The building blocks of organoid research

Organoid models include three-dimensional (3D) cell culture systems that closely resemble *in vivo* organs or tissues. These 3D systems reproduce the complex spatial morphology of a differentiated tissue to allow biologically relevant cell–cell and cell–matrix interactions, ideally sharing similar physiological responses with *in vivo* differentiated tissues.

The major focus of future organoid studies, beside the study of developmental processes, will most likely be in drug testing and modeling of diseases such as developmental disorders, genetic conditions, cancer, and degenerative disorders.

The hope is that organoids are another step in the long way towards *in vitro* construction of tissues and organs for transplantation.

Organoids	Proteins and growth factors	References
Brain organoids	BDNF	Lancaster MA and Knoblich JA (2014) *Nat Protoc* 9:2329.
	DKK-1	Li Y et al. (2017) *Cell Stem Cell* 20:1.
	EGF	Mariani J et al. (2015) *Cell* 162:375.
	FGF-basic	
	GDNF	
	Noggin	
Germinal center–like organoids	IL-4	Purwada A and Singh A (2017) *Nat Protoc* 12:168.
Inner ear organoids	BMP-4	Koehler KR and Hashino E (2014) *Nat Protoc* 9:1229.
	FGF-basic	
Kidney organoids	Activin A	Takasato M et al. (2014) *Nat Cell Biol* 16:118.
	BMP-2	Xia Y et al. (2013) *Nat Cell Biol* 15:1507.
	BMP-4	Xia Y et al. (2014) *Nat Protoc* 9:2693.
	BMP-7	
	FGF-9	
	FGF-basic	
Liver organoids	BMP-4	Broutier L et al. (2016) *Nat Protoc* 11:1724.
	EGF	Sato T and Clevers H (2015) *Cell* 161:1700.
	FGF-10	Takebe T et al. (2013) *Nature* 499:481.
	FGF-basic	
	HGF	
	Noggin	
	R-spondin-1	
	Wnt-3a	

Organoids	Proteins and growth factors	References
Lung organoids	Activin A FGF-basic FGF-4 Noggin	Dye BR et al. (2015) *eLife* 4:e05098.
Mammary organoids	EGF FGF-10 FGF-basic Heregulin β-1 Noggin Prolactin R-spondin-1 R-spondin-2 Wnt-3a	Jamieson PR et al. (2017) *Development* 144:1065. Jardé T et al. (2016) *Nat Commun* 7:13207.
Pancreatic organoids	EGF FGF-10 Noggin R-spondin-1 Wnt-3a	Boj SF et al. (2015) *Cell* 160:324. Broutier L et al. (2016) *Nat Protoc* 11:1724. Sato T and Clevers H (2015) *Cell* 161:1700.
Prostate organoids	Activin A EGF FGF-10 FGF-basic Noggin R-spondin-1	Drost J et al. (2016) *Nat Protoc* 11:347. Karthaus WR et al. (2014) *Cell* 159:163.
Retina organoids	Sonic hedgehog (Shh) Wnt-3a	Nakano T et al. (2012) *Cell Stem Cell* 10:771.
Small intestinal and colonic organoids	EGF Noggin R-spondin-1 Wnt-3a	Jung P et al. (2011) *Nat Med* 17:1225. Mahe M et al. (2013) *Curr Protoc Mouse Biol* 3:217. Sato T et al. (2011) *Gastroenterology* 141:1762. Sato T and Clevers H (2009) *Nature* 459:262. Sato T and Clevers H (2015) *Cell* 161:1700.
Stomach organoids	EGF FGF-10 Noggin R-spondin-1 Wnt-3a	Bartfeld S et al. (2015) *Gastroenterology* 148:126. Mahe M et al. (2013) *Curr Protoc Mouse Biol* 3:217. Sato T and Clevers H (2015) *Cell* 161:1700.

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