STEROID-INDEPENDENT ACTIVATION OF STEROID RECEPTORS

Factor [a]	ER [b]	PR [c]	AR
ATP	1		
CXCL12 / SDF-1	2		3
Dopamine	4	4	
Epidermal growth factor (EGF)	5,6	7	8
EGFR (activated by AR)	9		
erbB2 = HER-2	10		11
Fibroblast growth factor 2 (FGF-2 = bFGF)	12		
Gas-6			13
Gonadotropin release hormone (GnRH)	14	15	
GRP			13
Heregulin	10	16	13
Insulin and insulin-like growth factors (IGF)	17-19		8
Interleukin-1β	20		
Interleukin-4			21
Interleukin-6	22		23,24
Interleukin-8			25
Keratinocyte growth factor			8
Leptin	26		
Prolactin	27		
Sex hormone binding globulin			28
TGFα	6		
TNFα	20,29		
Amino acids (through mTOR and S6K)	30		
β-catenin + FKBP52			31
Cdk2		32	
Cyclin A-Cdk2	33		
Cyclin D1	34,35		
Ets-1	36		
Gα	37		
Hif-1α (hypoxia)	38		

IKKε	39		
MAPKK (constitutive mutant)	40		
MEKK1 (constitutive mutant)			41
Pak1	42		
PI3K	43		
PKCδ	44		
Progesterone receptor (PR)	45	NA	
Protein kinase B (= Akt)	43,46-48		
Ras (constitutive mutant)	49		
v-Src	50		
TBK1	51		
Vav3 (a Rho GEF)	52		53
XBP1s	54		
Activators of protein kinase A	17,55,56	57	58
Activator of protein kinase C	44,49,59		60
Caffeine	1		
Ca2+	1		
Inhibitors of protein phosphatases 1 and 2A	4	4,57	
Inhibitor of phosphotyrosine phosphatases		7	
SIRT1 inhibitors	61		
Metals, arsenite, selenite	62-65		

[a] This list may be incomplete as the extent of steroid-independent activation varies widely; moreover, several reports have indicated that some of the effects may be cell- and/or promoter-specific (see for example ref. [11,66]).

[b] Almost all publications have examined ERα. ERβ has only been shown to be activated by EGF ([67,68]) and SDF-1 (2), and indirectly by 3,3'-diindolylmethane ([69]).

[c] The response of PR displays marked species differences: chicken and rodent PRs can be activated in the absence of cognate hormone by a whole series of activators that will only affect human PR in the presence of a ligand, for example the partial antagonist RU486 (refs. [70-72]; exceptions to the rule are the activation of human PR by heregulin [16] and Cdk2 [32]).

<u>Notes</u>:

- other steroid receptors, notably GR and MR, are more restricted in their ability to be activated in the absence of ligands. A noteworthy "exception" is the activation of GR by GnRH and TNFα signaling ([73,74]).
- We have published a reformated version of this table in 2015 (ref. [75]).

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