A Spatial Analysis of the Genome

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Background

- Others have “mapped” and “spatially analyzed” genes
- visualization of gene fragments on a microarry(grid)
  - Does not correspond to location on chromosome
  - Does not consider spatial proximity of genes
  - Not true spatial mapping or analysis

Genes and Chromosomes in the GIS

- Genes as line segments
- Starting and ending nodes are known
- Chromosomes are genes end-to-end

The Question

- How do genes respond differently to radiation in parous and non-parous mice?
- Protective effect of parity on the risk of breast cancer

Mapping the Mouse Genome

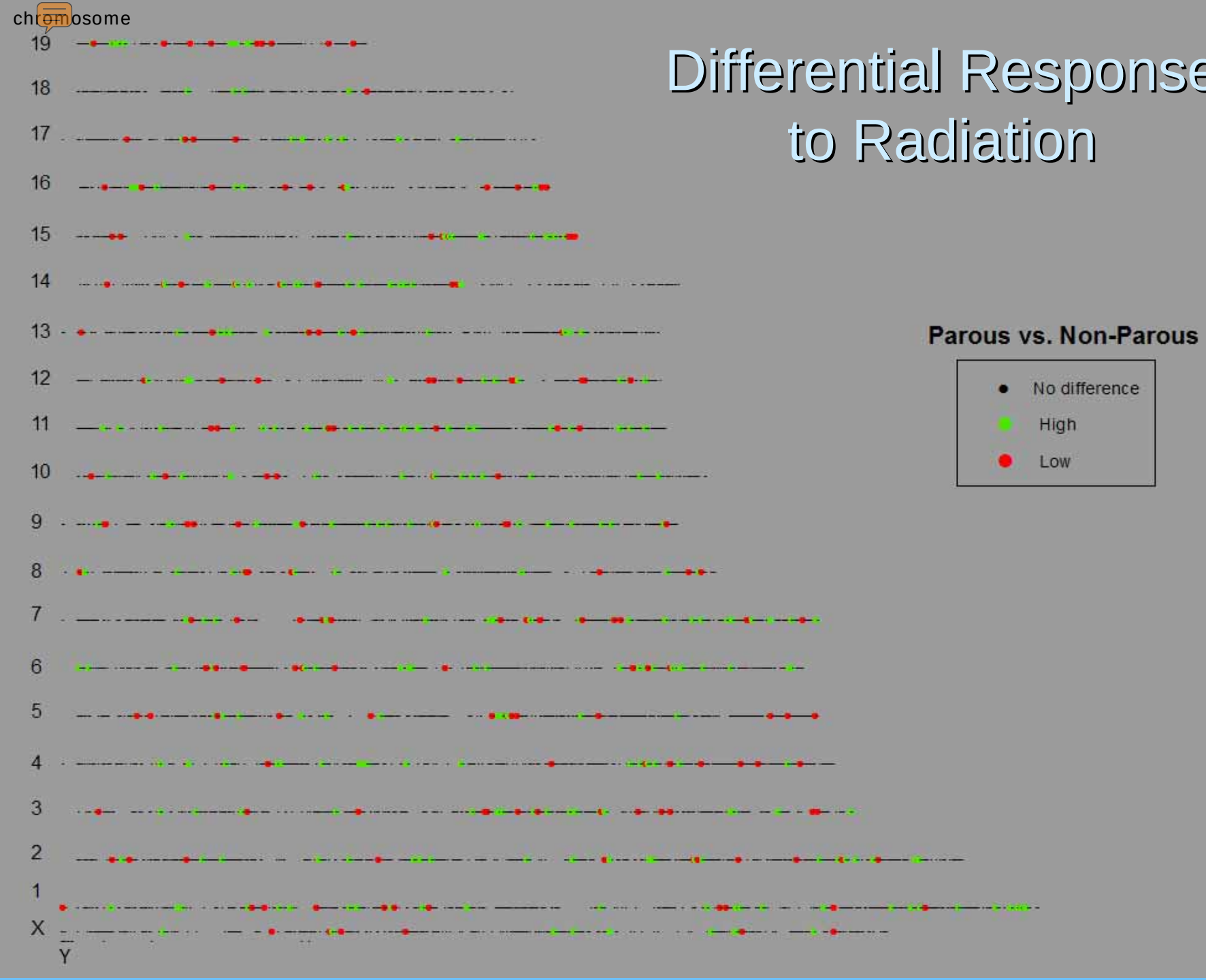
- 21, 000 genes on 21 chromosomes
- Starting and Ending Locations
- Used Cartesian Coordinate System
  - X = starting location
  - Y = chromosome # (for display)
- Mapped as points for analysis

Chromosomes.mxd - ArcMap - ArcInfo

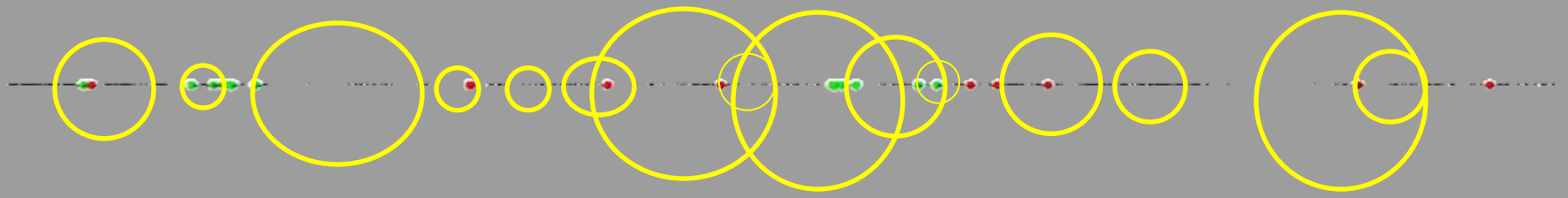
Table

FID	Shape *	Chrom	Start	End	Y	GeneID	Ratio	ID	Y1	ChromName	y2
14	Point ZM	1	132723271	132748377	1	18703	0.635269	15	1000000	1	10000000
15	Point ZM	1	135944511	135944738	1	14264	0.963892	16	1000000	1	10000000
16	Point ZM	1	136079053	136086608	1	12654	1.825004	17	1000000	1	10000000
17	Point ZM	1	153737977	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	Point ZM	1	153739451	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	Point ZM	1	167522308	167564662	1	68481	0.716575	20	1000000	1	10000000
20	Point ZM	1	174153643	[illegible]	1	[illegible]	[illegible]	21	[illegible]	1	10000000
21	Point ZM	1	180868682	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	Point ZM	1	188447313	188529868	1	21808	0.727743	23	1000000	1	10000000
23	Point ZM	1	188447313	188529868	1	21808	0.796258	24	1000000	1	10000000
24	Point ZM	1	188447313	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	Point ZM	1	192829710	192832334	1	226844	0.631068	26	1000000	1	[illegible]
26	Point ZM	1	193604596	193608134	1	226856 /// 98667	-0.673178	27	1000000	1	10000000
27	Point ZM	1	193604596	[illegible]	1	[illegible]	[illegible]	28	1000000	1	10000000
28	Point ZM	1	194332795	194334041	1	16510	1.27102	29	1000000	1	10000000
29	Point ZM	1	194670624	194677337	1	214791	0.873869	30	1000000	1	10000000
30	Point ZM	1	194680436	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	Point ZM	1	23373262	23390004	1	70155	0.60459	32	1000000	1	10000000
32	Point ZM	1	23373262	23390004	1	70155	0.818038	33	1000000	1	10000000
33	Point ZM	1	23373262	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
34	Point ZM	1	24184534	[illegible]	1	[illegible]	[illegible]	[illegible]	1000000	1	[illegible]
35	Point ZM	1	24202083	24259527	1	12839	1.912218	36	1000000	1	10000000
36	Point ZM	1	37668499	37682539	1	72097	0.88797	37	1000000	1	10000000
37	Point ZM	1	40911813	40913734	1	381339	-0.719477	38	1000000	1	10000000
38	Point ZM	1	43787446	43799411	1	78896	2.787244	39	1000000	1	10000000
39	Point ZM	1	43799089	43799409	1	78896	1.067007	40	1000000	1	10000000
40	Point ZM	1	43799089	43799409	1	78896	3.390719	41	1000000	1	10000000
41	Point ZM	1	45964907	45982736	1	53945	1.334782	42	1000000	1	10000000
42	Point ZM	1	45964907	45982736	1	53945	1.354228	43	1000000	1	10000000
43	Point ZM	1	51358226	51358473	1	20324	-0.580666	44	1000000	1	10000000
44	Point ZM	1	59539439	59543799	1	14369	0.655985	45	1000000	1	10000000
45	Point ZM	1	66485979	66489157	1	17756	0.764477	46	1000000	1	10000000

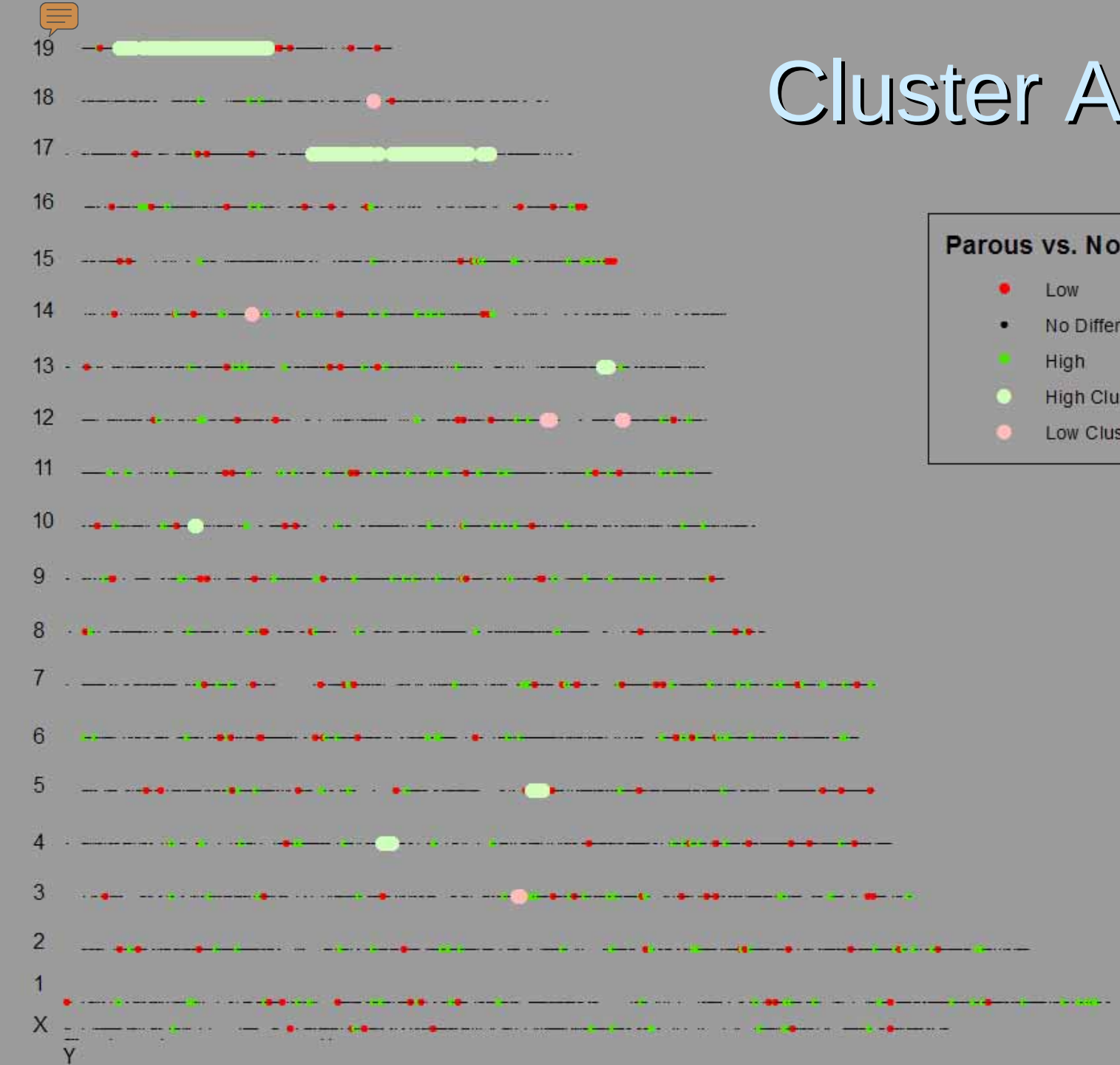
Differential Response to Radiation



The Spatial Scan Statistic



Cluster Analysis



Conclusions

- Genes act in a coordinated fashion based on their spatial organization
- Parous mice have a much stronger response to environmental stressors like radiation
- Discrete regions of chromosomes containing genes with enhanced response (clusters) suggest coordinated changes in DNA structure

Next Steps

- What are the functions of the individual genes in clusters?
- Are they related to disruption of oncogenesis?

Thank you

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