age/year	Tumor Location	Tumor size	Kidney functions						Liver functions					
					Urea (mg/DL)			Creatinine (mg/DL)			GPT(U/L)			GOT(U/L)		
					Before	After 1 year	Normal range	Before	After 1 year	Normal range	Before	After 1 year	Normal range	Before	After 1 year	Normal range
1	Dog Griffon	10	12-left anterior thoracic	T3	15	14.9	5--25	0.82	0.71	0.5-1.6	84	88	5-107	156	135	5-55
2	Dog Griffon	11	9-Right abdominal 4-left caudo-thoracic	T3 T1	28	34	5--25	0.87	0.91	0.5-1.6	49	84.4	5-107	84	61	5-55
3	Dog griffon	7	13-Right abdominal 2-left caudo-thoracic	T3 T1	26	24.2	5--25	1.6	1.1	0.5-1.6	115	117	5-107	142	123	5-55
4	Dog Griffon,	5	8-right cranio-inguinal	T3	27	26.8	5--25	0.96	0.85	0.5-1.6	72	76	5-107	140	96	5-55
5	Dog Griffon,	13.5	7-left cranio-inguinal 5-left cranio-inguinal 3-left inguinal lymph node	T3 T2 T3	15	20	5--25	1.2	1.1	0.5-1.6	76	88	5-107	35	42	5-55
6	Cat shirazy,	11	11- right caudo-inguinal 1- left cranio-thoracic	T2 T1	38.7	35.6	14-36	1.6	1.4	0.6-2.4	56.2	58.4	10-100	34.5	36.2	10-100
7	Cat shirazy,	4	6-left anterior thoracic 10-right post caudo-inguinal	T2 T3	26.4	24.9	14-36	1.8	1.3	0.6-2.4	19	25	10-100	16	14	10-100

# 111. Metastasis (the migration of the cancer cells from its original location to more serious location) is the cause of 90% of Cancer Patient's Death.

**Weigelt, B., Peterse, J. L. & van 't Vee L. J. Breast cancer metastasis: markers and models. Nature Rev. Cancer 5, 591–602 (2005)**  
**<https://www.cancer.gov/types/metastatic-cancer>**





## Past attempts to develop anti-metastasis drugs have not been successful in clinical trials

- Resistance
- Side effects

Weber, G. F. Why Does Cancer Therapy Lack Effective Anti-Metastasis Drugs? *Cancer Lett.* **2013**, 328, 207-11.

Morgillo, F.; Lee, H. Y. Resistance to Epidermal Growth Factor Receptor-Targeted Therapy. *Drug Resist. Updat.* **2005**, 8, 298-310.

Effects of Chemotherapy and Hormonal Therapy for Early Breast Cancer on Recurrence and 15-Year Survival: an Overview of the Randomised Trials. *Lancet (London, England)* **2005**, 365, 1687-717.

# Nanoparticles can inhibit cancer cell migration or metastasis (Recently, observed by different researchers)

Not very biocompatible

- Chor Yong Tay *et al* used nano-ceramics, such as titania, silica, and hydroxyapatite
- Arvizo *et al.* used non-specific targeted gold nanospheres (AuNSs)
- Murphy *et al* used gold nanoparticles (AuNPs)
- Zhou *et al* used gold nanorods (AuNRs) coated with bovine serum albumin (BSA)



Yang, J. A.; Phan, H. T.; Vaidya, S.; Murphy, C. J. Nanovacuums: Nanoparticle Uptake and Differential Cellular Migration on A Carpet of Nanoparticles. *Nano Lett.* **2013**, *13*, 2295-2302.

Arvizo, R. R.; Saha, S.; Wang, E.; Robertson, J. D.; Bhattacharya, R.; Mukherjee, P. Inhibition of Tumor Growth and Metastasis by a Self-Therapeutic Nanoparticle. *Proc. Natl. Acad. Sci. U.S.A.* **2013**, *110*, 6700-6705.

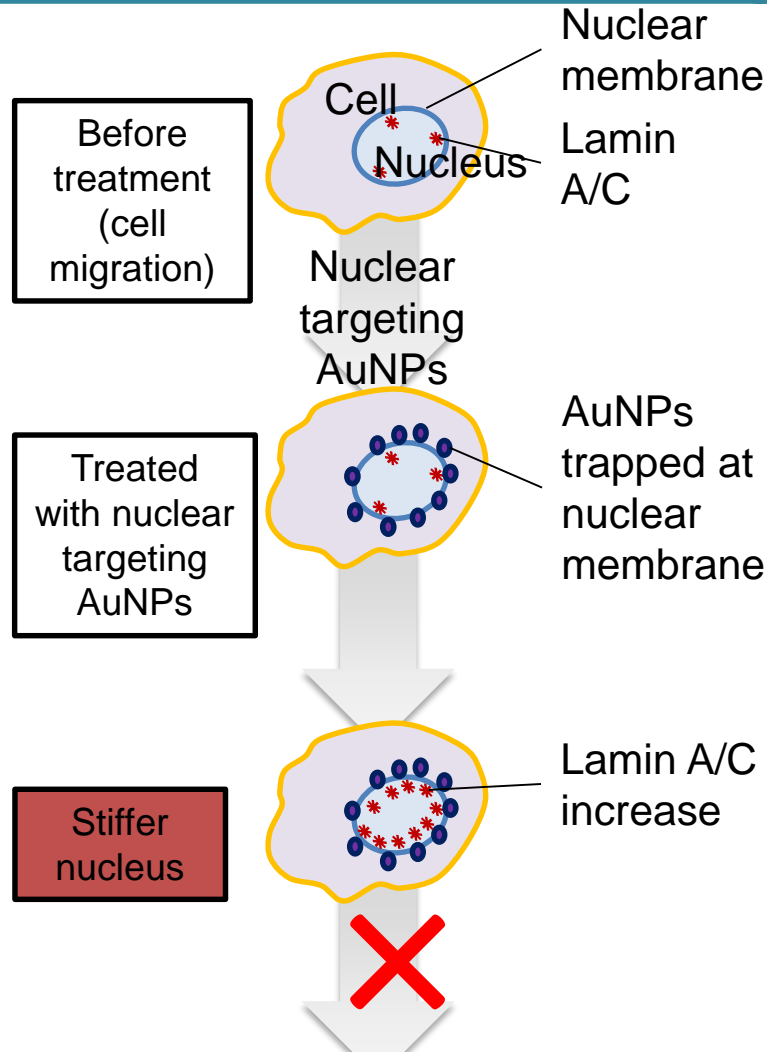
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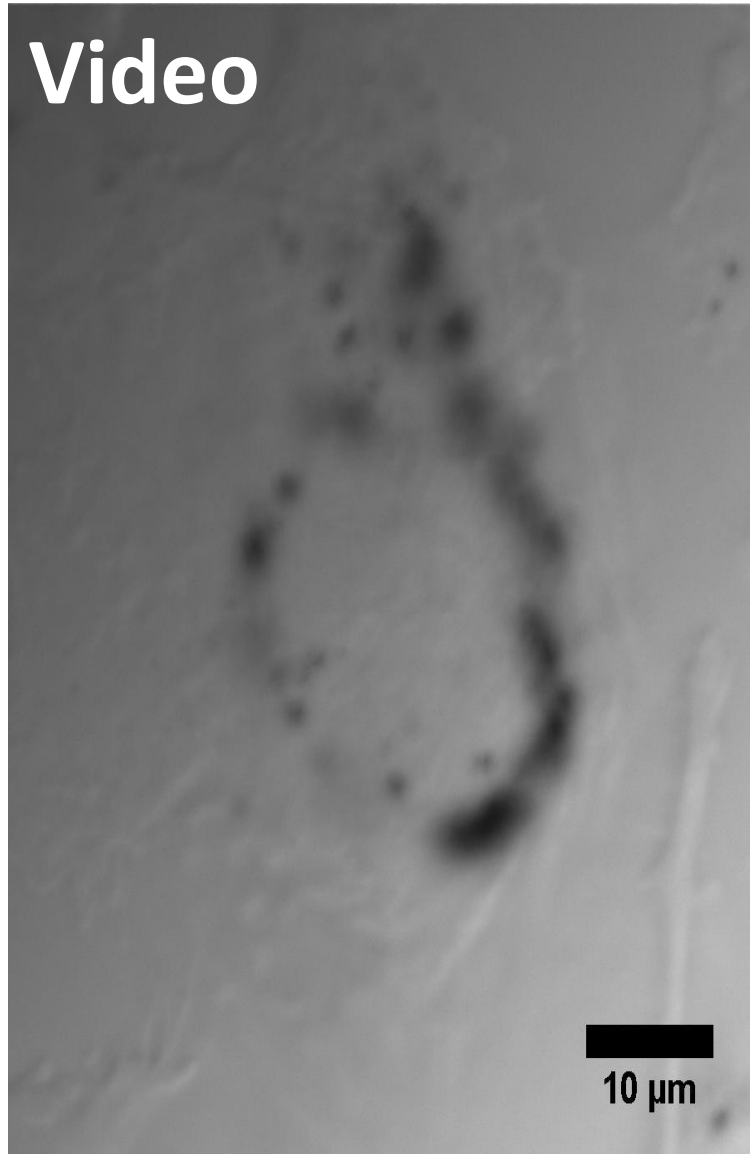
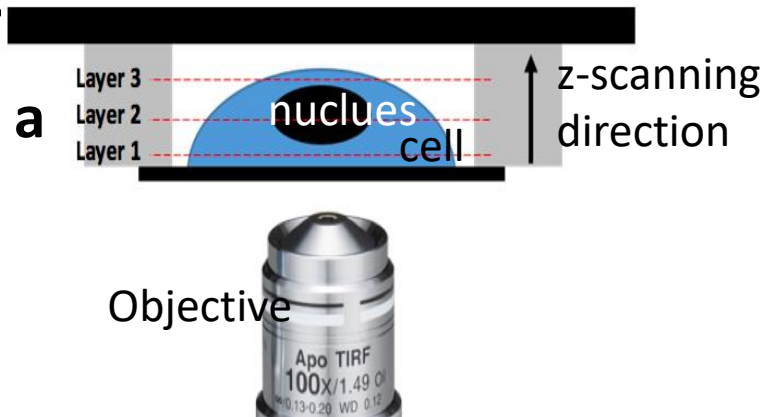
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- Increase lamin A/C proteins

Thus inhibit migration



# Gold Nanoparticles Inhibit Cancer Cell Migration

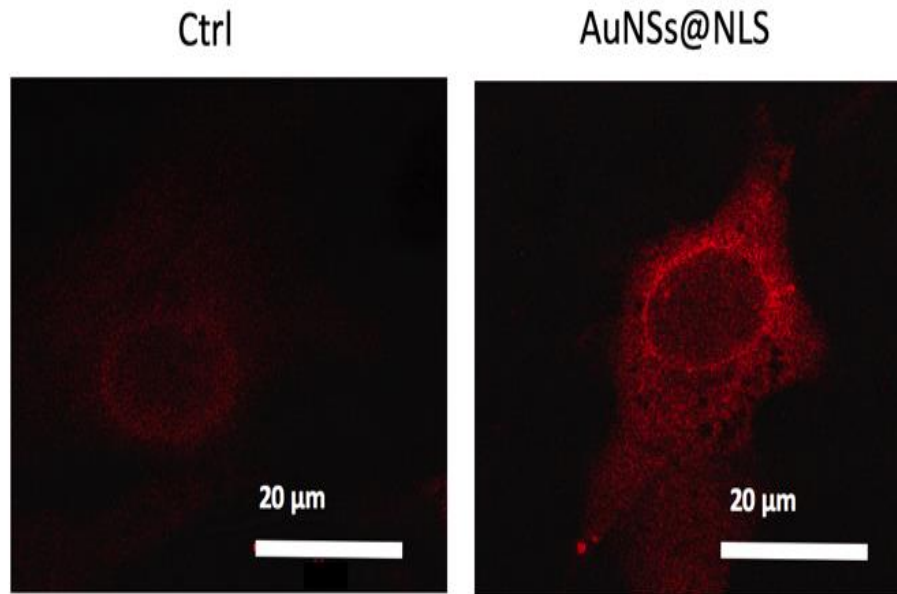
**3 dimensional  
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**AuNPs stuck at nuclear membrane cause increase in lamin A/C protein expression**

**Red fluorescent signal represents lamin protein**

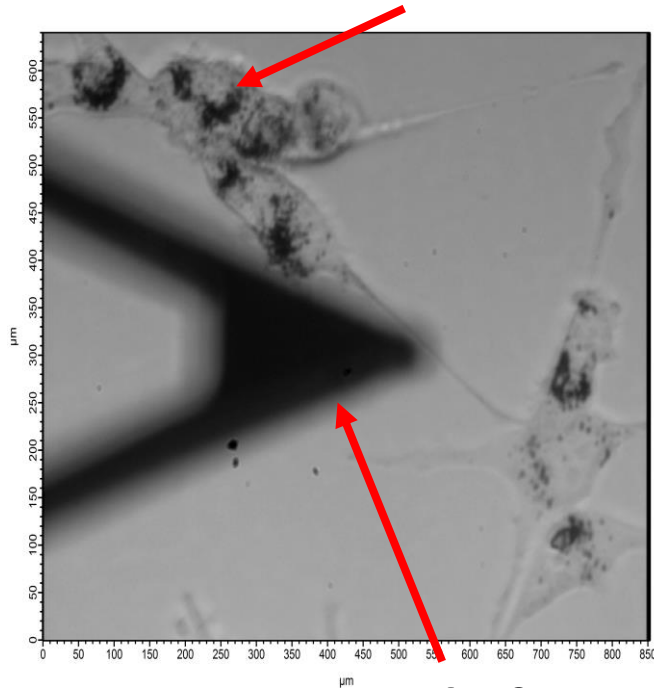


Moustafa R. K. Ali ‡; Yue Wu ‡; Deepraj Ghosh; Brian H. Do; Kuangcai Chen; Michelle R. Dawson; Ning Fang\*; Todd A. Sulchek\*; Mostafa A. El-Sayed\* 2017, **ACS Nano**, DOI: 10.1021/acsnano.6b08345

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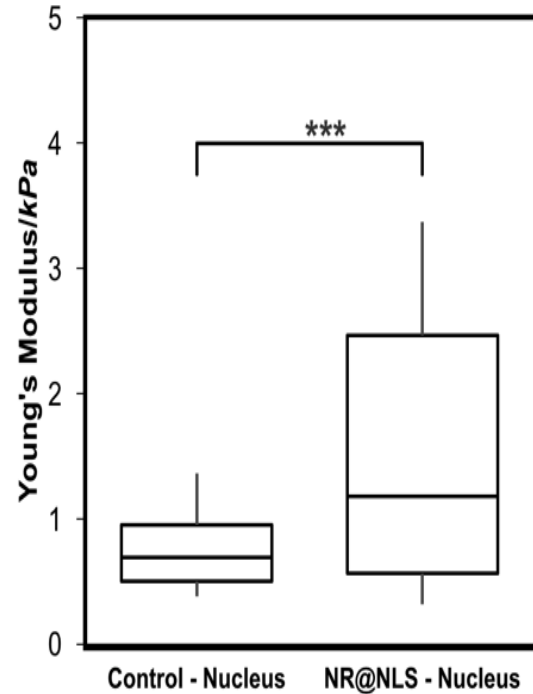
Nuclear stiffness increased by AuNPs detected by atomic force microscope (AFM)

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AFM tip to apply force on cell

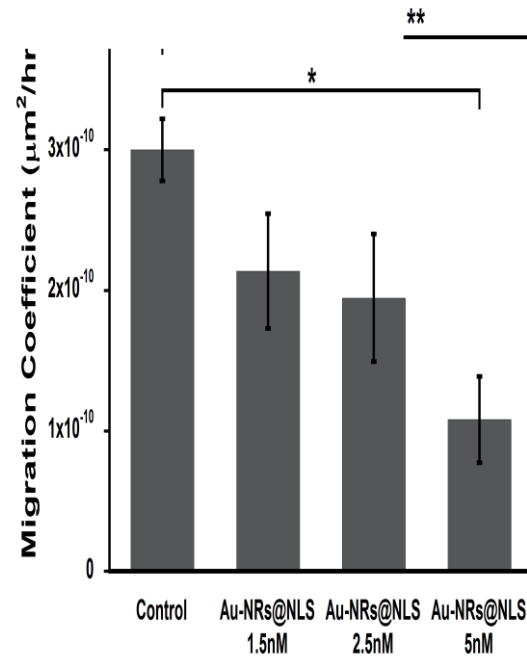
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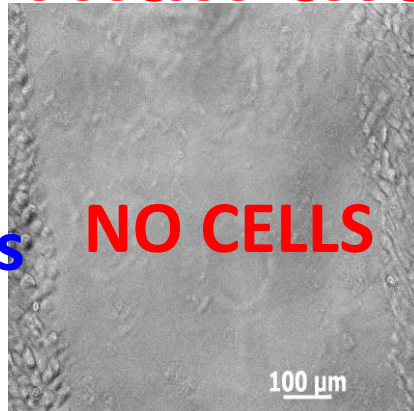


Moustafa R. K. Ali <sup>‡</sup>; Yue Wu <sup>‡</sup>; Deepraj Ghosh; Brian H. Do; Kuangcai Chen; Michelle R. Dawson; Ning Fang<sup>\*</sup>; Todd A. Sulchek<sup>\*</sup>; Mostafa A. El-Sayed<sup>\*</sup>  
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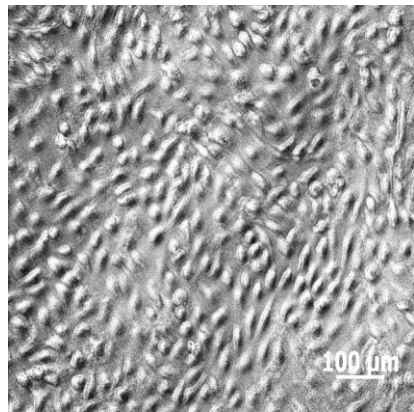
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Normal  
Cells on  
The Sides

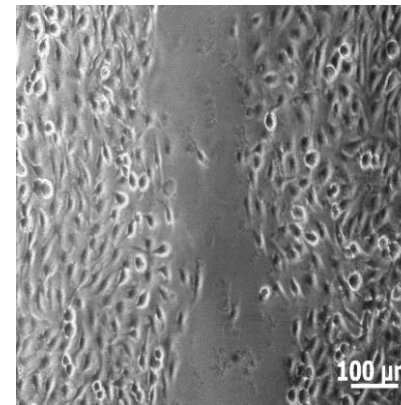
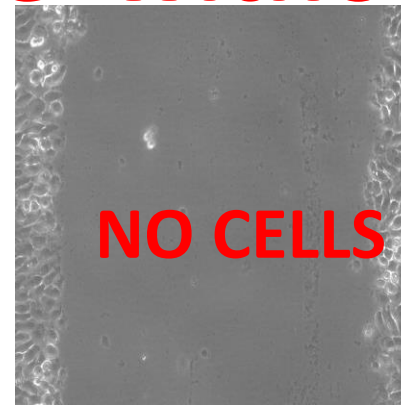
0 h



12 h



Cells with  
AuNRs on  
the sides

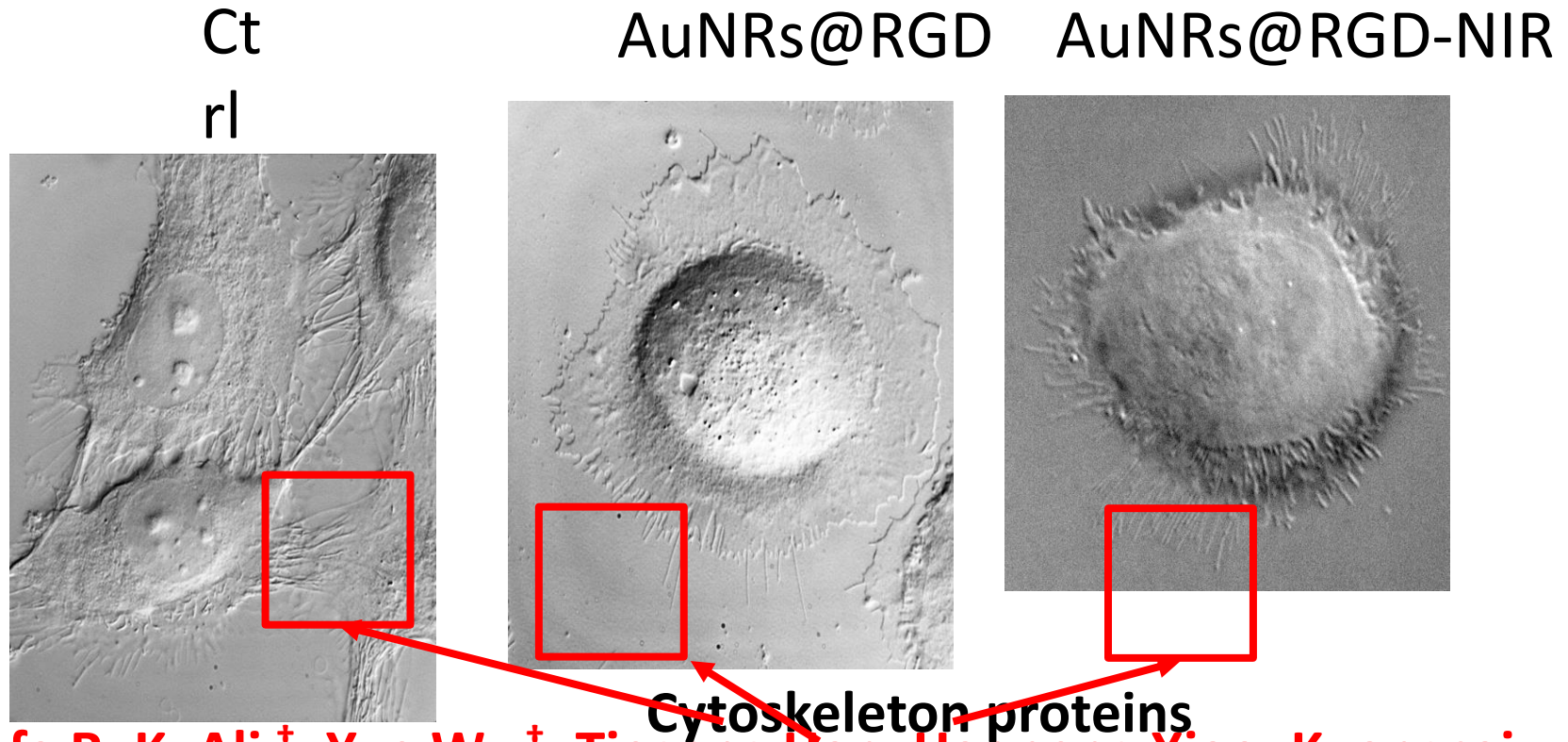


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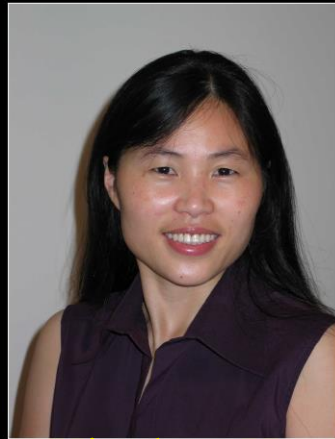
Moustafa R. K. Ali ‡; Yue Wu ‡; Tiegang Han; Haopeng Xiao; Kuangcai;

Ning Fang \*; Ronghu Wu \*; Mostafa A. El-Sayed \*, *PNAS, accepted*

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**Dr Ivan El-Sayed.  
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MAC KEY**



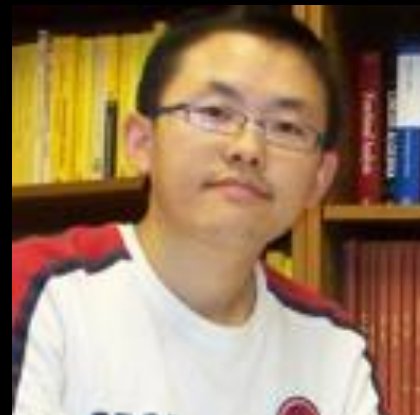
**Mena Aioub**



**Dr Erik C.  
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**Dr Lauren A. Austin**



**Dr BIN KANG**



**MOUSTAFA ALI**

**Moustafa Ali**  
Georgia Tech



**JANE, GT**  
Georgia Tech



**DR Dong Shin**  
EMORY



**Rahman Aminur**  
EMORY



**Dr Abdoon NRC, group Cairo**



**NRC, group**



**DR Salah Selim**  
Head of CAIRO U group Cairo u



**Haithem Farghaliy**  
Emor Cairo u





Thank  
You



CLOSE



AFTER HIS PhD

# **MORE THAN ONE WAY TO BEAT CANCER (or any sick) CELL TO DEATH WITH GOLD NANOPARTICLES**

***All based on the Size and Shape Dependent Properties of Gold Nano-particle:***

- 1. Too Small compared to the size of the photon it captures giving rise to focusing electro-magnetic fields thus having strong scattering (USED IN CELL DETECTION) or absorption followed by heating: used in photo-thermal therapy.***
- 2. Too large compared to molecular size thus it can deliver Thousands of drug molecules to sick cells Rapidly and Simultaneously: USED IN DRUG DELIVERY***
- 3. Comparable to the size of the cell components that can bind to them and change cell functions, like cell division thus causing cells to kill themselves USED IN***