

# The bioinformatic analysis of CRK in *Arabidopsis thaliana*



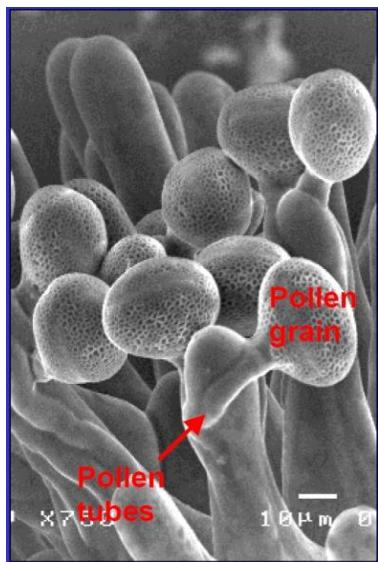
2018/06/23



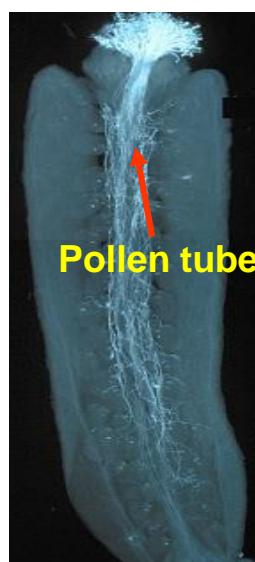
PKU G01-G03

## 双受精过程

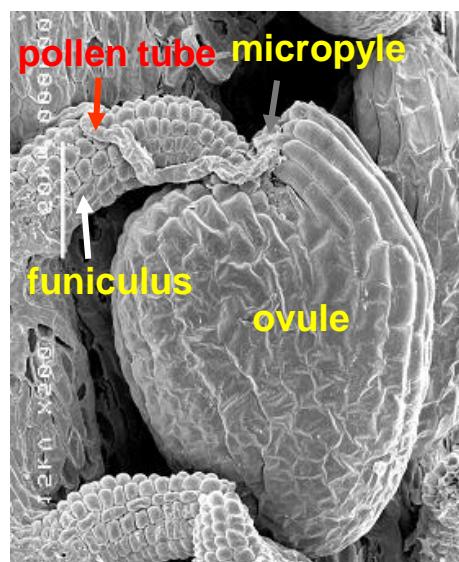
Pollen germination



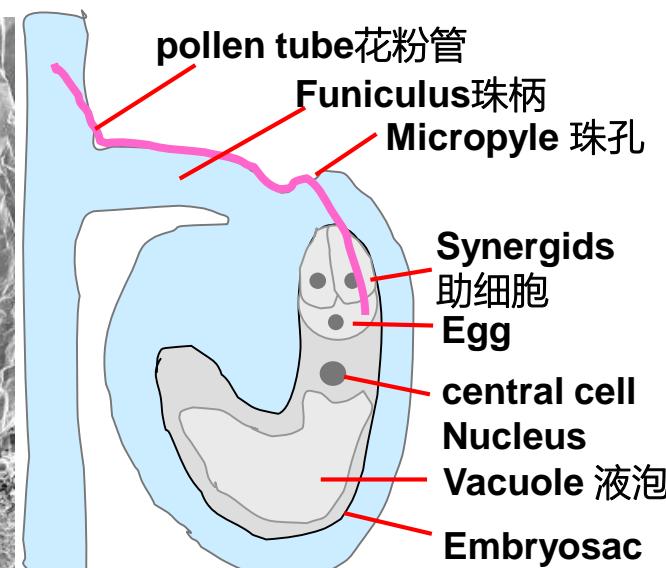
Pollen tube growth in pistil



Pollen tube attracted to ovule



Pollen tube reception and sperm release



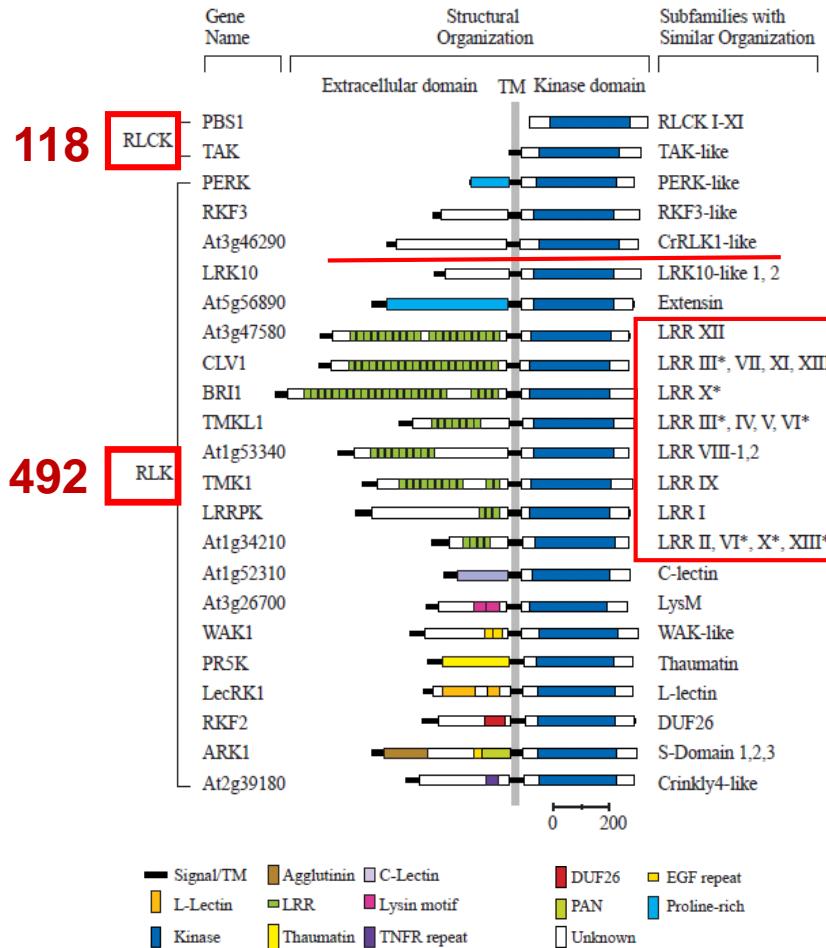
**Receptor**

信号与受体相互作用

## RLKs家族分类

# Receptor-like kinase ( RLK )

## 类受体激酶



## RLKs家族分类

## DUF26 (Domain of Unknown Function 26)

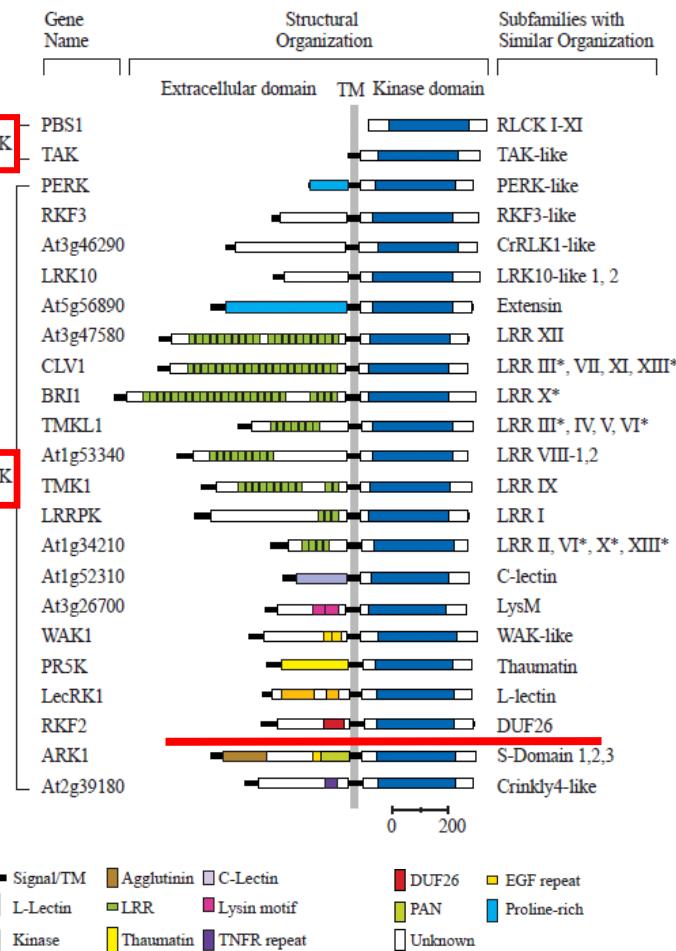
### DUF26 功能未知

118

RLCK

492

RLK



## CRKs研究进展



## Cysteine-rich Receptor-like Kinases (CRKs)

### 富含半胱氨酸的类受体激酶

Name	Sequence
sp Q8H199 CRK14_AR_P_D	R V Y A V G M C L P G T E - E E S C I G C L T S A Y A L M M Q C T P D L S L E D C H I C L R Q S V G
sp Q8RX80 CRK18_AR_P_D	- R V Y A L G M C I E G A E - P D V C S D C I E Y A S A L M Q C T P D V S S E D C N N C L Q R Q V L
sp Q8M479 CRK20_AR_P_D	- M V T G L F L C R G N V S - P E V C R S C I A L S Y A L M Q C T P D I S S D E C N N C L Q Q N V V
sp Q8NQ87 CRK22_AR_Q_D	- R V Y A L G M C I P R S T - P S D C F N C I K G A Y G M V Q C T P D I S E E D C G S Y C L S Q G I A
sp Q8M483 CRK24_AR_P_N	- R A Y G L G M C V P G T D - A H S C S D C I I L A F G L V Q C T P D I S E E D C G S Y C L S Q G I A
sp Q8TQJ1 CRK26_AR_D_E	- K V N V S I S Q C R G D V K - L E V C I N C I A M A Y A L M Q C T P D I S E E D C G S Y C L S Q G I A
sp Q9CAL3 CRK24_AR_P_D	- N Y G L A Q C Y G D L P - L N D C V L C Y A E A F V L A N C W R T L S P D S C K Q C L E N A S A
sp Q9LDS6 CRK32_AR_P_D	- R I Y A L G L C I P G T D - P K V C C D D C M Q I A Y A L M Q C I R G I S S S M E C E T C I R D N V R
sp Q9XEC6 CRK36_A_	- R I Y A L G L C R K H Y E - V Q A C R R C V D R A Y N M L M Q C T P D L S S S D C N H C L R E N V R
sp Q9CAL2 CRK13_AR_N_L_T	- V Y A Y G E C I K D L D - K K D C D L C F A Q I H G L A Q C W E T L N R S G C V E C L S K A S V
sp O23081 CRK41_AF_S_D_Q	- E R V E A I G I C N R V V N - R V D C L N C I A Q A F G A V V Q C T P D L S E K D C N D C L S Y G F S
sp Q8L7G3 CRK7_AR_L_D	- R V T G L F L C R G D V S - P E V C R N C V T F A Y G L V Q C T P D L S R Q N C M N C L T S S I N
sp Q005R2 CRK10_O_P_D	- A I Y A L A L C R G D T N - S S C S C A T C V A A A Y S L A Q C T P D M A A T A C R S C L E D I V G
sp Q0PW40 CRK13_A_Q_D	- R V Y A L G M C I P K S T - P S D C S N C I K G A Y A L M Q C T P D I S S D E C N N C L Q R G V L
sp O65476 CRK16_AF_P_D	- R L Y A S G T C I Q G S E - P E L C S A C I D S Y A F V L C S K D I S P W N C S R C L R R G N V D
sp Q9LMB9 CRK14_AF_V_S_P_P	- I Y V F L Q C R E D L S - V S D C R H C F N E S Y A L A Q C W Q T L D E N T C R E C L V N A R S
sp Q9LDM5 CRK31_A_G	- R I Y A L G L C I P G S D - P R V C S D C I Q L Y A L M Q C I P G I S S E D C E T C L G K C V D
sp O65468 CRK6_AR_P_D	- R V T G L F L C R G D L S - P E V C S N C V A F S Y G L V Q C T P D L A R Q D C F S C L T S S I N
sp Q3E9X6 CRK21_AF_P_N	- I A H G L G M C S R G T T - T Q D C S D C I T S Y A I A Q C N K D L T K L N C E K C L Q H L R I
sp Q9M0X5 CRK25_A_N_D_S	- N R V G V F L C R G D V S - A E I C R D C V A F A Y S L V Q C T P D L T N Q D C D C L R Q V I N
sp O65405 CRK28_AF_S_G	- E R A Y A I G L C R R E V K - R D D C L S C I Q I I Y G S A H C T P D L S E Q D C N D C L V F G F E
sp Q9LDT0 CRK30_Ai_P_D	- Q L Y A M G M C I P G A K - Q K L L C R D C I M D Y Y A L M Q C T P D V S P S N C N T C L K L Q S V D
sp Q9LDQ3 CRK35_A_P_N	- R V F I N G M C I P G T K - P E T C S D C I K G S Y Y A M M Q C T P D V S S K D C E F C L K T S V G
sp Q9XEC7 CRK37_A_S_K_N	- N R V H V V V A L C R R G Y E - K Q A C K T C L E H Y Y A L M Q C V P D L S P G N C K R C L R E C V N
sp Q9M9QY CRK43_A_P_E_R	- M V Y V L S Q C V S D L S - S D E C S L C W S R A Y G L V Q C W R T L N D E L C K C L C L A D G A L
sp Q9CS85 CRK5_AR_S_D	- M V F G L Y L C K G D L S - P E P S C R E C V I F A Y A S V Q C I P D L T S E D C V M C L Q Q S I K
sp Q8W4G6 CRK15_A_P_D	- R V T G L F L C R G D V S - P A V C R N C V A F S Y G L V Q C T P D L T R Q D C F S C L E S S I K
sp Q8P170 CRK17_Af_T_D	- R V Y A M G M C A P G A E - P D V C S N C I K N T S V V M Q C T P D V S S K D C N L C L E R S L D
sp Q8P10 CRK34_AR_P_N	- Q M F I I S M C I P G T K - P E R C S D C I K G S Y T M V Q C T P D V S S G D C E F C L K R T V L
sp Q9SY7 CRK39_A_P	- N I V H A V A L C R G R G Y E - Q Q A C I R C V D S A Y Y M L M Q C T P D I T S Q D C K I C L G E C V T
sp Q9FNE1 CRK42_A_T_S	- I A L I Q C H D D L S - P S D C Q L C Y A I A Y H A L A Q C W E S L G K E D C R V C L E K A V K
sp Q8CY82 CRK45_A	- M V F G L Y L C K G D L S - P E P S C R E C V I F A Y A S V Q C I P D L T S E D C V M C L Q Q S I K
sp Q0D5R2 CRK6_OR_P_D	- K V Y G L A L C R G D A N - A S A C E R C V A A A Y A L A Q C T P D K T P E V C R T C L S T V I G
sp O65469 CRK9_AR_P_D	- L V T G L F L C R G D L S - P E V C S N C V A F S Y G L V Q C T P D L T S Q D C L R C L T R S I N
sp Q8GYA4 CRK10_A_P_D	- R V T G L F N C R G D V S - T E V C R R C V S F A Y G L V Q C T P D L T R Q D C S R C L Q L V I N
sp Q9ZP16 CRK11_Ai_P_N	- R V Y A I G M C I P G S T - S E D C S D C I K K E Y A L M Q C T P D L S S G D C E F C L R Q S A I
sp Q8GWJ7 CRK19_A_P_D	- R V T G L F L C R V D V S - S E V C R S C V T F A Y G M V R C T P D L R E Q D C L D C L K I G I N
sp O65482 CRK23_AF_P_D	- R V T G L F N C R G D V S - P E V C R R C V S F A Y T L V Q C T H D L T R Q D C S L C L Q Q I I N
sp O49564 CRK27_AF	- E V N A I A L C R G D V K P N Q D C I S C I T T A Y A L A Q C T P D L S E S D C R I C L A Q I F A
sp Q8S9L6 CRK29_Ai_S_G	- E R A Y A I G L C R R E V K - R D D C V S C I Q T A Y G T V Q C T P D L S E Q D C N D C L V F G F E
sp Q9LDN1 CRK33_A_P_D	- E V H V M G M C I D G T E - P T V C S D C L K V A Y A L M L Q T P D L E K G A C H N C L E K A V S
sp Q9XEC9 CRK38_A_	- V H V V G L C R R D Y D - R Q G C I N C V E E S Y M M M Q C T P D I N S G A C K R C L Q A S V T
sp Q9SYS3 CRK40_A_P	- D K V A L V S C A R G Y D - Q D A C Y N C V Q S I Y M L M Q C T P D L S S R D G C Q C L G D C V M

## CRKs研究进展

*CRK20*

*CRK20* modulates host responses  
to *Pseudomonas syringae* infection.

*CRK6* and *CRK7*

*CRK6* and *CRK7* protect  
against apoplastic oxidative  
stress.

*CRK13*

*CRK13* Enhances resistance to  
*Pseudomonas syringae*.

*CRK45*

*CRK45* functions in the responses  
to abscisic acid and abiotic stresses.

**CRKs** 在拟南芥抗病、抗逆、细胞凋亡等过程中起作用。

Acharya *et al.*, Plant Journal for Cell & Molecular Biology, 2010

Ederli *et al.*, Journal of Plant Physiology, 2011

Zhang *et al.*, Plant Physiology & Biochemistry, 2013

Idänheimo *et al.*, Biochemical & Biophysical Research Communications, 2014

*Arabidopsis thaliana*中的CRK基因

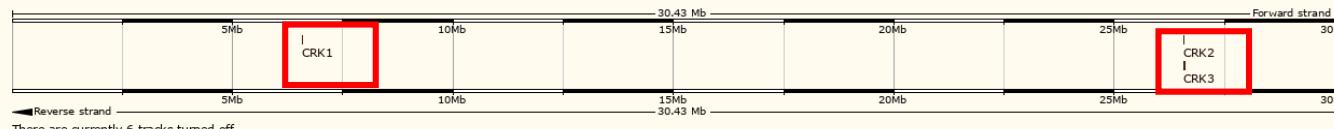
No.	Entry	Gene_id	Gene_name	Chromosome	No.	Entry	Gene_id	Gene_name	Chromosome
1	Q9LMB9	At1g19090	CRK1	1	23	Q9C5S9	At4g23140	CRK6	4
2	Q9CAL3	At1g70520	CRK2	1	24	Q8L7G3	At4g23150	CRK7	4
3	Q9CAL2	At1g70530	CRK3	1	25	O65468	At4g23160	CRK8	4
4	Q9LZU4	At3g45860	CRK4	3	26	O45469	At4g23170	CRK9	4
5	O23081	At4g00970	CRK41	4	27	Q8GYA4	At4g23180	CRK10	4
6	Q9XEC6	At4g04490	CRK36	4	28	Q9ZP16	At4g23190	CRK11	4
7	Q9XEC7	At4g04500	CRK37	4	29	O65472	At4g23200	CRK12	4
8	Q9XEC8	At4g04510	CRK38	4	30	Q0PW40	At4g23210	CRK13	4
9	Q9SYS7	At4g04540	CRK39	4	31	Q8H199	At4g23220	CRK14	4
10	Q9SYS3	At4g04570	CRK40	4	32	Q8W4G6	At4g23230	CRK15	4
11	Q9M0X5	At4g05200	CRK25	4	33	O65476	At4g23240	CRK16	4
12	Q9LDT0	At4g11460	CRK30	4	34	Q8L710	At4g23250	CRK17	4
13	Q9LDM5	At4g11470	CRK31	4	35	Q8RX80	At4g23260	CRK18	4
14	Q9LDS6	At4g11480	CRK32	4	36	Q8GWJ7	At4g23270	CRK19	4
15	Q9LDN1	At4g11490	CRK33	4	37	O65479	At4g23280	CRK20	4
16	Q8LPI0	At4g11521	CRK34	4	38	Q3E9X6	At4g23290	CRK21	4
17	Q9LDQ3	At4g11530	CRK35	4	39	Q6NQ87	At4g23300	CRK22	4
18	Q8GY82	At4g11890	CRK45	4	40	O65482	At4g23310	CRK23	4
19	O49564	At4g21230	CRK27	4	41	O65483	At4g23320	CRK24	4
20	O65405	At4g21400	CRK28	4	42	Q9M0G5	At4g28670	CRK43	4
21	Q8S9L6	At4g21410	CRK29	4	43	Q9T0J1	At4g38830	CRK26	4
22	Q9C5S8	At4g23130	CRK5	4	44	Q9FNE1	At5g40380	CRK42	5

## Preliminary results



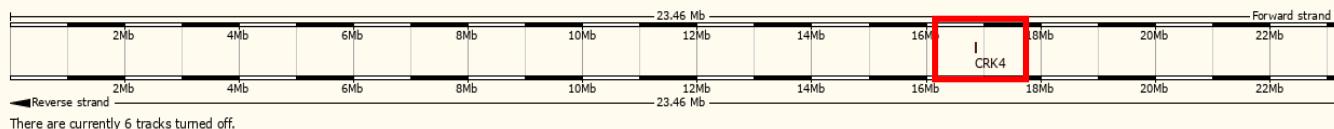
### 44 CRK Genes in *Arabidopsis thaliana*

Chr 1



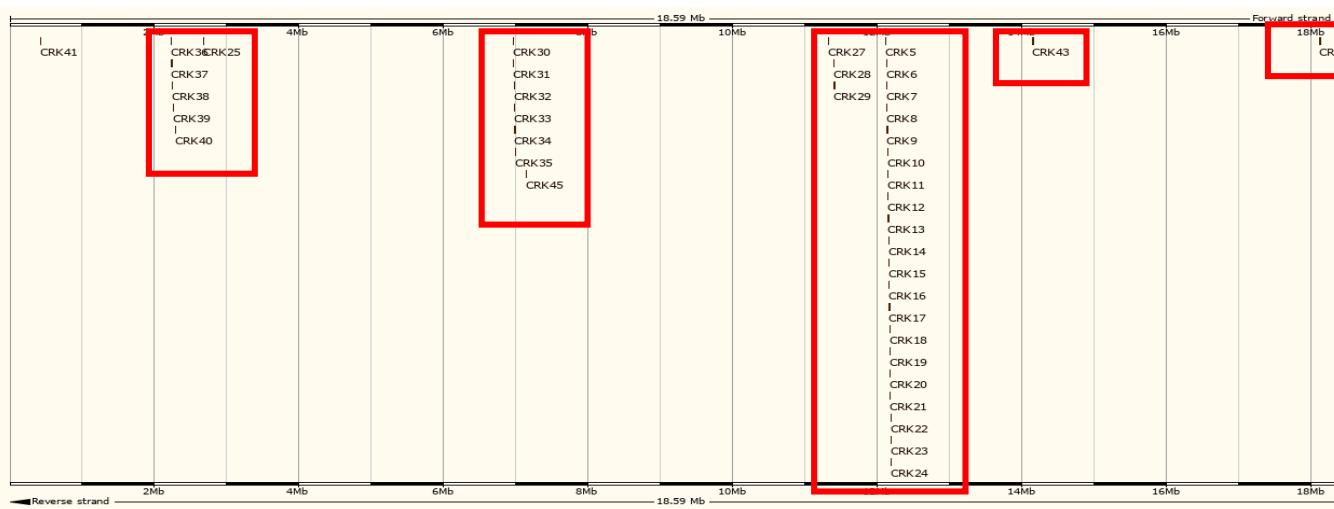
3个

Chr 3



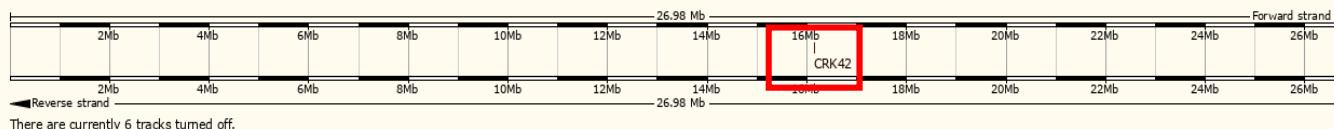
1个

Chr 4



39个

Chr 5



1个

大多CRK定位在4号染色体上.

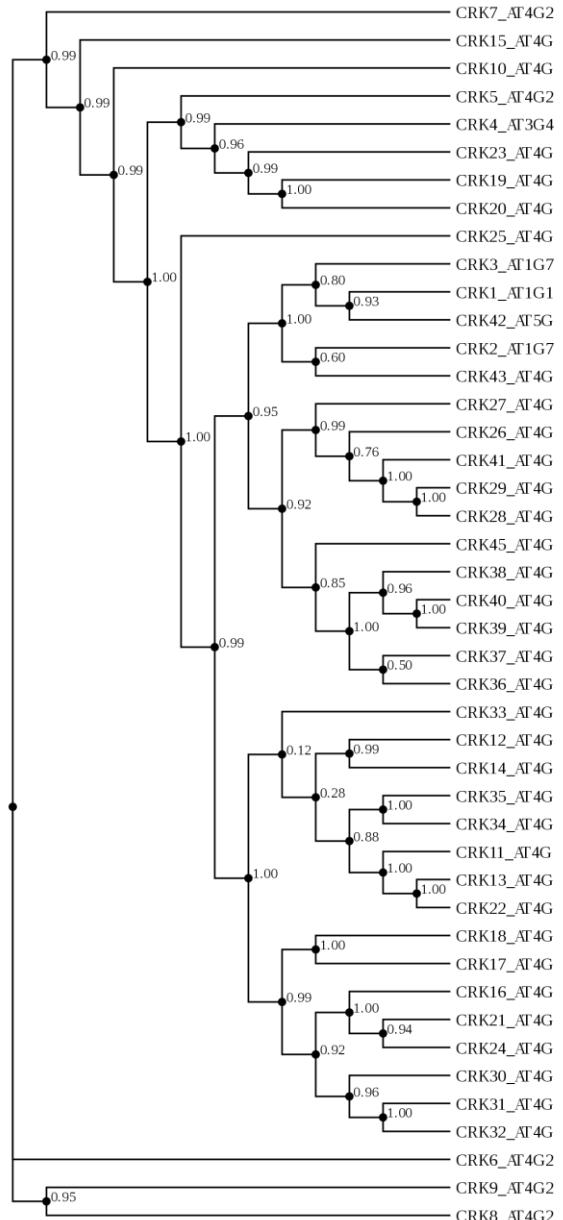
Ensembl

## CRKs进化树分析

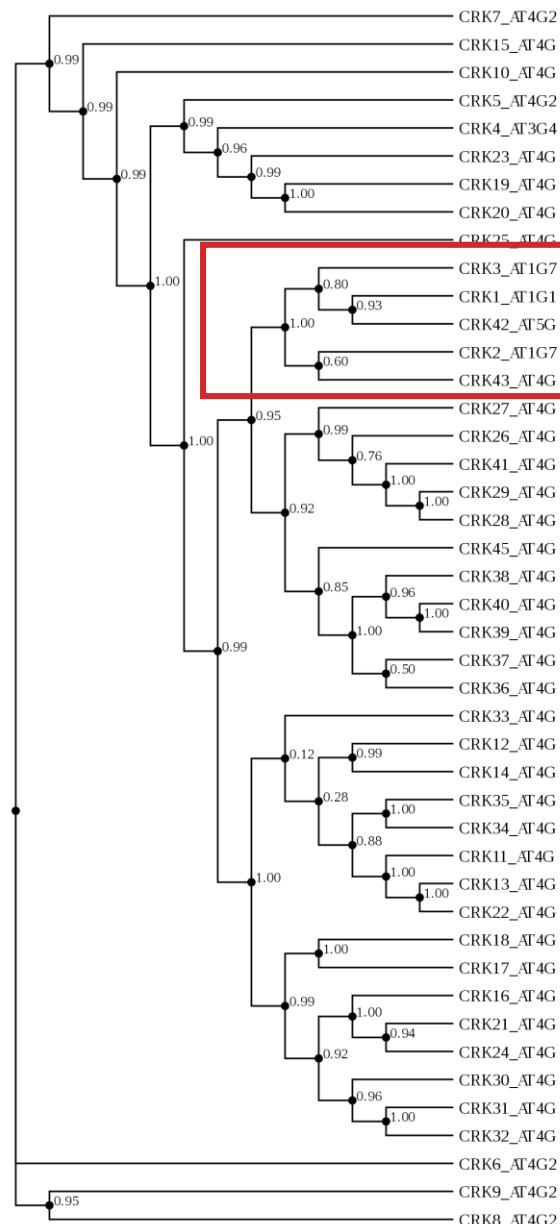
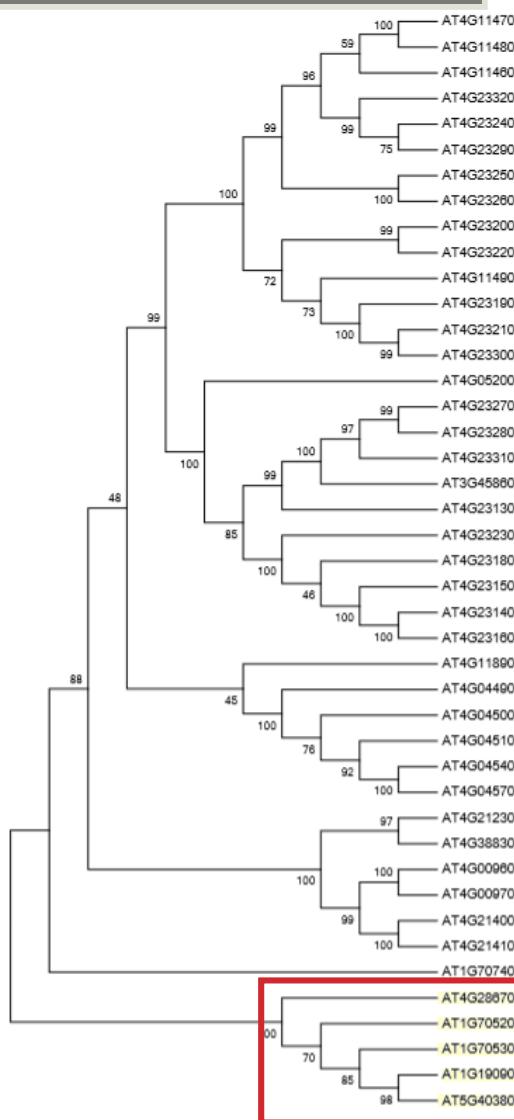
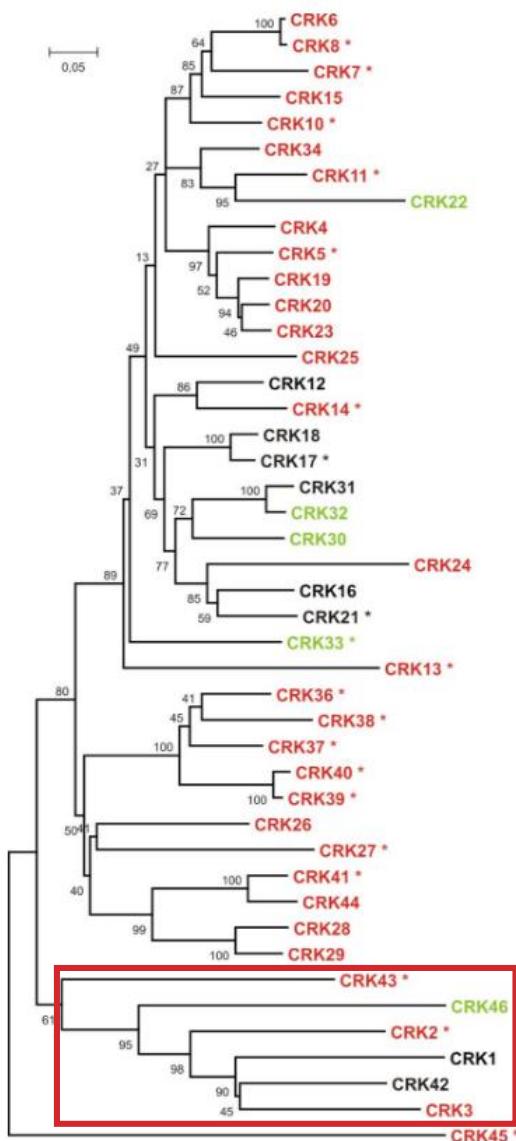
### PhyML 3.0: new algorithms, methods and utilities

Please cite:

"New Algorithms and Methods to Estimate Maximum-Likelihood Phylogenies: Assessing the Performance of PhyML 3.0."  
Guindon S., Dufayard J.F., Lefort V., Anisimova M., Hordijk W., Gascuel O.  
Systematic Biology, 59(3):307–21, 2010.



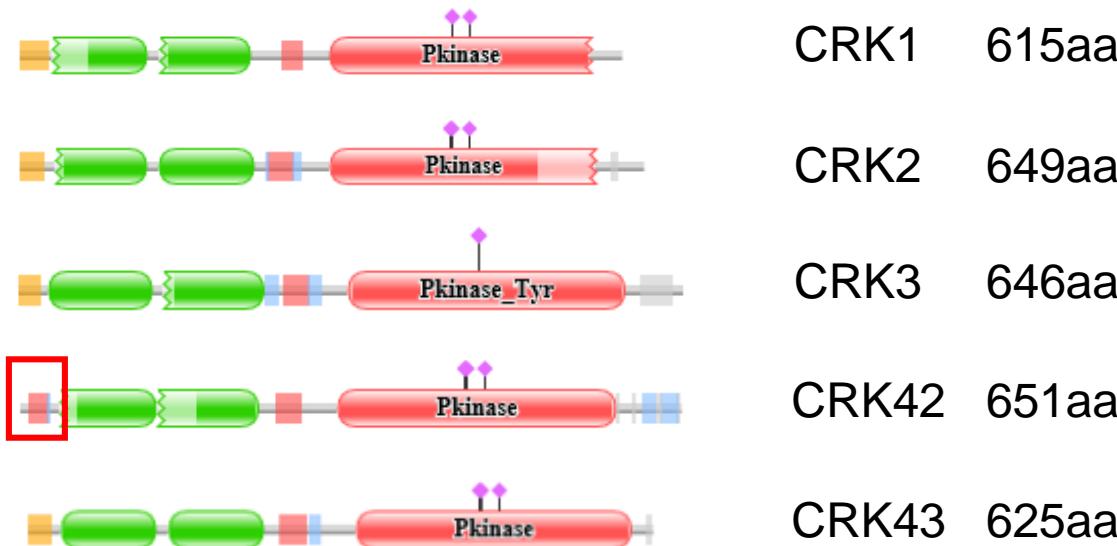
## CRKs进化树分析



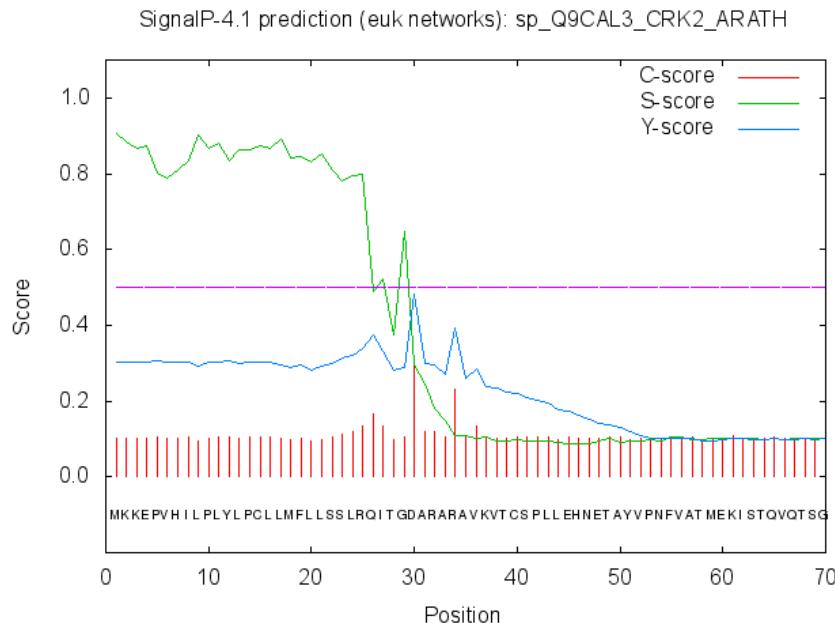
## 5 个CRK 基因及其不同剪接体

Gene ID	Gene Name	Location	Transcripts ID	Transcripts Length(bp)	Protein Length(aa)	Biotype
AT1G19090	CRK1,RKF2	Chromosome 1	AT1G19090.1	2509	NA	Nontranslating CDS
AT1G70520	CRK2	Chromosome 1	AT1G70520.1	2403	649	Protein coding
AT1G70530	CRK3	Chromosome 1	AT1G70530.3	2720	488	Protein coding
			AT1G70530.2	2699	538	Protein coding
			AT1G70530.1	2697	646	Protein coding
AT5G40380	CRK42	Chromosome 5	AT5G40380.1	2694	651	Protein coding
			AT5G40380.2	2569	556	Protein coding
			AT5G40380.3	1820	480	Protein coding
AT4G28670	CRK43	Chromosome 4	AT4G28670.1	1878	625	Protein coding

## 蛋白结构预测

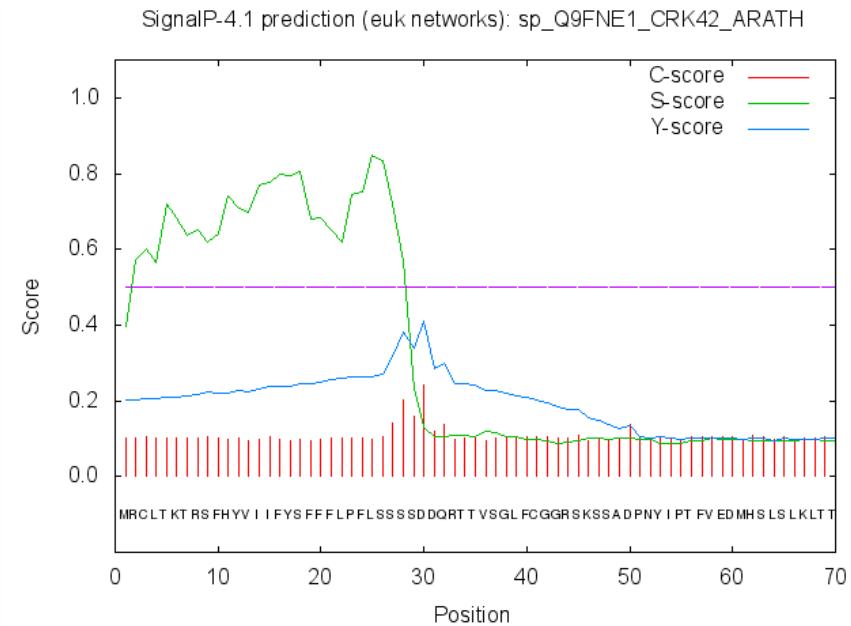


# CRK2&CRK42信号肽预测



#	Measure	Position	Value	Cutoff	signal peptide?
	max. C	30	0.295		
	max. Y	30	0.481		
	max. S	1	0.907		
	mean S	1-29	0.800		
D		1-29	0.653	0.450	YES

CRK2

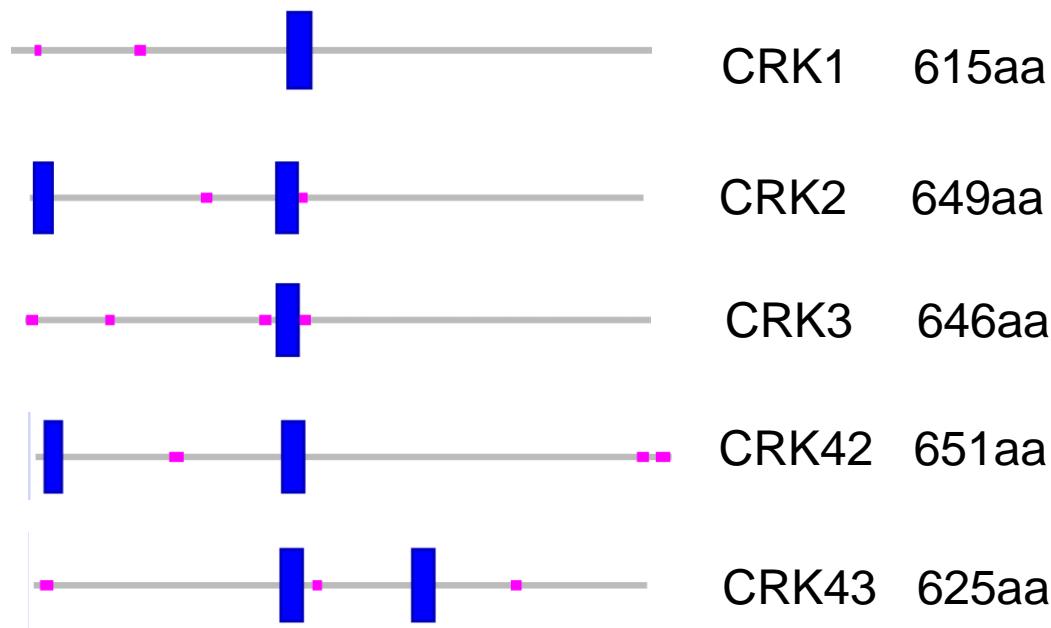


#	Measure	Position	Value	Cutoff	signal peptide?
	max. C	30	0.243		
	max. Y	30	0.412		
	max. S	25	0.848		
	mean S	1-29	0.673		
D		1-29	0.553	0.450	YES

CRK42

被预测为有信号肽区域，但分值较低。

## 跨膜域预测

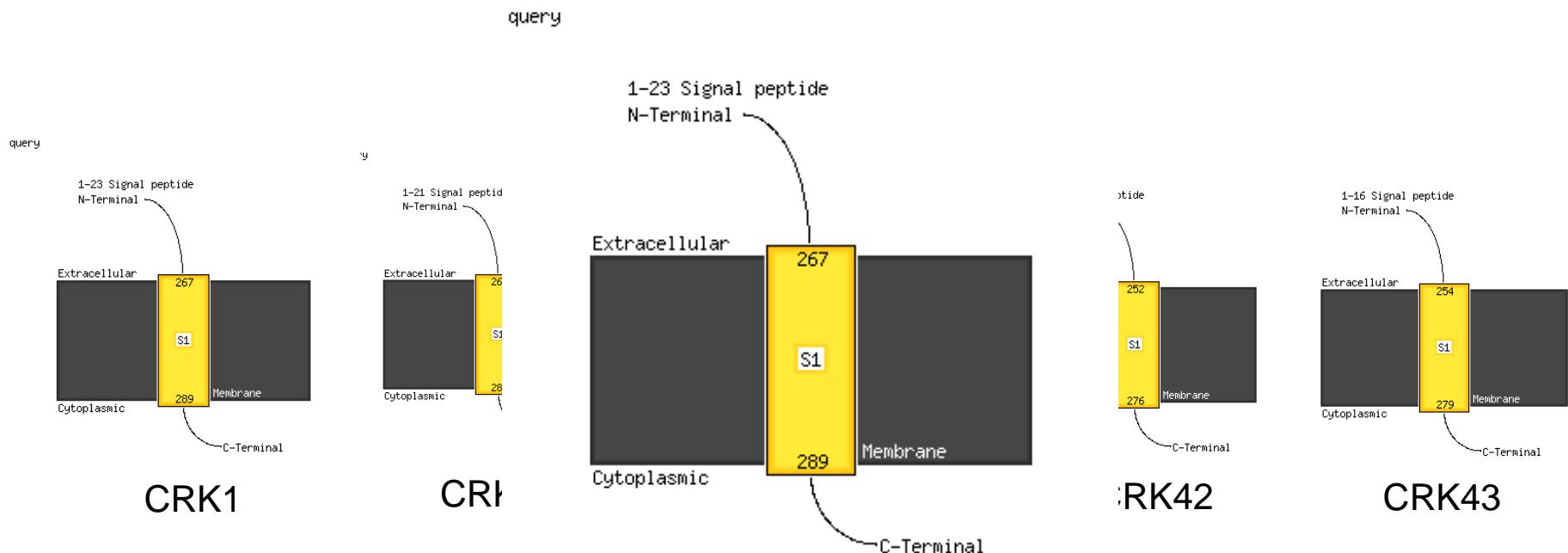


跨膜域



低复杂度域

## 跨膜域预测

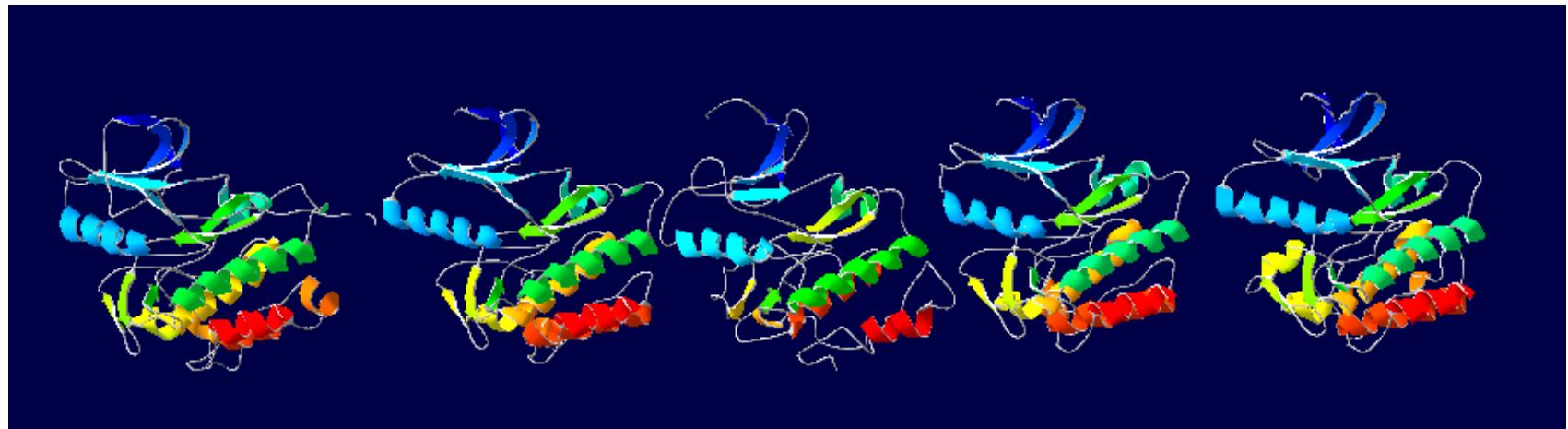


CRK1

## 3D结构

Protein	Precision	Coverage	Top Template PDB ID	Template binding small molecules
CRK43	100%	43%	2FO0	Yes
CRK2	100%	39%	2FO0	Yes
CRK3	100%	40%	5EBZ	Yes
CRK1	100%	39%	2FO0	Yes
CRK42	100%	39%	2FO0	Yes

## 3D结构



CRK1

CRK2

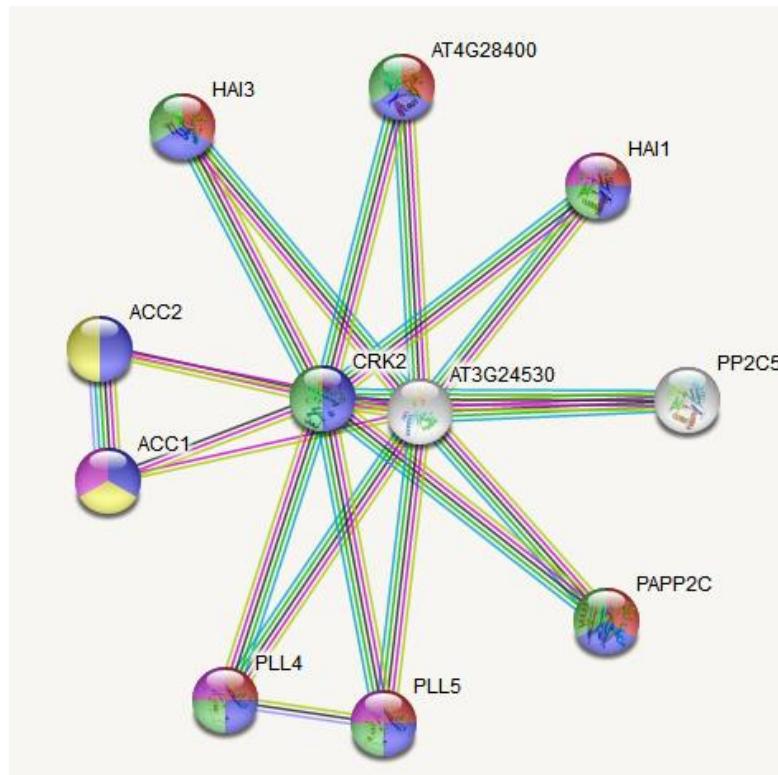
CRK3

CRK42

CRK43

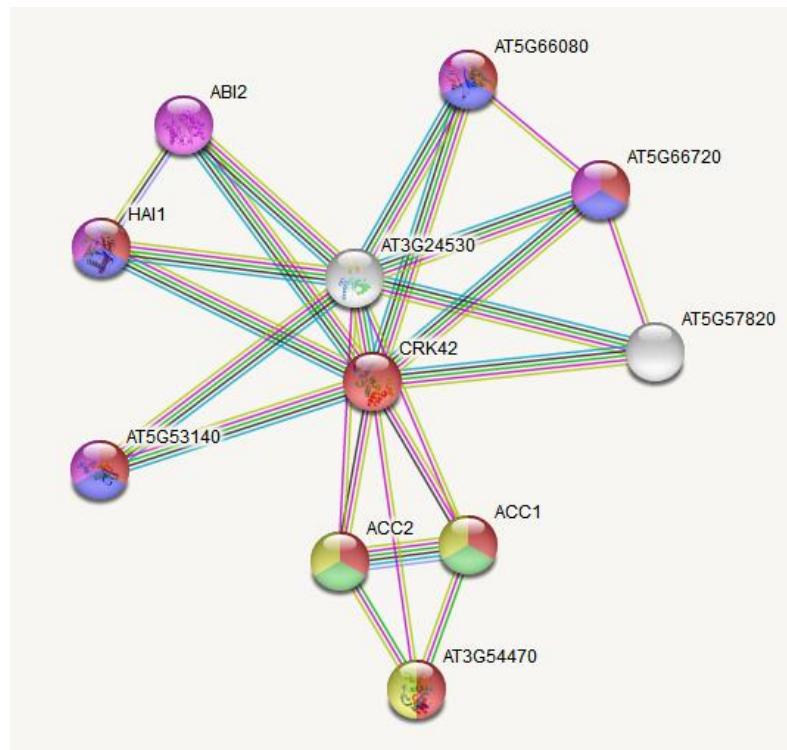
	CRK1	CRK2	CRK3	CRK42	CRK43
CRK1	-				
CRK2	2.62	-			
CRK3	5.15	3.69	-		
CRK42	3.05	1.53	4.02	-	
CRK43	3.73	2.56	4.53	3.38	-

## CRK2互作蛋白分析



Biological Process (GO)			
pathway ID	pathway description	count in gene set	false discovery rate
GO:0006470	protein dephosphorylation	6	1.83e-08
GO:0006796	phosphate-containing compound metabolic process	9	2.28e-07
GO:0006464	cellular protein modification process	7	0.000903
GO:2001295	malonyl-CoA biosynthetic process	2	0.000998
GO:0048367	shoot system development	4	0.0108
(more ...)			

## CRK42互作蛋白分析



Biological Process (GO)			
pathway ID	pathway description	count in gene set	false discovery rate
GO:0006796	phosphate-containing compound metabolic process	8	2.43e-05
GO:0006470	protein dephosphorylation	4	0.000221
GO:2001295	malonyl-CoA biosynthetic process	2	0.00141
GO:0042455	ribonucleoside biosynthetic process	3	0.00318
GO:0009260	ribonucleotide biosynthetic process	3	0.00334
(more ...)			



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BioGRID is an interaction repository with data compiled through comprehensive curation efforts. Our current index is version 3.4.161 and searches 65,218 publications for 1,585,828 protein and genetic interactions, 27,785 chemical associations and 39,028 post translational modifications from major model organism species. All data are freely provided via our search index and available for download in standardized formats.

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#### View Our Interaction Statistics

Find out how many organisms, proteins, publications, and interactions are available in the current release of the BioGRID.

### Search the BioGRID

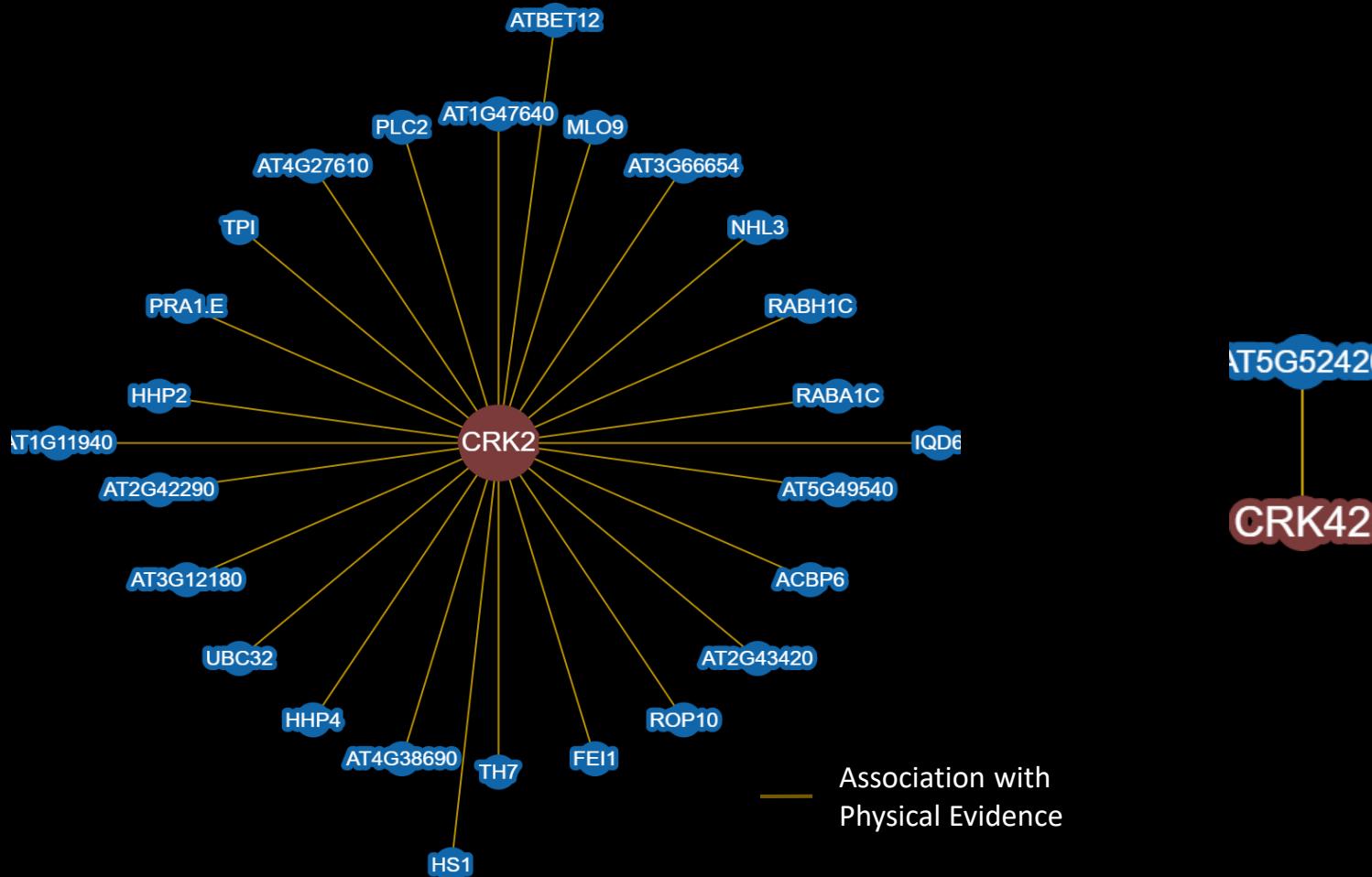
Search by identifiers, keywords, and gene names...

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# CRK2&42 蛋白互作网络分析



## Summary

### Wet-lab

- RNA-seq
- Double mutant

### Phylogenetic analysis

- Gene tree& amino acid tree
- CRK2、CRK3、CRK43

### Structure analysis

- Domain analysis
- 3D structure

### Protein-Protein Interactions

- Protein dephosphorylation
- Biosynthetic process

Ensembl/Uniport/  
MEGA/PhyML

Pfam/signalP/  
SMART/Phyre

String/BioGRID

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