

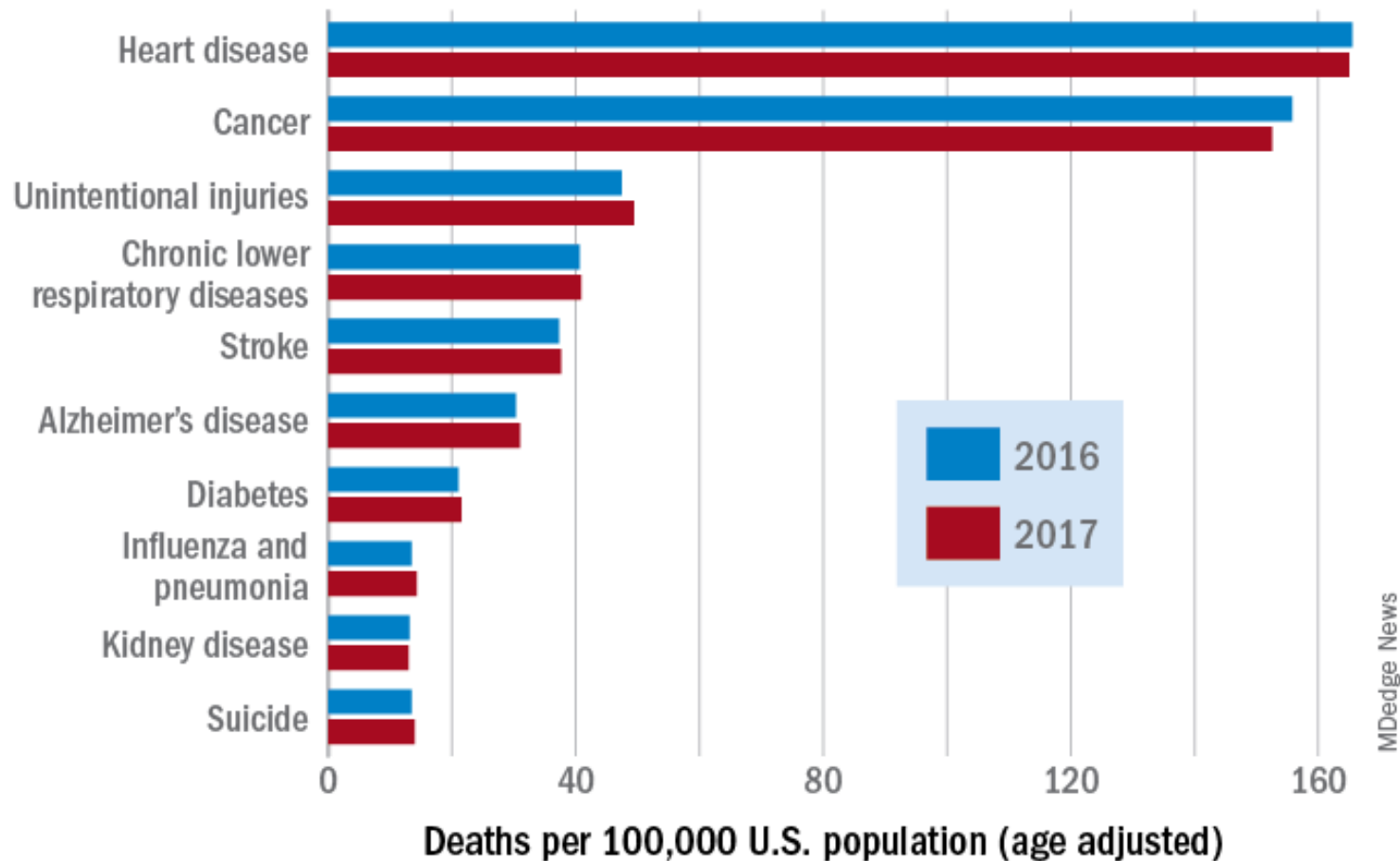
Перспективы использования магнитных наночастиц в медицине

Абакумов Максим

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- НИТУ МИСиС

Россия, Москва, 01.11.2019

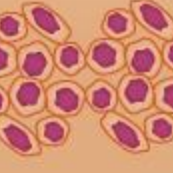
Ten leading causes of death, 2016 and 2017



Note: Based on data from the National Vital Statistics System.

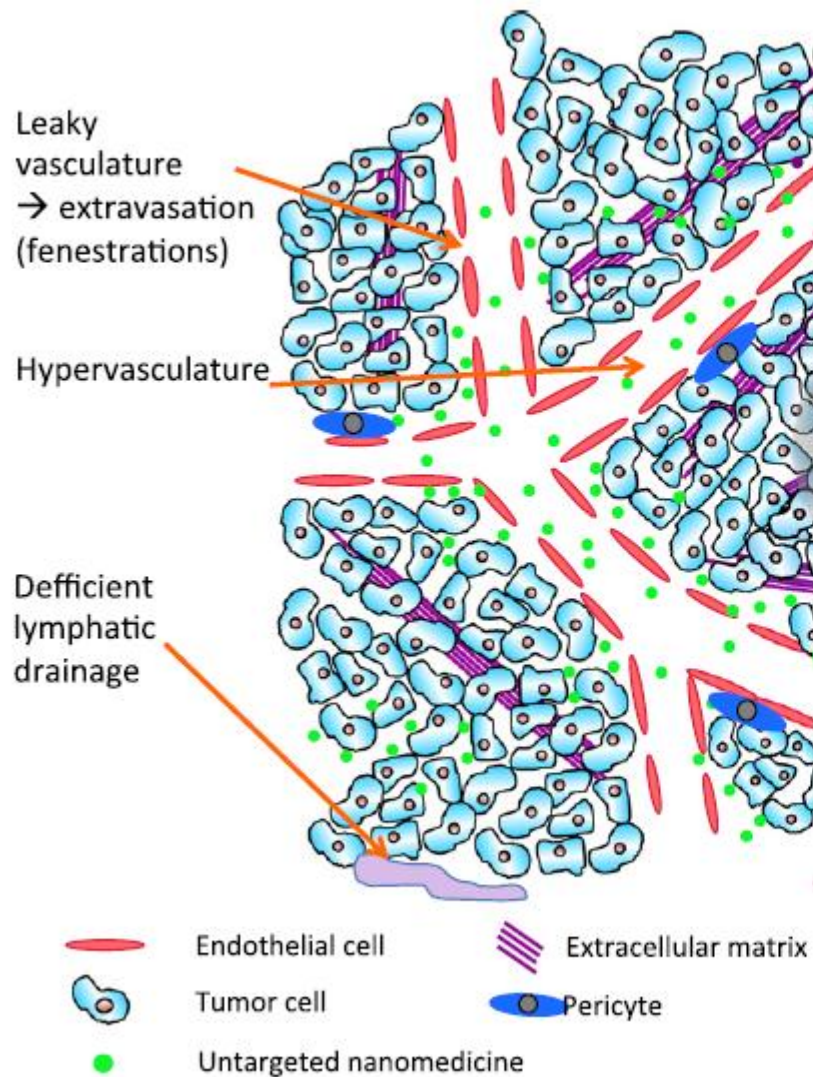
Source: National Center for Health Statistics

Уникальные свойства раковых клеток

Normal Cells			Cancer Cells
Small, uniformly shaped nuclei Relatively large cytoplasmic volume			Large, variable shaped nuclei Relatively small cytoplasmic volume
Conformity in cell size and shape Cells arranged into discrete tissues			Variation in cell size and shape Disorganised arrangement of cells
May possess differentiated cell structures Normal presentation of cell surface markers			Loss of normal specialised features Elevated expression of certain cell markers
Lower levels of dividing cells Cell tissues clearly demarcated			Large number of dividing cells Poorly defined tumor boundaries

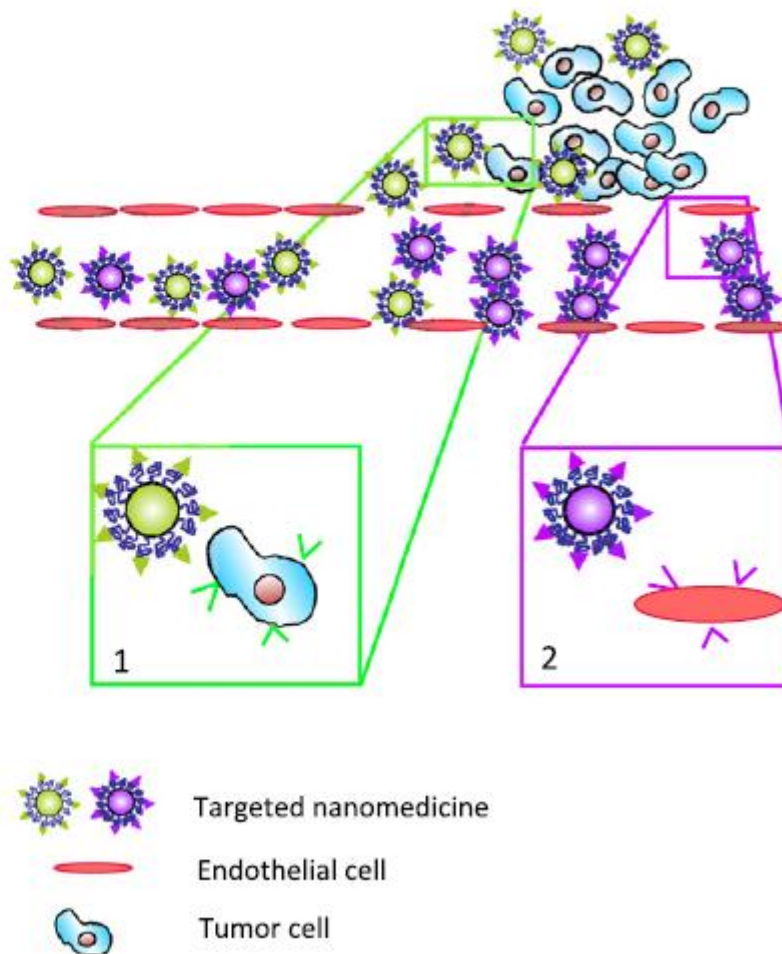
Активная и пассивная доставка

A

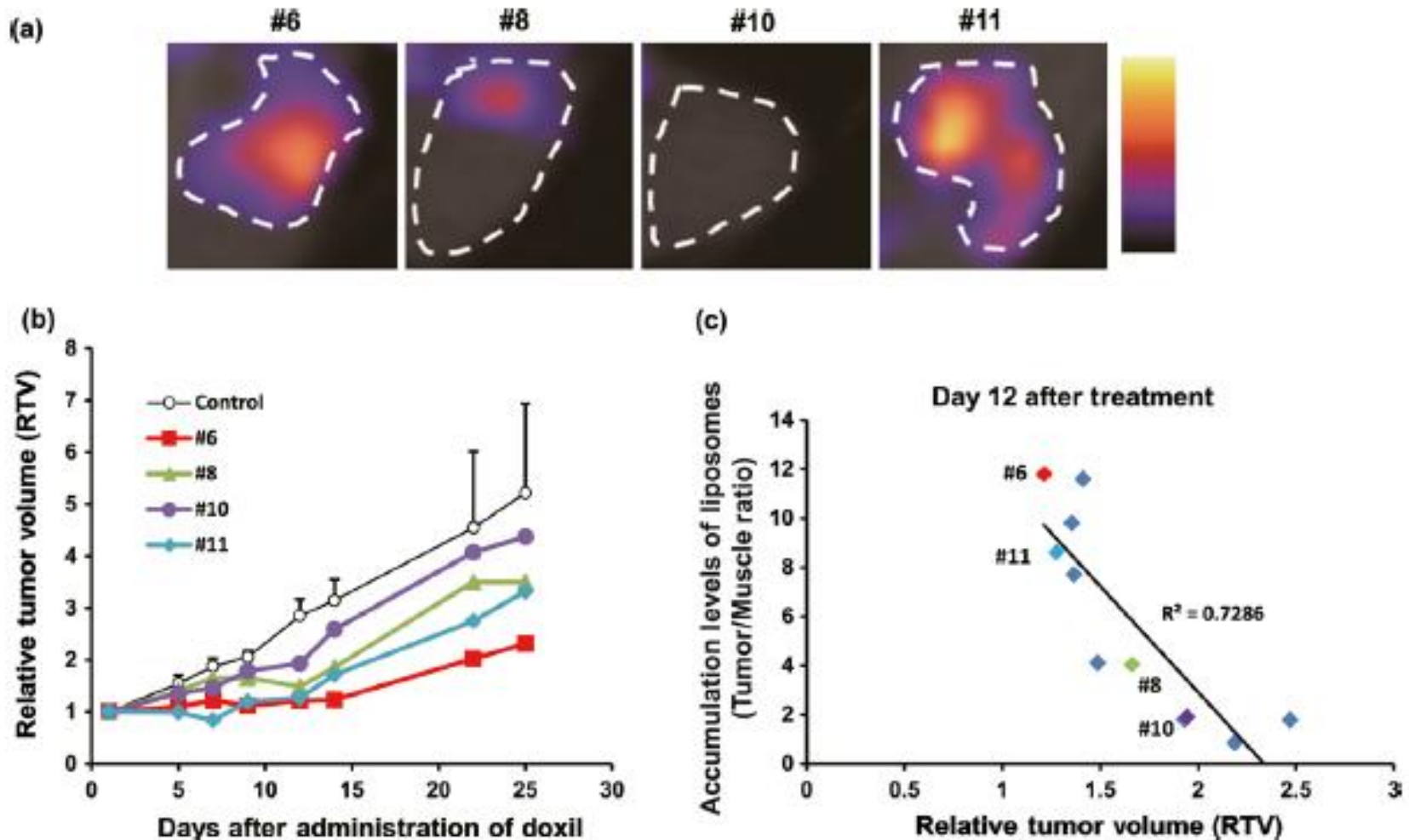


B

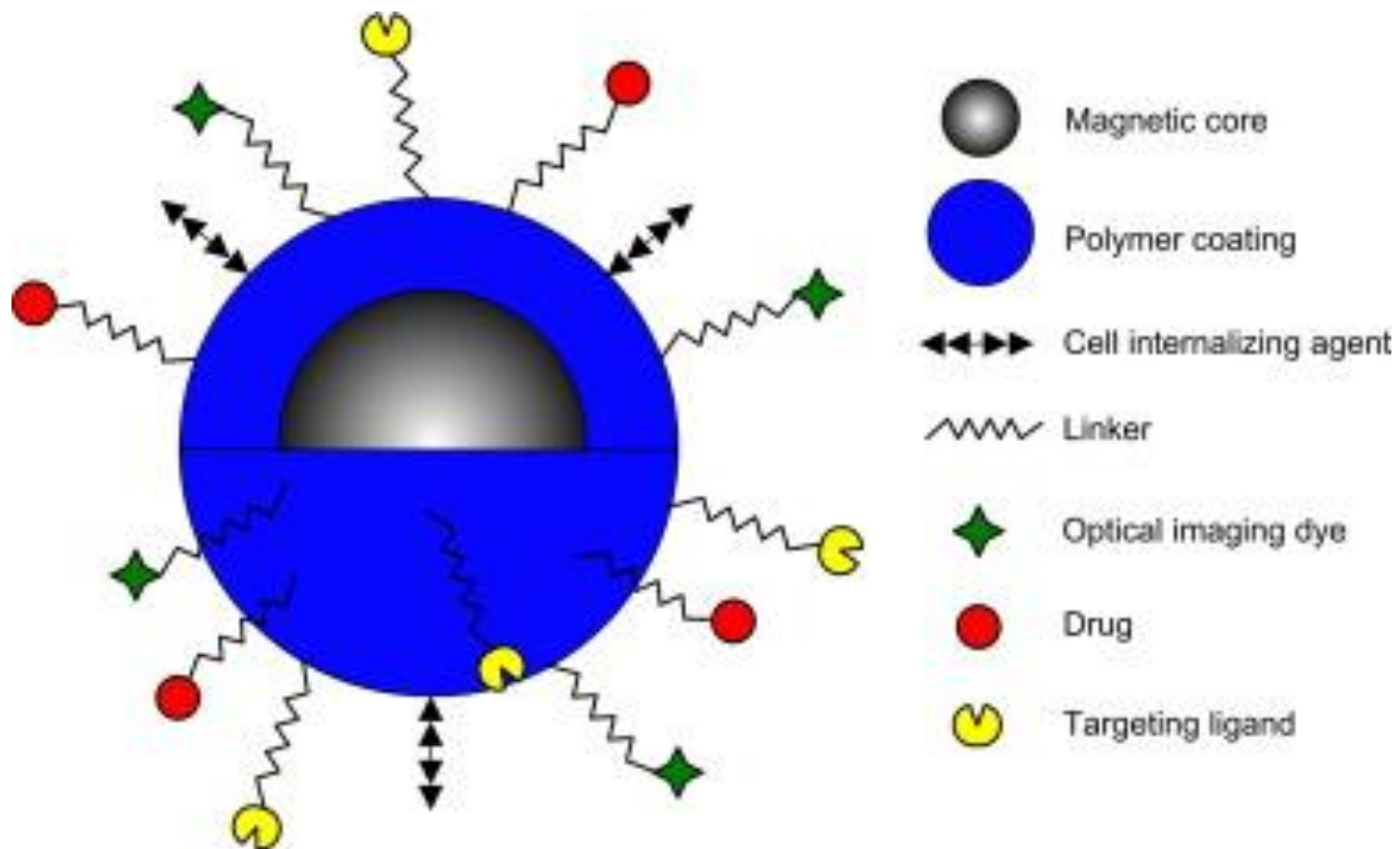
F. Danhier, Journal of Controlled Release
244 (2016) 108–121



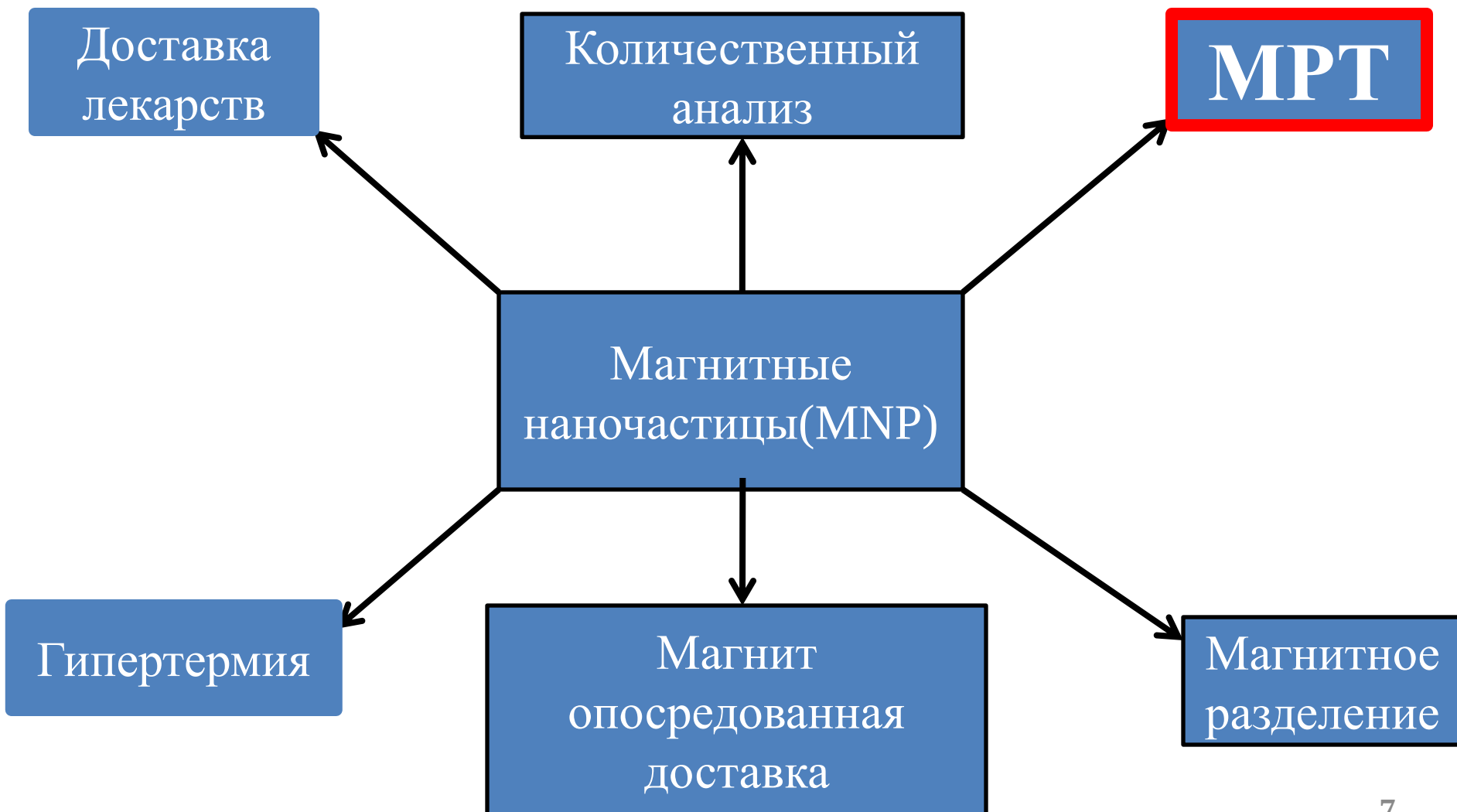
«Умные» подходы к увеличению эффективности доставки



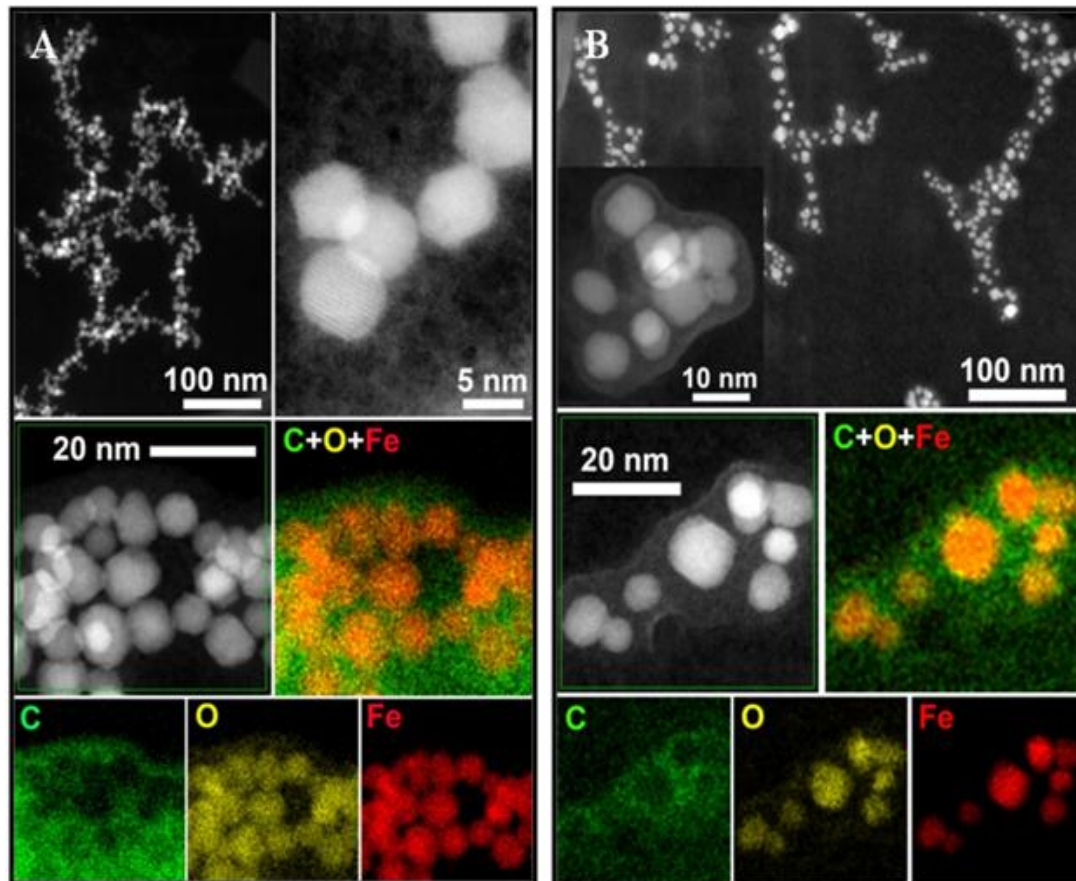
Магнитные наночастицы для биомедицины



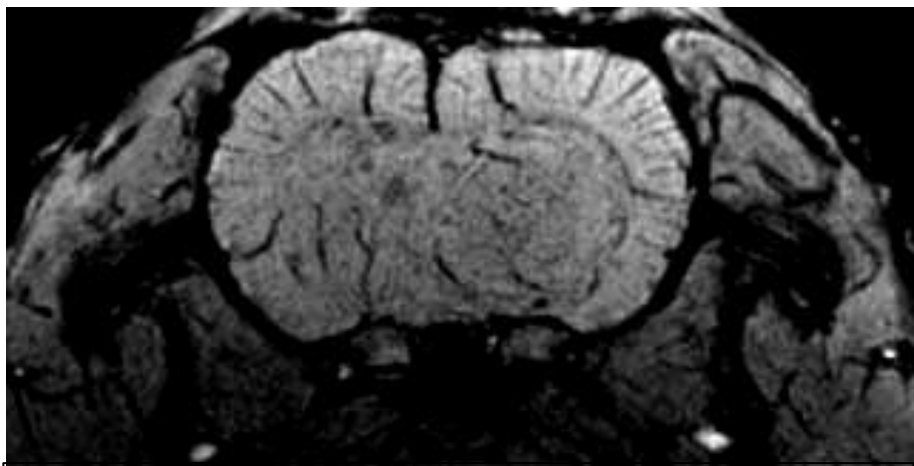
Применение магнитных наночастиц



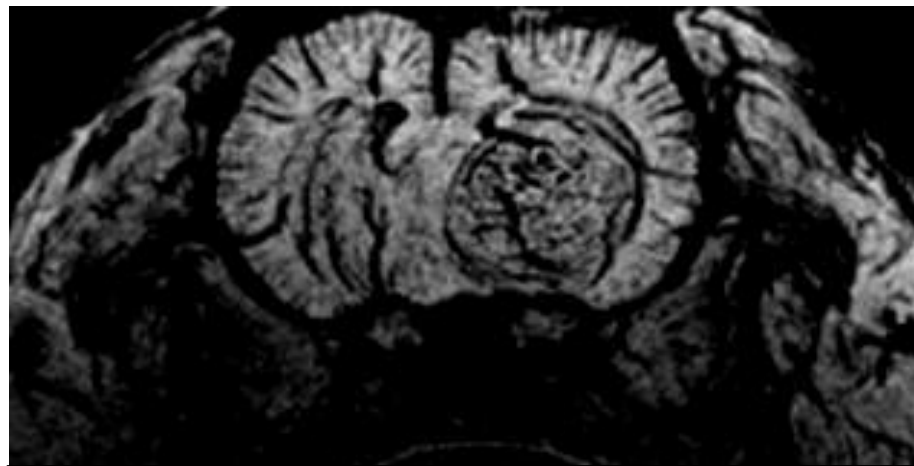
Стабилизация магнитных наночастиц



Визуализация глиомы С6 крысы

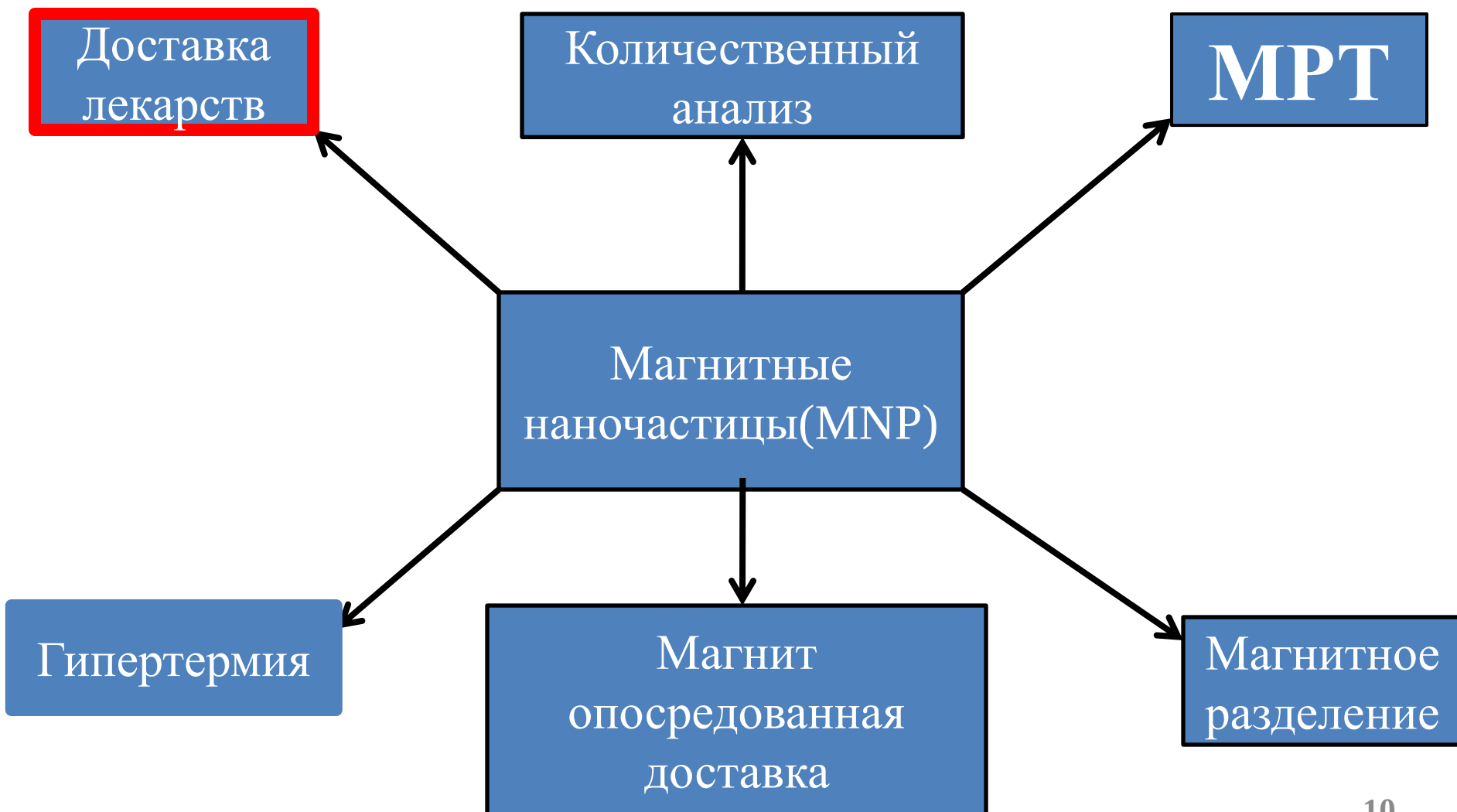


0 min



5 min

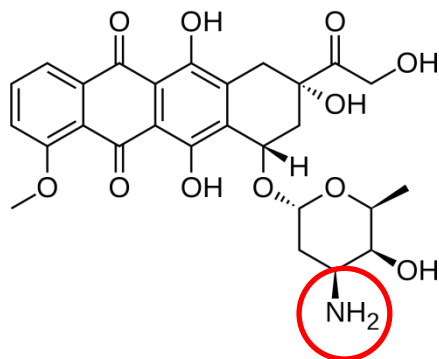
Применение магнитных наночастиц



Доставка лекарств с помощью МНЧ

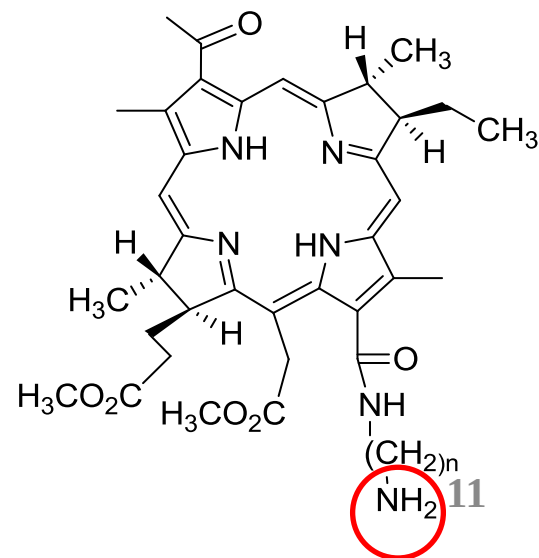
Доксорубицин

- Increase delivery efficiency
- Decrease side effects

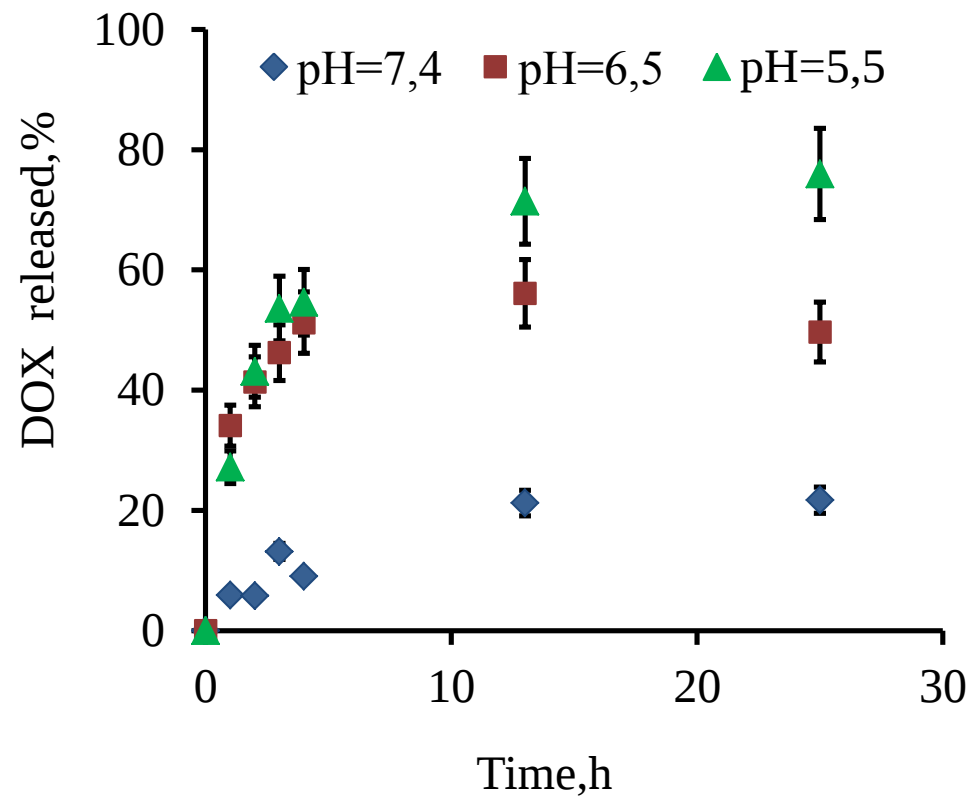
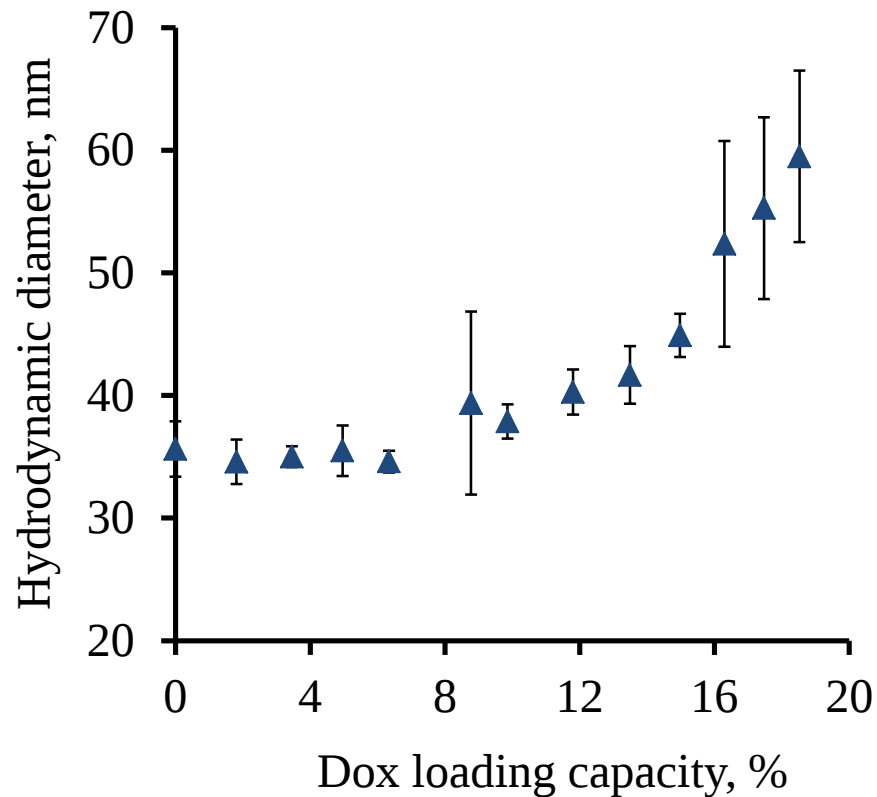


Фотосенсибилизаторы

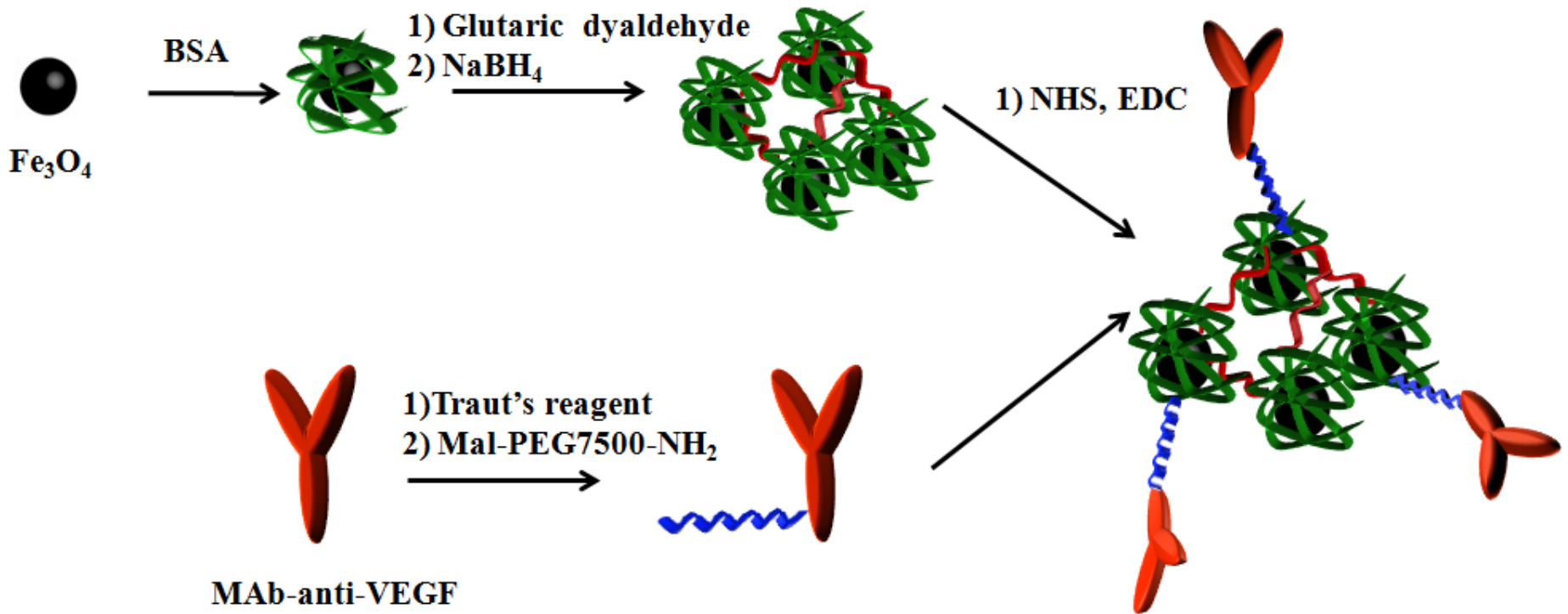
- Increase solubility
- Increase circulation time



Загрузка и высвобождение доксорубицина



Конъюгация с анти-VEGF антителами

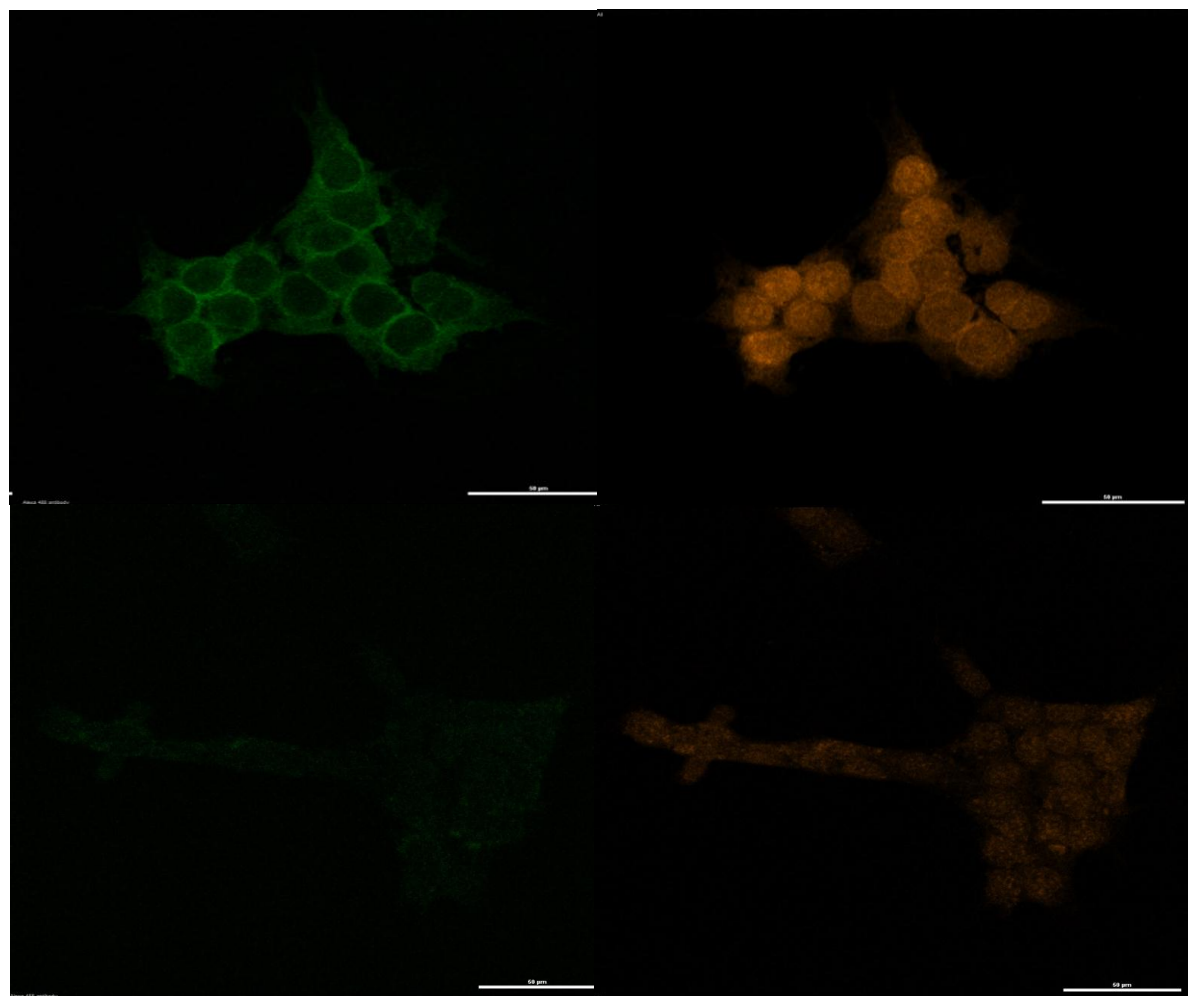


Взаимодействие с клетками аденокарциномы 4Т1 мыши

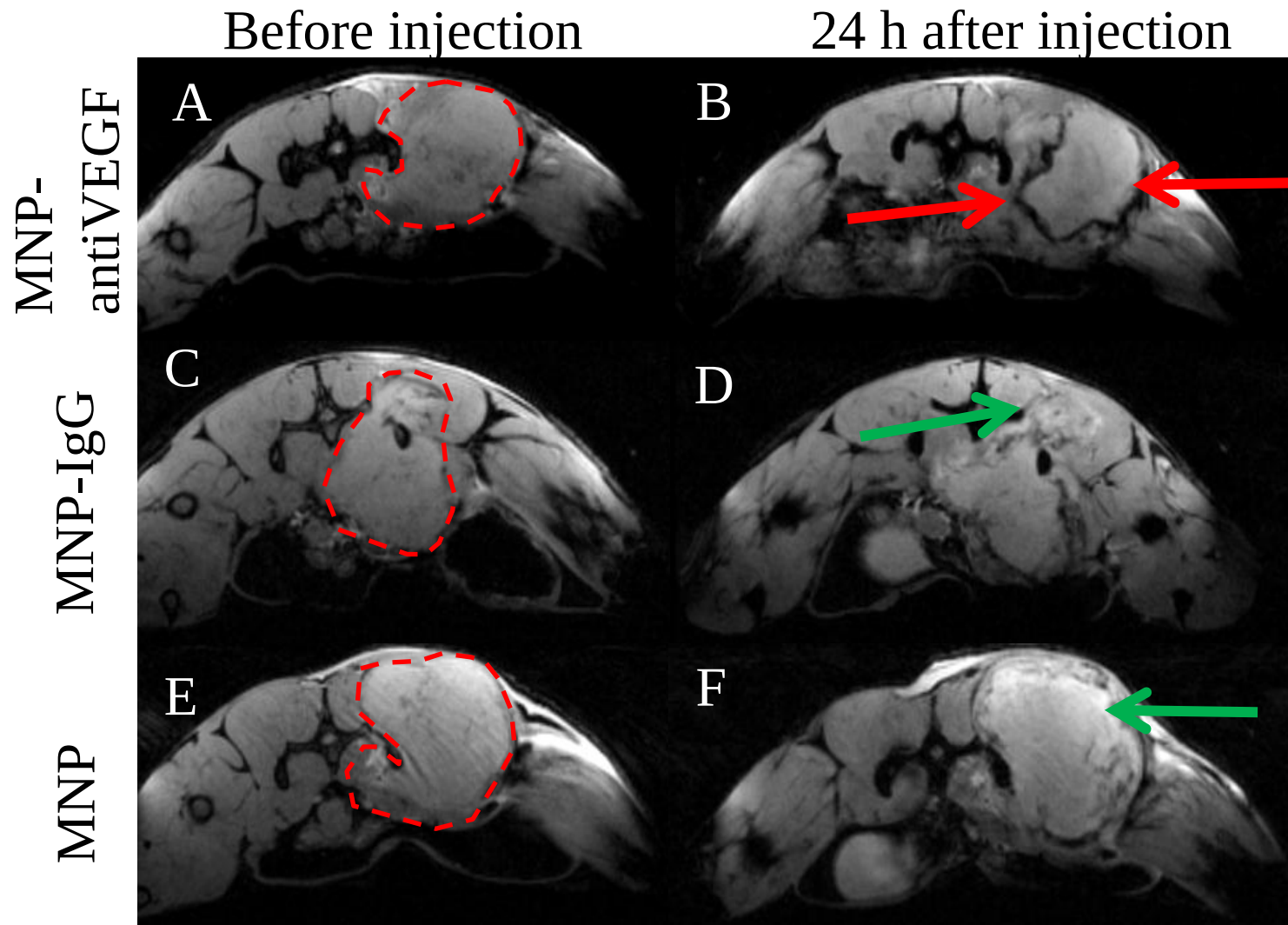
MNP

Dox

MNP-IgG MNP-antiVEGF

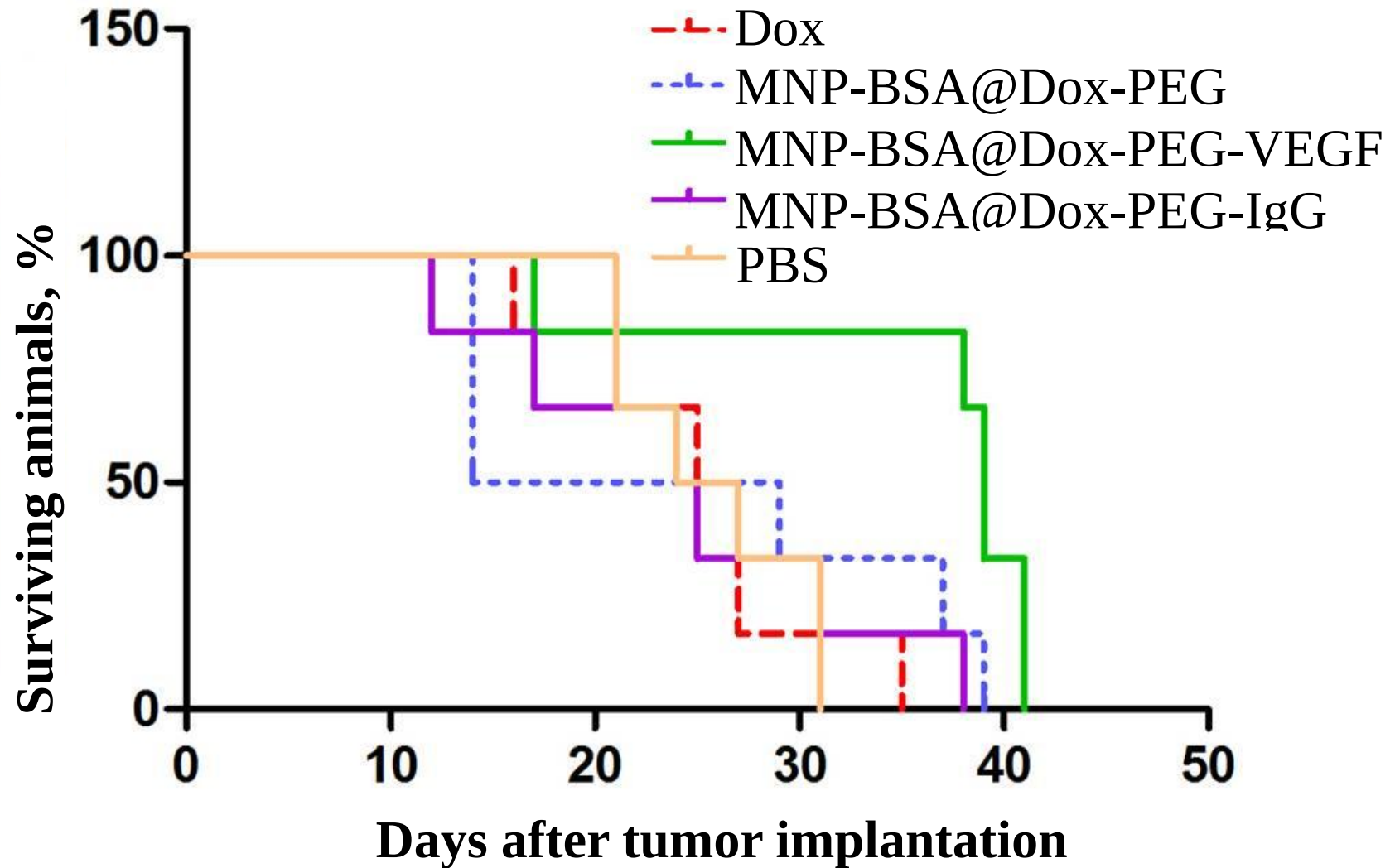


Визуализация аденокарциномы 4T1 мыши



Терапия аденокарциномы 4Т1

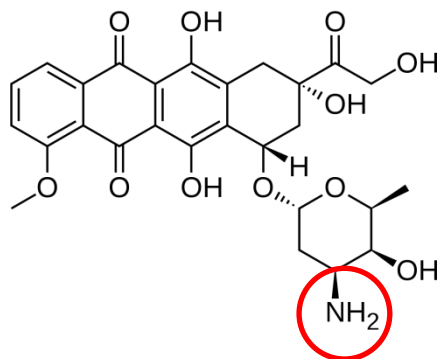
МЫШИ



Доставка лекарств с помощью МНЧ

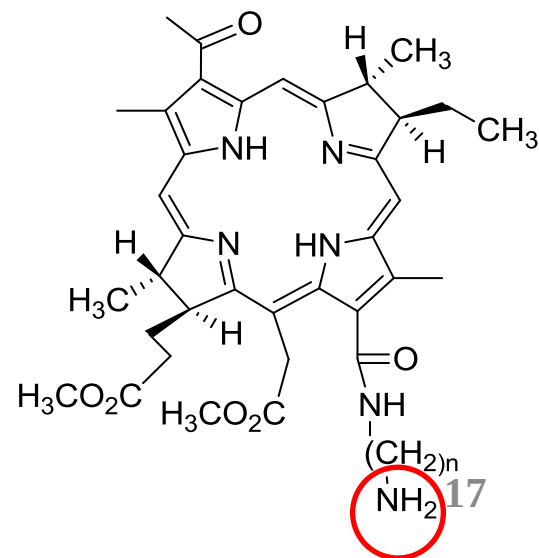
Доксорубицин

- Increase delivery efficiency
- Decrease side effects

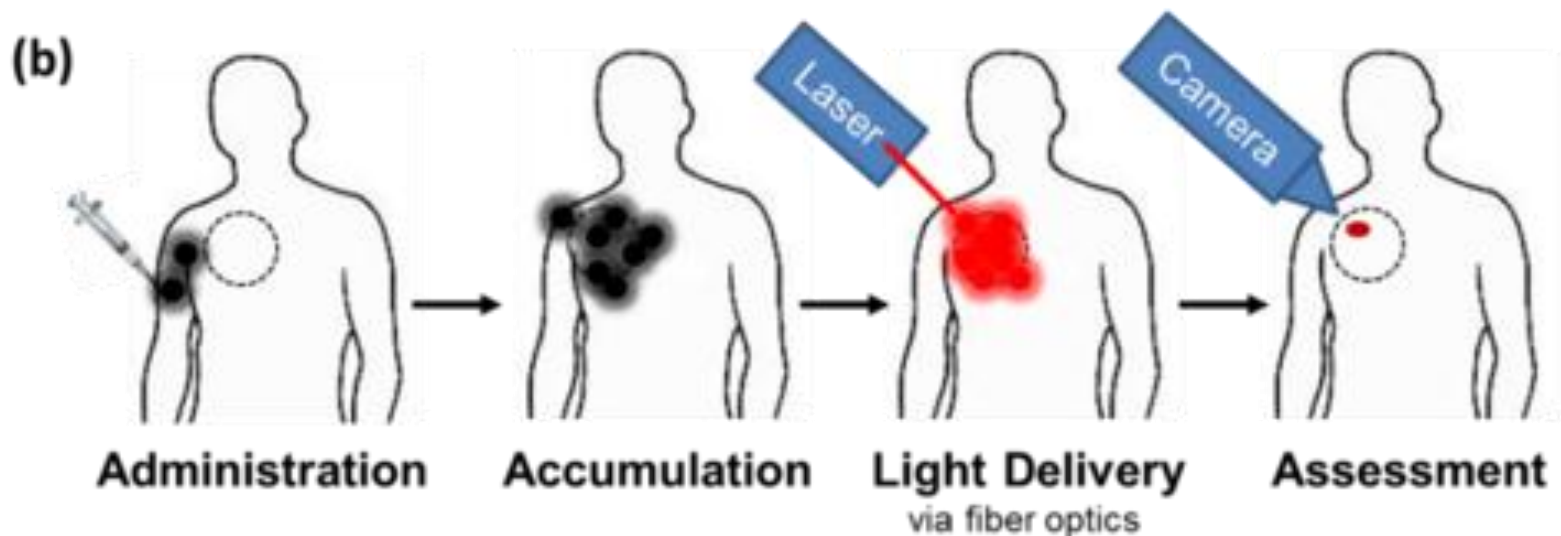
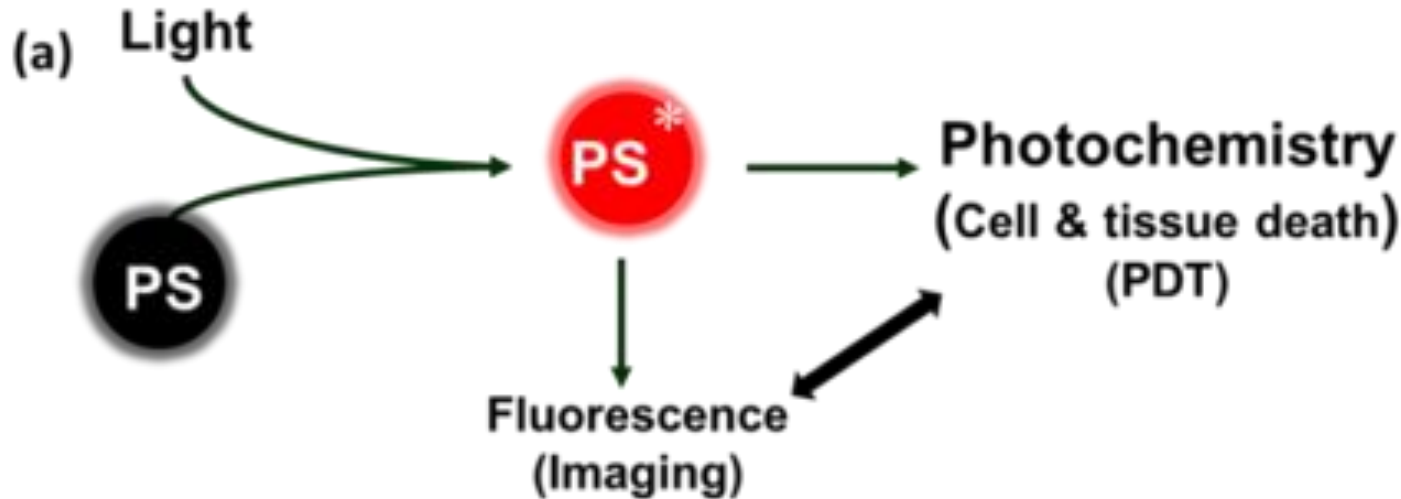


Фотосенсибилизаторы

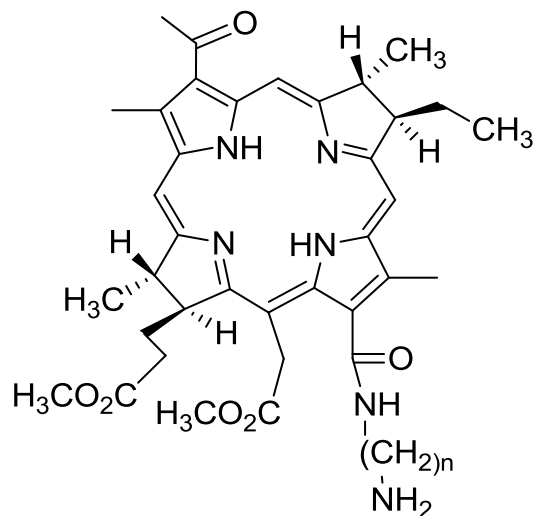
- Increase solubility
- Increase circulation time



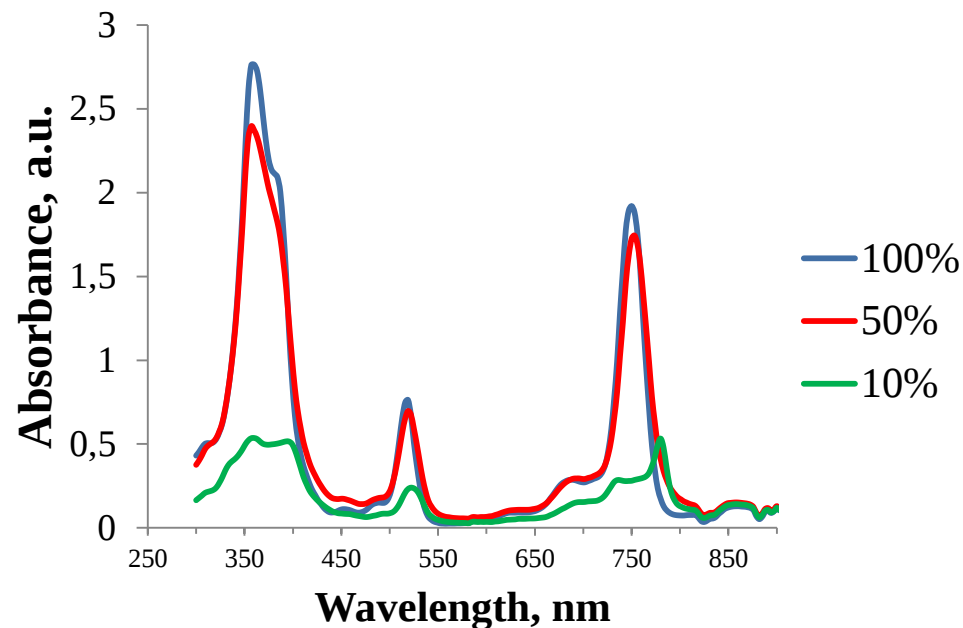
Фотодинамическая терапия



Синтез МНЧ@ФС

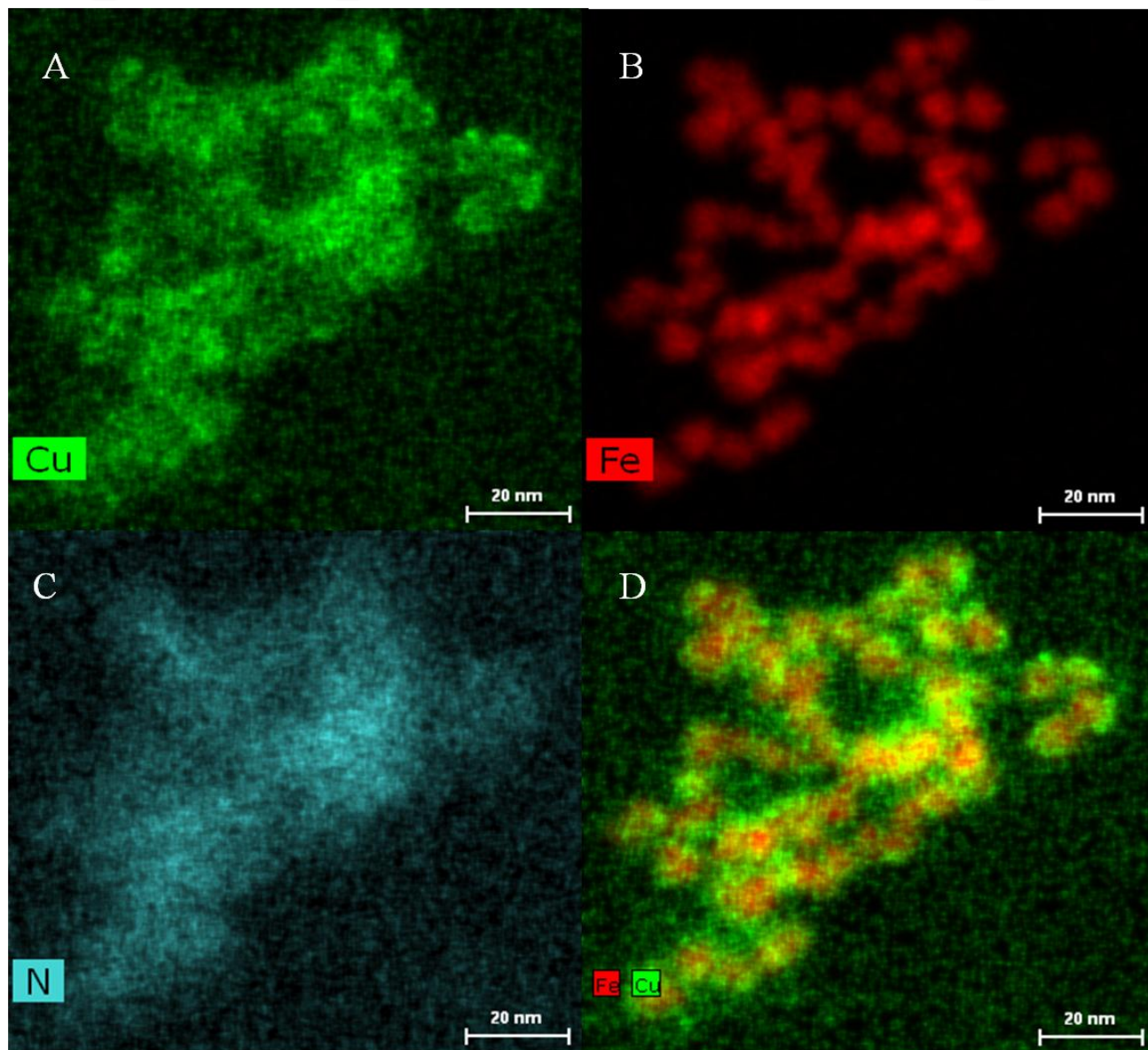


4: $n = 4$
5: $n = 6$
6: $n = 8$



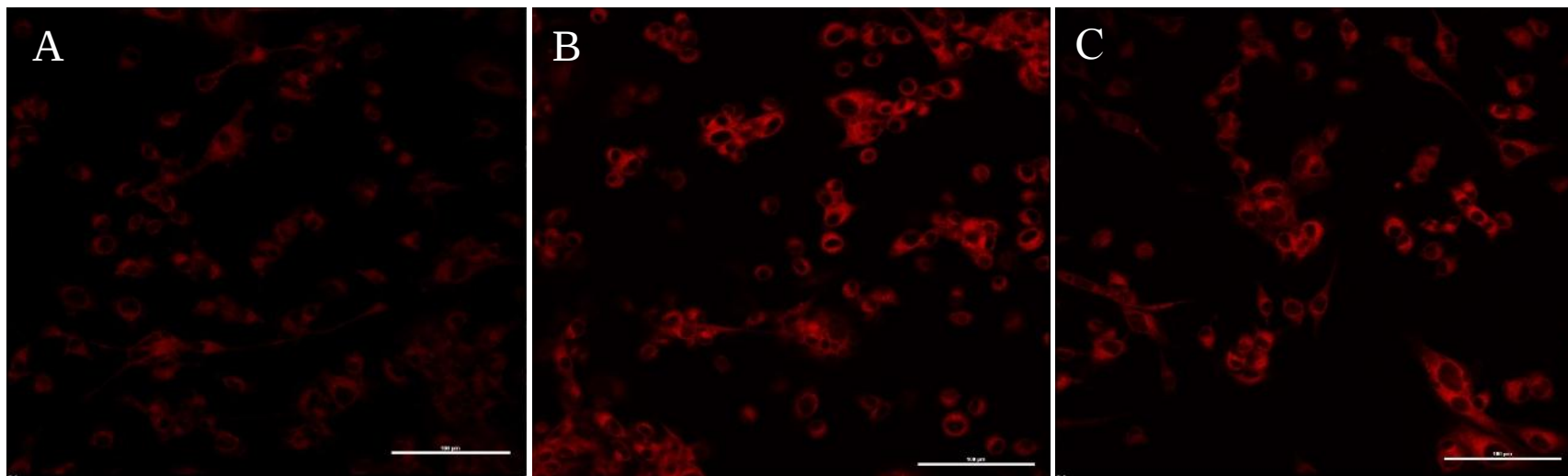
	PS 4	PS 6	PS 8
After purification	$D_{av} = 88,8 \text{ nm}$ PDI: 0,228	$D_{av} = 68 \text{ nm}$ PDI: 0,195	$D_{av} = 64,1 \text{ nm}$ PDI: 0,195
5 days after	$D_{av} = 87,4 \text{ nm}$ PDI: 0,245	$D_{av} = 69,1 \text{ nm}$ PDI: 0,189	$D_{av} = 63,7 \text{ nm}$ PDI: 0,167
Loading capacity, %	43.2±0.52	61.7±2.8	52.5±3.1 ¹⁹

Характеристика МНЧ@ФС



Темновая и световая токсичность МНЧ@ФС

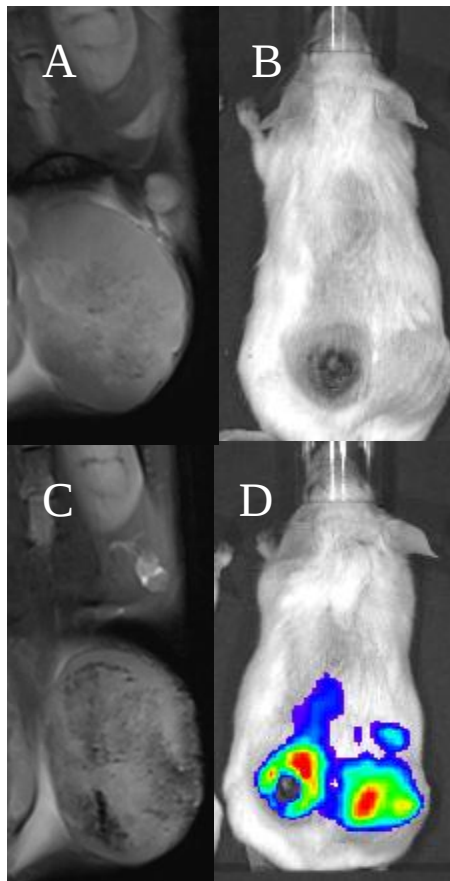
IC ₅₀ , ng/ml				
<i>Incubation time</i>	<i>30 min</i>	<i>2h</i>	<i>4h</i>	<i>dark</i>
MNP@PS4	195±9	70±4	44±3,5	2783±39
MNP@PS6	57±3	54±4,5	49±2	1093±35
MNP@PS8	95±7	65±4	58±4,5	1042±17



Колокализация МНЧ и ФС в опухоли

Before

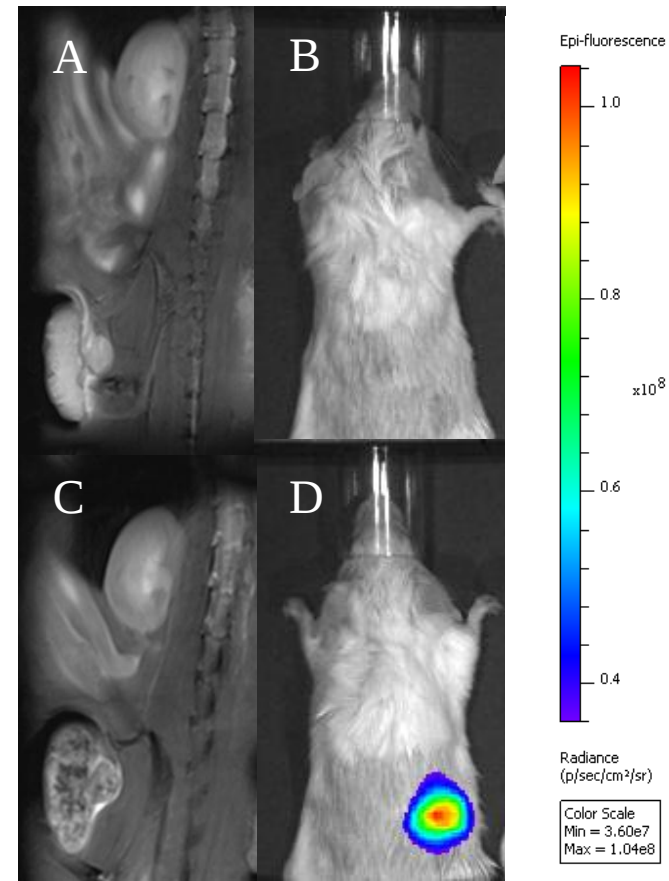
4h



CT26

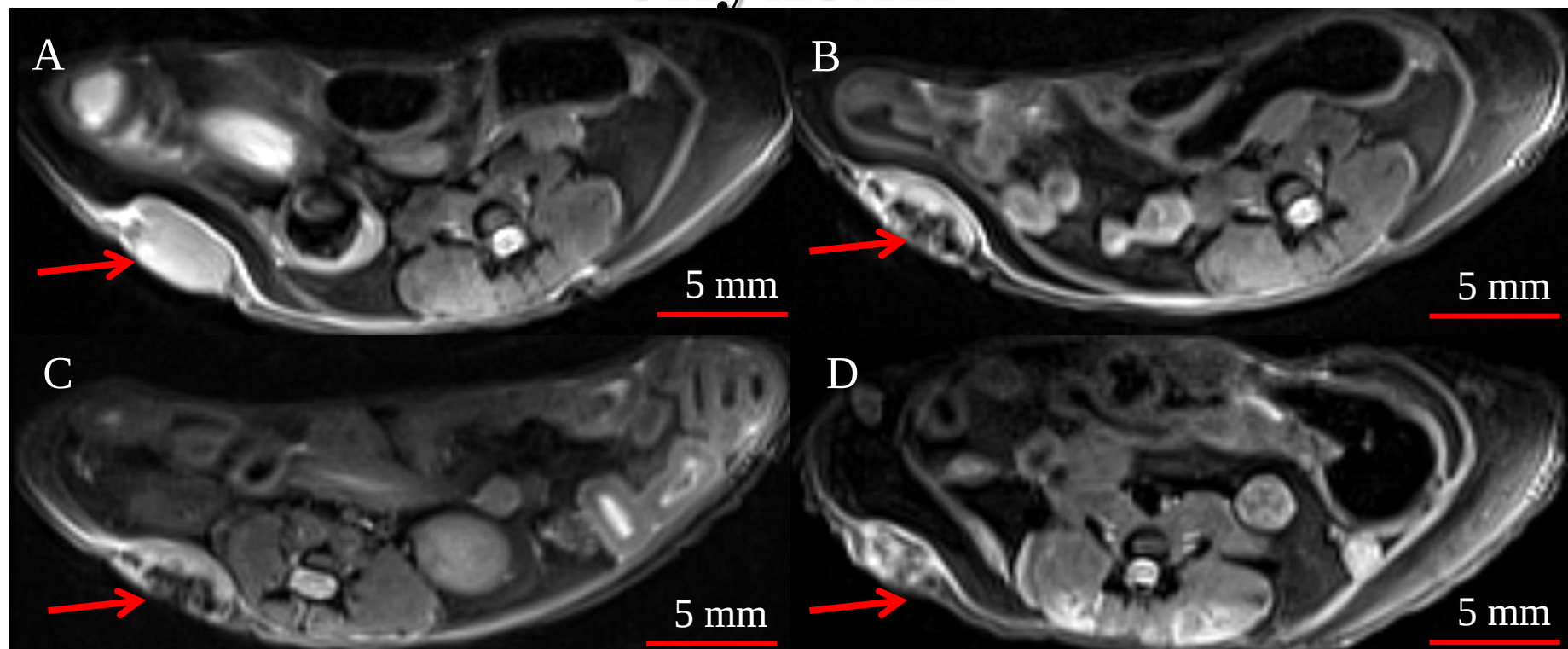
Before

6h



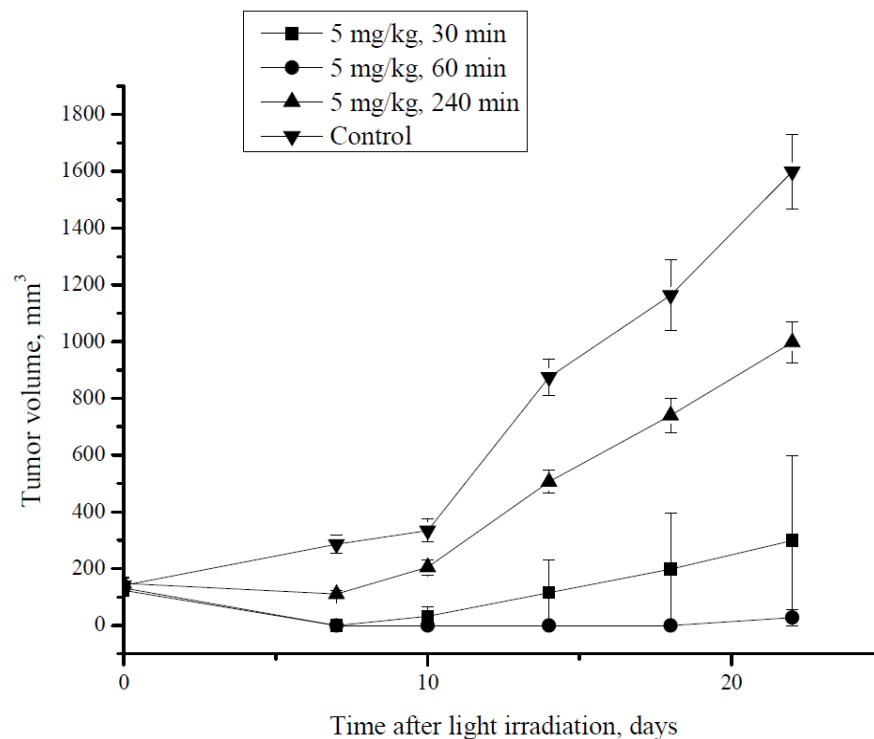
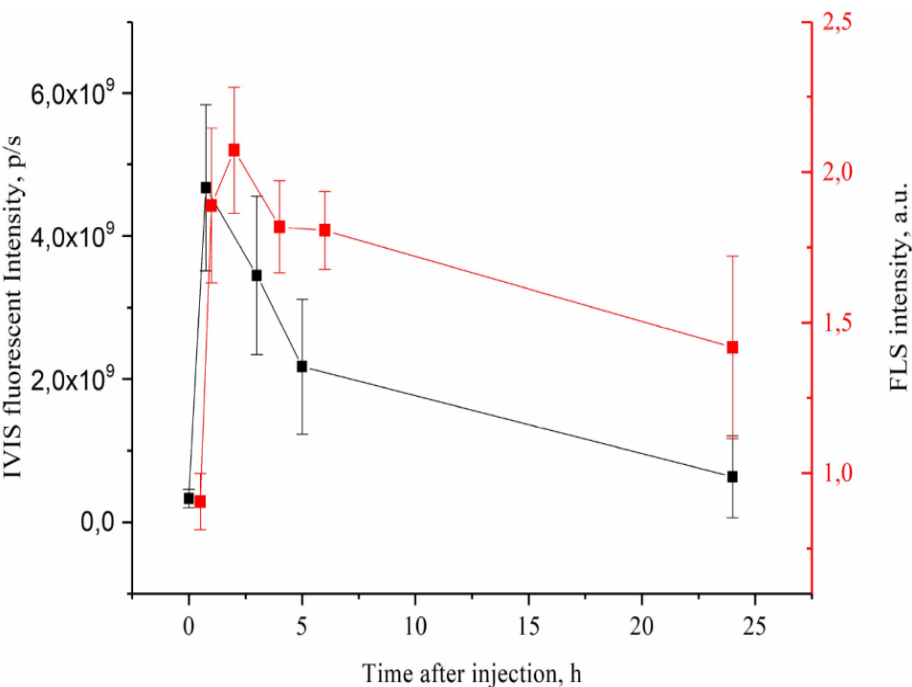
4T1

Колокализация МНЧ и ФС в опухоли

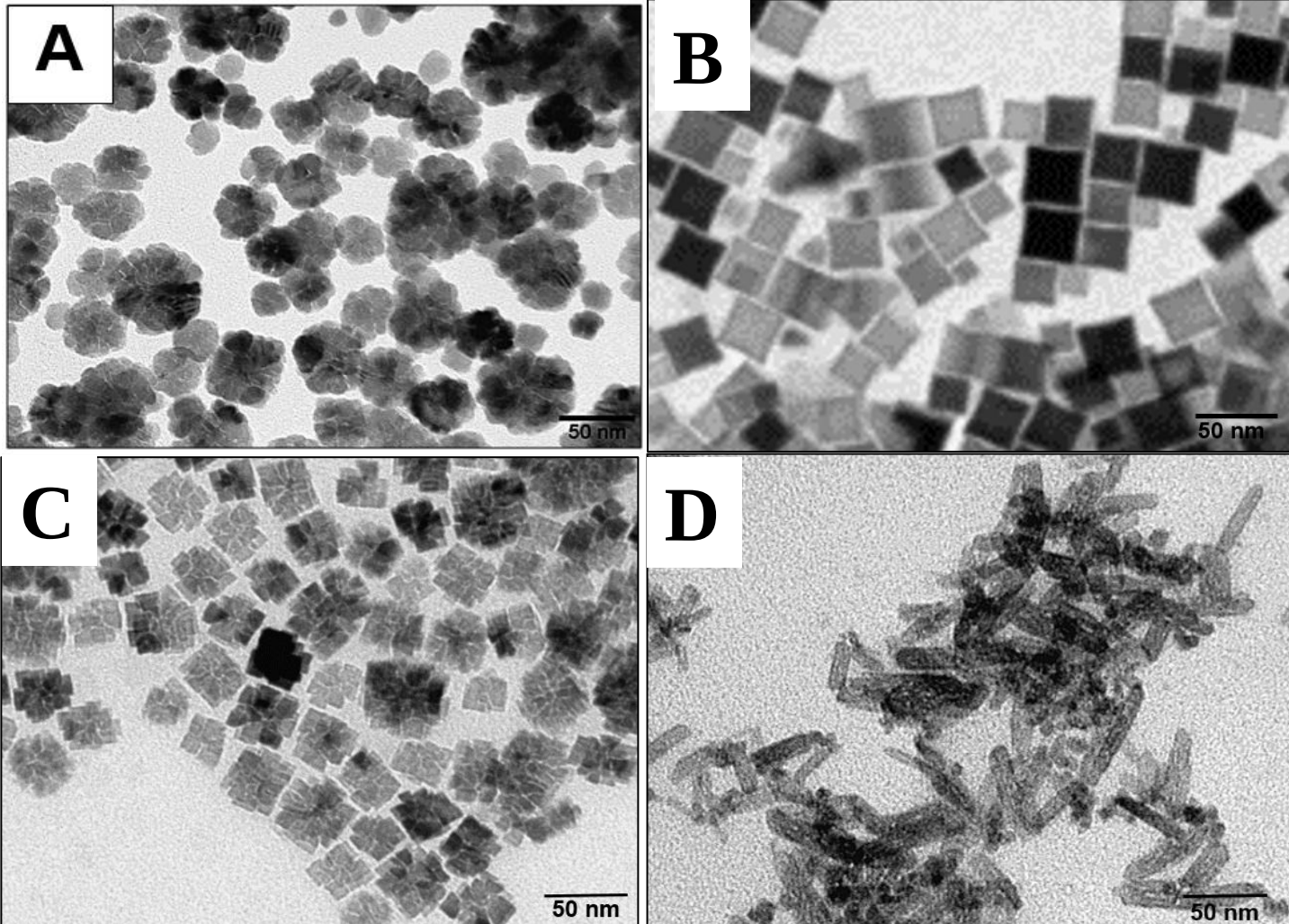


Representative T2 weighted images of subcutaneous CT26 tumors (red arrows) before (A) and 1 h (B), 4 h (C) and 24 h (D) after i.v. injection of MNP-HSA@PS.

Терапия опухоли карциномы кишечника мыши СТ26



Синтез анизотропных магнитных наночастиц



A. Nikitin et. al. *Journal of Magnetism and Magnetic Materials*, 2017

A. Nikitin et. al. *Langmuir*, 2018

Влияние формы и размера на биораспределение

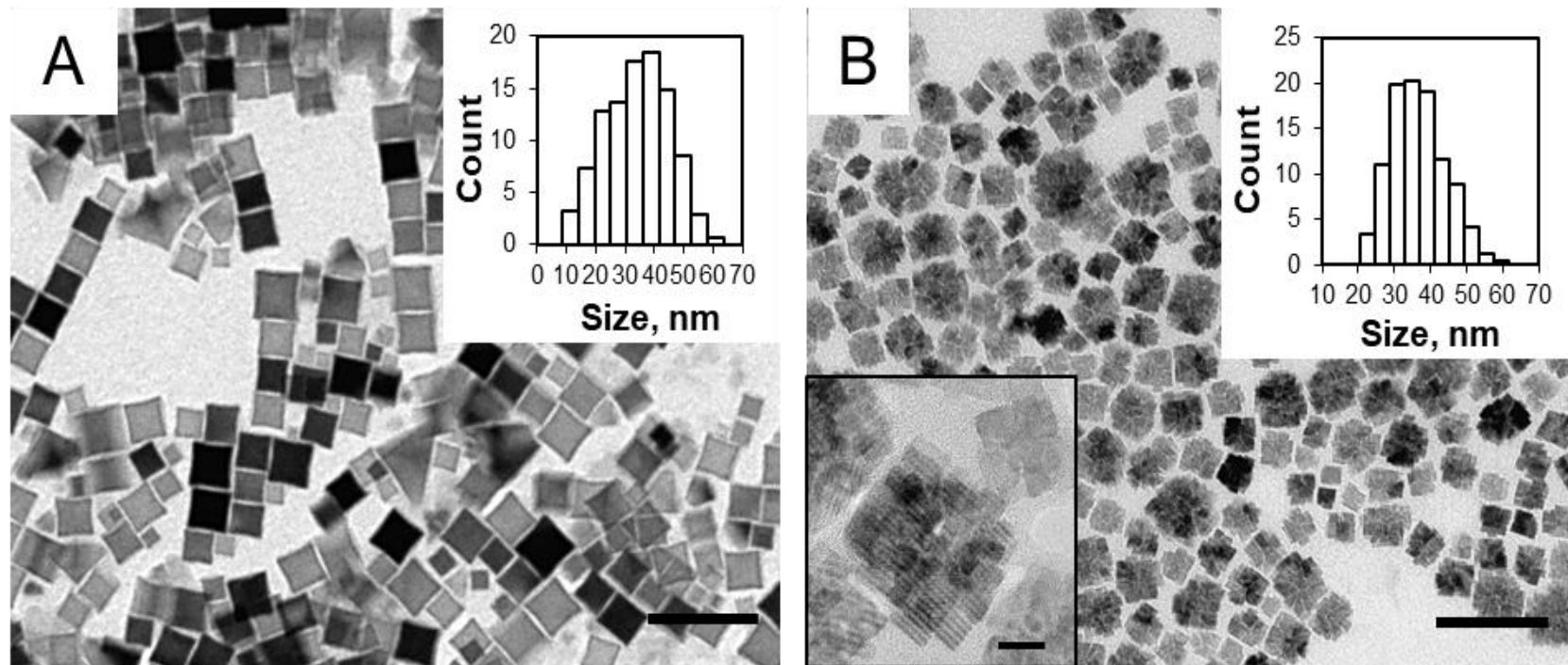
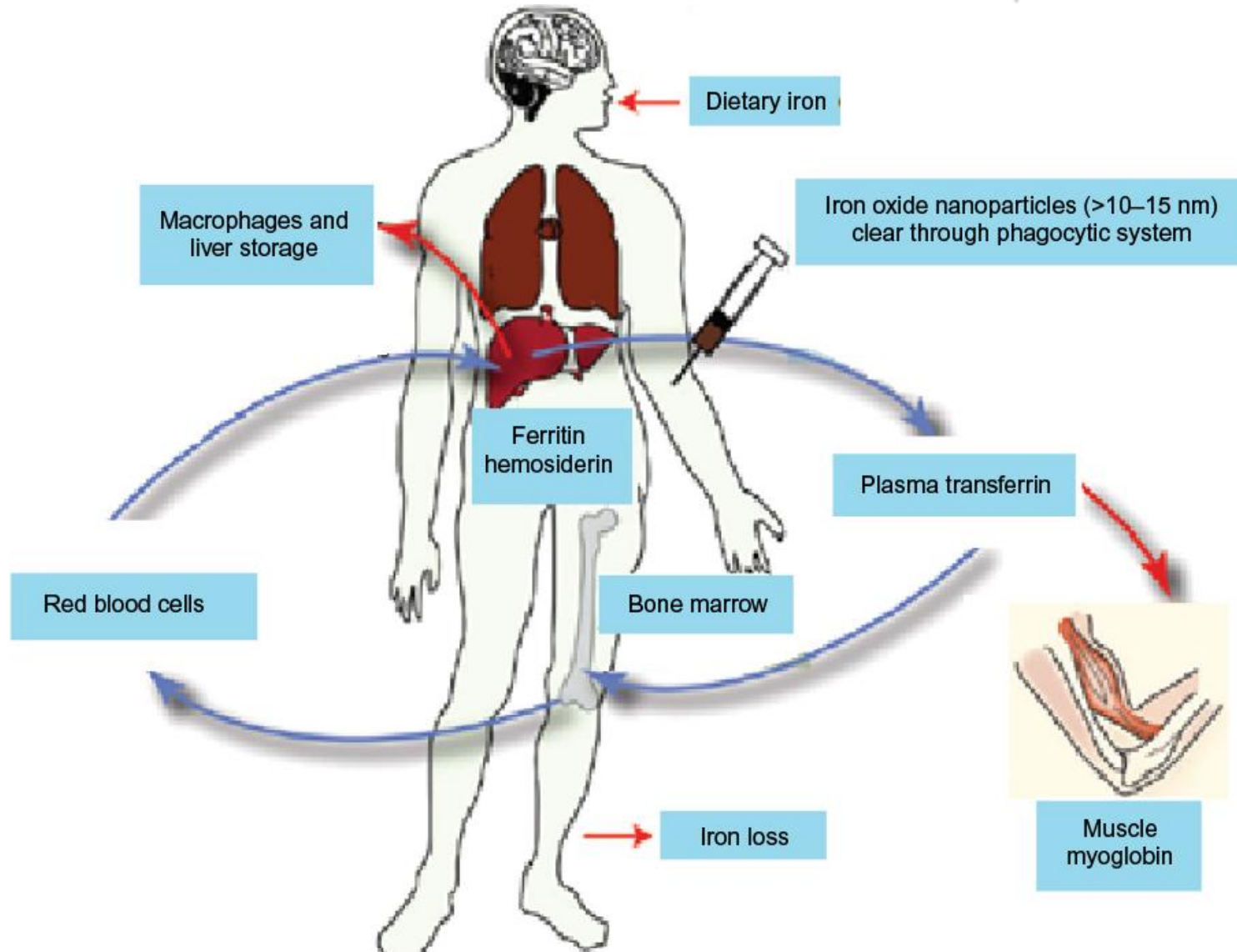
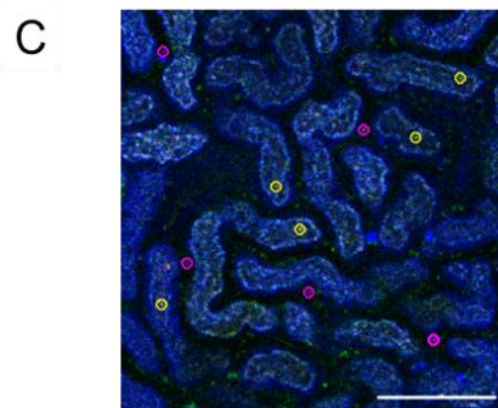
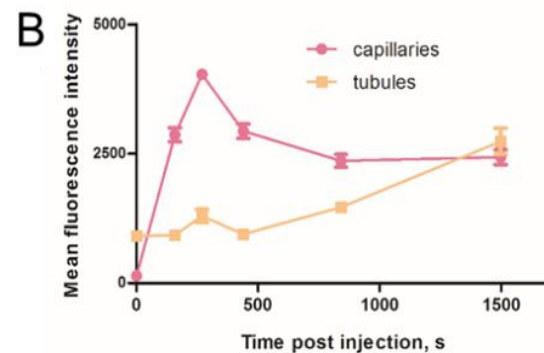
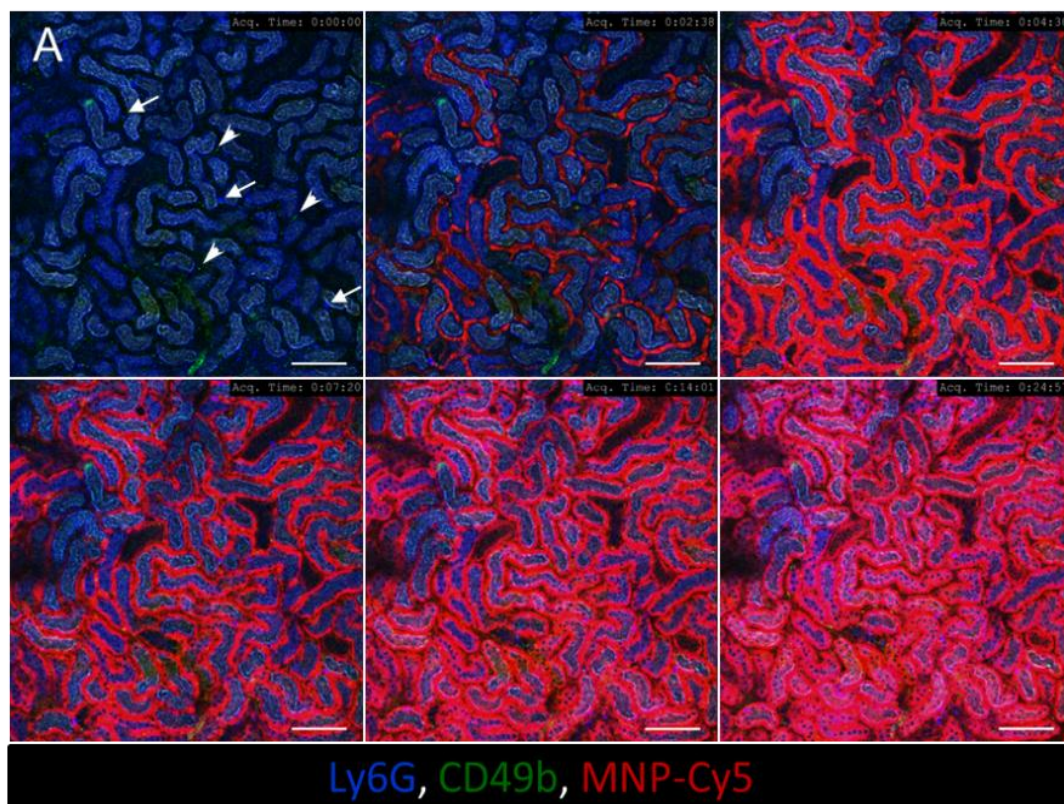


Схема биораспределения магнитных наночастиц

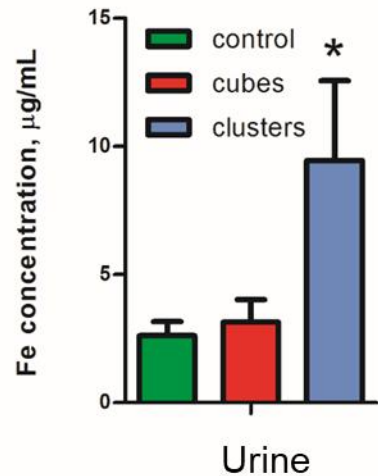


Фильтрация почками



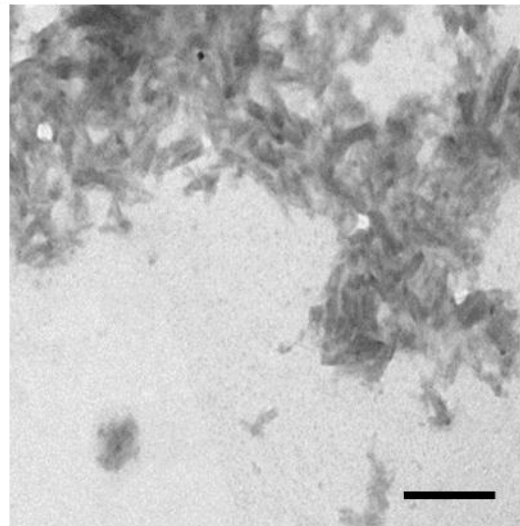
Фильтрация почками

A



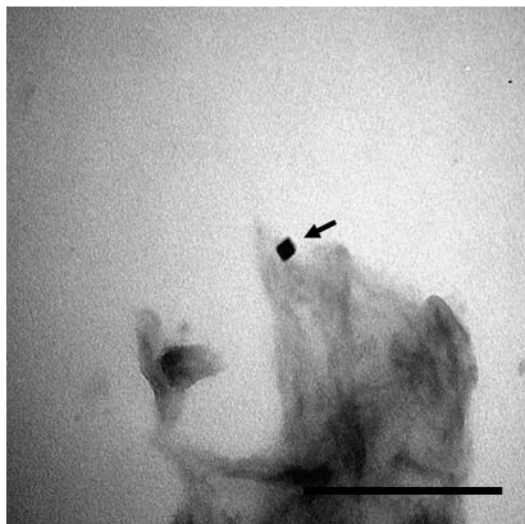
B

Control



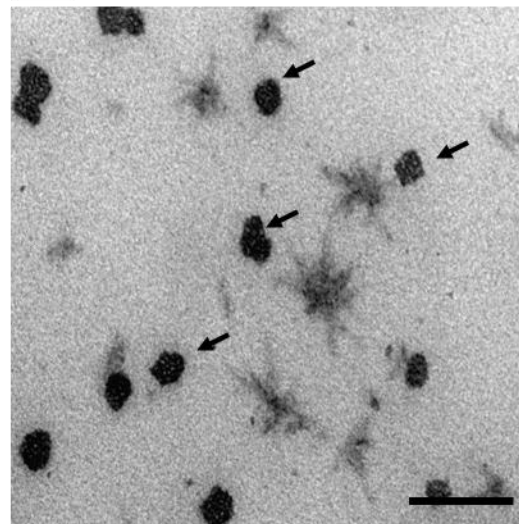
C

Cubes



D

Clusters





Благодарности

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- Prof, Dr.Sci, Majouga A.G.
- Dr. Sci, Baklaushev V.P.
- Ph. D., Semkina A.S.
- Ph.D., Naumenko V. A.
- Ph.D., Nukolova N.V.
- Skorikov A.S.
- Ostroverkhov P.V.
- Ph.D., Grinenko N.F.
- Ionova K.P.
- Ph.D., Savchenko A.G.
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- Ph.D., Erofeev A.S.
- Ph.D., Garanina A.S.
- Ph.D., Naumenko V.A.

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