Presenting your data effectively: In papers, slides and proposals

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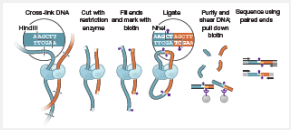
Topics

Principles of good graphic design
&
Strategies for designing persuasive graphics design
according to Judith Swan



Points of View
on Graphics by Bang Wang

Principles of good graphic design — Judith Swan

- Let the content drive the design
- Define the relationship probed in the visual
- Let the reader / viewer into the analysis – label the relevant content
- Design each visual to make a point
- Make the point of the visual visible to the reader / viewer
- Reduce “Chart Junk”
- Make changes visible
- Use difference in appearance to indicate significance
- Make differences when trying to show change
- Make differences *only* when showing change

Edward Tufte:

The Visual Display of quantitative Information. Cheshire, CT: Graphics Press, 1983

Envisioning Information. Cheshire, CT: Graphics Press, 1993

Visual Explanations: Images and Quantities, Evidence and Narrative. Graphics Press, 1998

Strategies for designing persuasive graphics design

Understand how visuals work:

- The visual field is finite – use its boundaries to provide structure
- The visual field is deep – use the eye’s full range of resolution
- Viewers have natural patterns of motion: use them to pull viewers in
  - Left to right
  - Top to bottom
  - Chronology
- Viewers are bored with description — allow them to analyze

Strategies for designing persuasive graphics design

Make it possible for the viewer to analyze:

- Provide context and emphasis
  - Context: will gleaned from the static and predictable
  - Emphasis: will be gleaned from change and novelty

Limit *differences* to moments of *change* and *novelty*

- Organize the visual so that viewers find the context before the point of emphasis
- Keep track of the what is implied – with respect to quantity, quality, relevance and probability
  - If you violate a principle unintentionally you won't be able to violate it deliberately

Strategies for designing persuasive graphics design

Discover the most revealing (and relevant) representation

- Every picture tells a story – select the one whose basic story is the one you want to tell.
- The default settings in most software are probably not helpful
  - Design your own template
  - Match ink to information
  - Use open space purposefully
- The first representation is rarely the most informative
  - Plan to revise
  - Question the context
  - Try an alternative – it might tell you something new
  - Get feedback

Strategies for designing persuasive graphics design

Discover the most revealing (and relevant) representation

- Scientific reviewers read figures before text – make sure the figures stand on their own.
- Listen to your viewers' description of their problem with interpretation – the viewer is always right!.

Color Coding — use a systematic approach

When using color to differentiate information into classes:

- Colors are not always easily be discriminated (by everybody)
- The assignment of meaning / ordering colors is inherently ambiguous
- Incremental changes don't always translate to magnitude of change
- Transitions from one to the next can be uneven

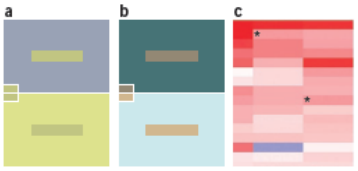


Figure 1 | Perception of color can vary. (a,b) The same color can look different (a), and different colors can appear to be nearly the same by changing the background color (b)[1]. (c) The rectangles in the heat map indicated by the asterisks (*) are the same color but appear to be different.

Can use to represent categorical data but:

- Need to be careful not to bias reader
- Must be discernable but comparable in visibility
- Perception of color can be affected by neighboring color (problem with heat maps)

Bang Wong | *Nature Methods* | VOL.7 NO.8 | AUGUST 2010 | 573

Color Coding — use a systematic approach

Recommends using color wheel in Illustrator/Photoshop and

- Spiraling through color wheel
- And varying lightness

Other considerations:

- Size of "visual objects" … smaller / thinner require more variation in hue, saturation, & lightness
- And vary lightness

Do *not* use more than 6-8 colors!

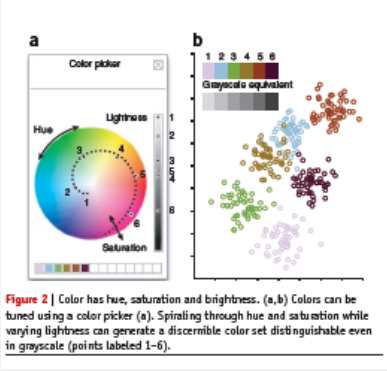


Figure 2 | Color has hue, saturation and brightness. (a,b) Colors can be tuned using a color picker (a). Spiraling through hue and saturation while varying lightness can generate a discernible color set distinguishable even in grayscale (points labeled 1–6).

Data Figures – pay attention to visual design

Use to encode information that the reader will the decode, based on:

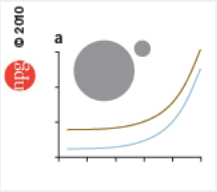
- Intuition
- Common sense
- Precedent

Careful to accommodate reader needs and perception without:

- Being misleading
- Making data difficult to discern

Beware of optical illusions created by:

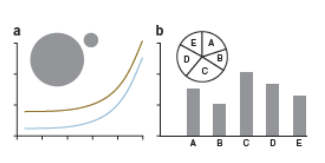
- Curves
- Bubble charts (relative area)



Data Figures – pay attention to visual design

Use:

- Tables to give precise names & numbers
- Graphs to show patterns / trends
  - Pie charts – good for showing the parts of a whole
  - Bar charts – better for showing relative values



When inventing new ways to plot data

- Ideally, use highly efficient and accurate perceptual tasks (see Table)
- Examples: 5 values plotted differently
  least effective –> most effective

Table 1 | Elementary perceptual tasks

Rank	Aspect to compare
1	Positions on a common scale
2	Positions on the same but nonaligned scales
3	Lengths
4	Angles, slopes
5	Area
6	Volume, color saturation
7	Color hue

Tasks are ordered from most to least accurate. Information adapted from ref. 2.

Gestalt Principles – use to make more of your graphics

Gestalt =

- Interplay between parts and the whole
- The whole (i.e., emergent entity) is other than the sum of the parts — *Kurt Koffka*
- Additional layers of meaning can be imparted by composing figure parts according to specific principles

Grouping Principles:

- Similarity
- Proximity
- Connection
- Enclosure

Gestalt Principles – use to make more of your graphics

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Subjective contour

Grouping Principles:

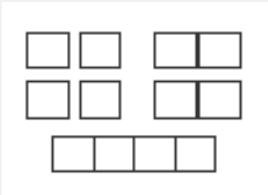
- Similarity — can give the impression of relationship
  - Shape, size and color
  - Font, type size, orientation and white space

Visual grouping

Gestalt Principles – use to make more of your graphics

Proximity:

- Bring more closely related panels together
  - Arrange in pairs to for pairwise comparisons
  - Arrange in rows for reading in sequence
- Relative spacing influences vertical vs horizontal perception



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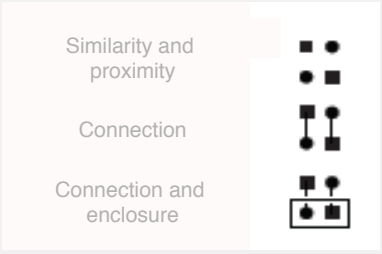
Gestalt Principles – use to make more of your graphics

For perception as unified whole…

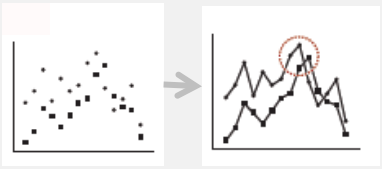
Connection:

- Lines
  - Create clear connections
  - Bring out overall shape of data
  - Good for encoding information in graphs & network diagrams



Enclosure:

- More powerful than others
- Overcomes similarity, proximity and connection



Gestalt Principles – use to make more of your graphics

Goal:

- Layout of Information should enhance the message

Principles:

- Visual completion
- Continuity

Visual interpolation:

- Illusion of contours that do not exist (a, b)
- Viewers tend to complete objects as simple and familiar shapes (b) — we fill in voids
- All elements on a page affect perception of every other element
  - therefore forgo clutter

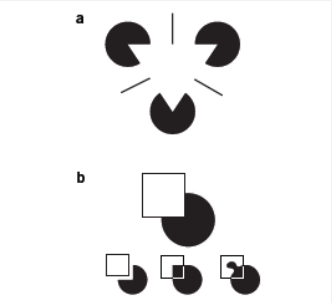


Figure 1 | Visual completion. (a) The Kanizsa triangle and illusory contour. (b) Spontaneous and automatic completion of occluded surfaces as a simple and familiar circle.

Gestalt Principles – use to make more of your graphics

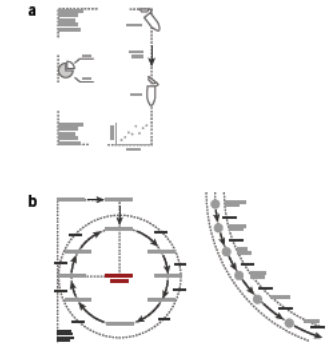


Figure 2 | Alignment. (a) Graphics and text used as vertices and edges of geometric shapes. (b) Geometric and curvilinear shapes used as flexible guides to align content.

Constructing unified compositions:

- Draw in background shapes and use as guides in constructing figures (use grids in graphics programs)
- Compositions that use guides look clean and professional
- Different types of guides:
  - Distinguish labels that describe actions from names (e.g., color, typography)

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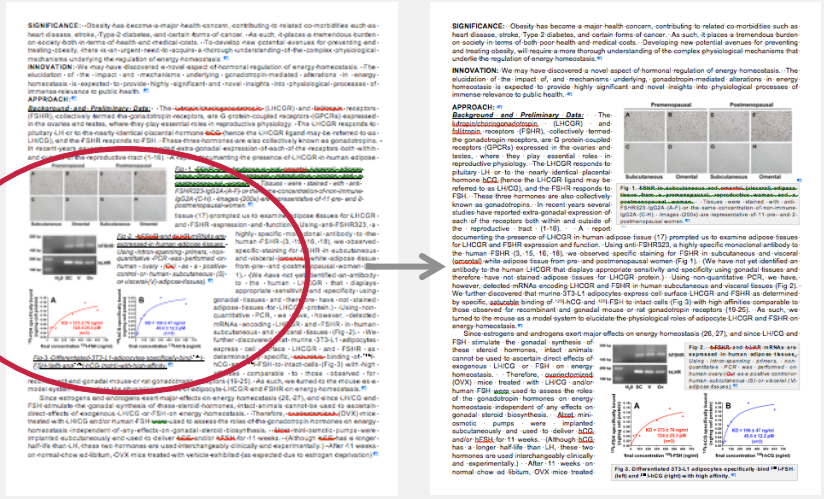
Gestalt Principles – use to make more of your graphics



Negative space – use to attract the reader's attention

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Negative space – use to attract the reader's attention

Judicious use:

- Gives elements breathing room
- Has visual appeal
- Can guide reader through the figure
- More effective than color in a crowded space

Overcrowded graphics:

- Taxing to comprehend
- Often biggest problem is irregularity of white space
- Sometimes it's hard to tell the difference between elements of a composition…

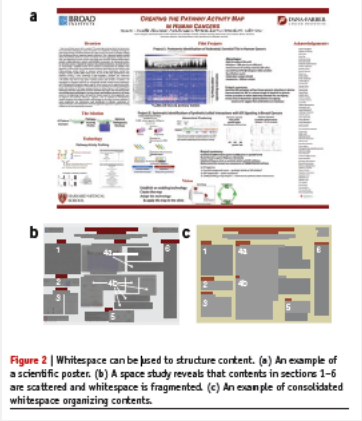

Figure 2 | Whitespace can be used to structure content. (a) An example of a scientific poster. (b) A space study reveals that contents in sections 1–6 are scattered and whitespace is fragmented. (c) An example of consolidated whitespace organizing contents.

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Negative space – use to attract the reader's attention

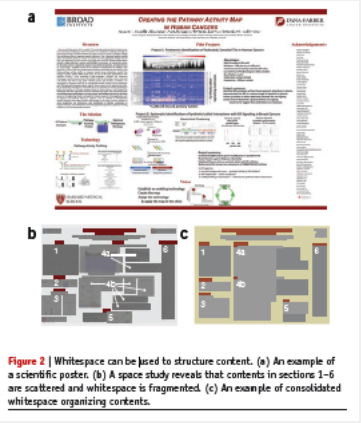

Figure 2 | Whitespace can be used to structure content. (a) An example of a scientific poster. (b) A space study reveals that contents in sections 1–6 are scattered and whitespace is fragmented. (c) An example of consolidated whitespace organizing contents.

Additional solutions:

- Unify white spaces into regular blocks
- Align horizontally and vertically in ways that provide information about grouping
  - E.g. gaps between sections larger than between subsections
  - Will symbolize hierarchy and organization of content
- Text gives you more flexibility in filling gaps than images do

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Conceptual figures – use layout to express the figure's meaning

Used intent of figure to guide revision:

- Purpose of figure – to illustrate the three parts of a microscope
- Grouped and compartmentalized, and added a prominent horizontal feature linking the parts of the system
- Consolidated white space into more regular shapes
- Eliminated irrelevant detail

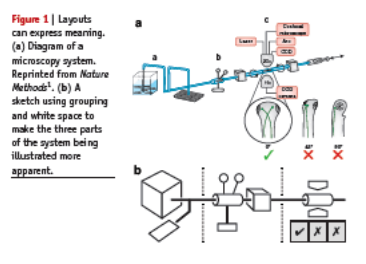

Figure 1 | Layouts can express meaning. (a) Diagram of a microscopy system. Reprinted from *Nature Methods*[1]. (b) A sketch using grouping and white space to make the three parts of the system being illustrated more apparent.

Becomes harder as complexity of system increases…

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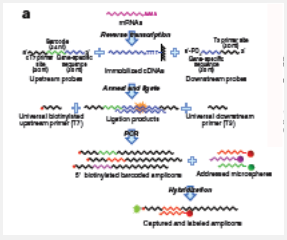
Conceptual figures – use layout to express the figure's meaning

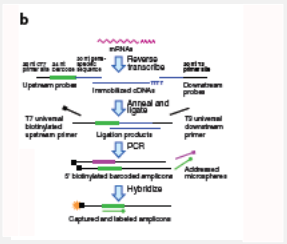
Protocol for analyzing gene expression:

- Division into steps is good
- Even distribution vertically but no good path to follow and no visual cues with respect to relationships



Adjustments:

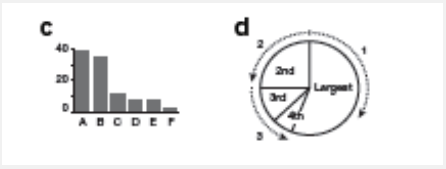
- Used visual completion – aligned arrows to connect and order the process
- Presented additional agents (not on central path) misaligned or at angle
- Simplified symbols (straight lines)
- Made language more consistent (parallel)



Data Figures – pay attention to visual design

Purpose of graphs:

- Reveal connections
- Depends on reader to form patterns
- Graphical encoding needs to support this
  - To convey magnitude of difference – use bar chart
  - To show the components of a whole – use pie chart
- A recommendation for pie charts –
  - Largest wedge to right of 12:00
  - Second to the left
  - Continue counter-clockwise



Typography –

Know conventions of your industry:

- Possible bias with regard to use of serif vs sans serif fonts
- Some believe
  - serif better for posters and written documents
  - sans serif better for headings and labels (slides)

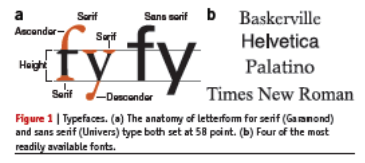


Figure 1 | Typefaces. (a) The anatomy of letterform for serif (Garamond) and sans serif (Univers) type both set at 58 point. (b) Four of the most readily available fonts.

Guidelines

- Do not mix fonts in a document
- Use text spacing to show relationships (e.g. section vs. subsection)
  - Use space before / after instead of carriage returns
- Use minimal highlighting in documents (e.g. italicize and underline)

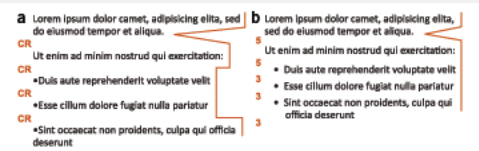


Figure 2 | Spacing can reveal structure and give meaning to text. (a) Uniform carriage return (CR) spacing is incongruous with hierarchical content. (b) Relative spacing using paragraph formatting expresses relationships in the text. Numbers are 'space after' values given in point sizes.

Overview figures – use to provide context

Illustration of a procedure:

- To portray a continuous process, create continuity in imagery and descriptions
- Relate each step to the one before and to the one after
- Highlight all differences
- Use "A to B" states (graphics) connected by an action (text)
- In redrawing A to create B, highlight only the effective change
- Avoid confusion by accounting for all elements added to or removed from figure
- Make as few marks as possible and keep them compact

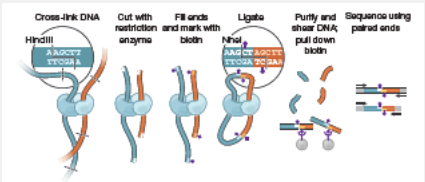


Figure 1 | Overview figures can clarify concepts. Outline of the Hi-C technique used to decipher the three-dimensional structure of the human genome. Reprinted from reference 1.

In this example, saved space by

- Taking advantage of left-to-right ordering – no need to use connecting arrows
- Moved actions to headers above images

Overview figures – use to provide context

Avoid using the same symbols for more than one purpose:

- e.g. arrows to indicate motion and to point (Fig – used only to indicate primers)

Stick to concepts

- Do not try to incorporate data
- Authors of this initially wanted to include heat-map data

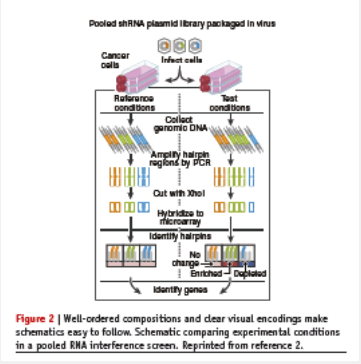
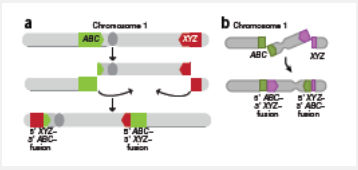


Figure 2 | Well-ordered compositions and clear visual encodings make schematics easy to follow. Schematic comparing experimental conditions in a pooled RNA interference screen. Reprinted from reference 2.

Simplify to clarify – pay attention to visual design

In science, communications should be accurate and concise:

- Tufte: reduce proportion of graphic that is there for decorative purposes / can be erased without loss of data information
- Reduce number of elements ("marks") on page
- Do not give in to the impulse to fill all white space
- Approach – focus on intent of figure to pare down
- Create hierarchy of information, eliminate extraneous elements, and refine the remainder



Inversion event

- Combined first two steps
- Removed arrows to indicate movement

Simplify to clarify – pay attention to visual design

Eliminate redundant elements:

- Multiple uses of reaction – extract reaction and use as a header (more tidy)
- Mutliple examples – use the minimum necessary to make your point

Systematic reorganization, e.g.:

- Move labels of steps to above arrows
- Keep labels of products with images
- Create clear boundaries between groups by aligning elements to imaginary horizontal and vertical lines

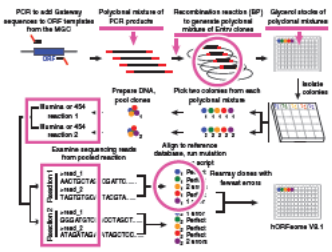
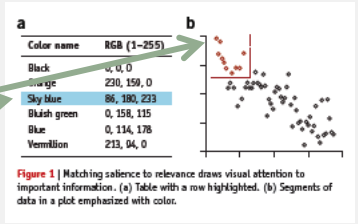


Figure 2 | Reducing redundant elements. Words repeated in several labels (magenta boxes) can be pulled out as headers. Using the smallest number of examples to convey a concept will make ideas easier to understand (magenta circles). Grouping labels that describe transformations between steps with arrows and starting or ending products with images (magenta arrows) will add meaningful structure to layouts. Reprinted from *Nature Methods*[2].

Salience to relevance – careful not to misdirect attention

Be sure that salience aligns with relevance:

- E.g. in slides, highlight most relevant information
- Although not appropriate in most situations in papers, can be helpful in slides because of time constraints
- Do *not* highlight something that is not very important OR obscure something that is important (high values in red, but can't see well on background)
- Use powerpoint judiciously – animations can distract



Color name	RGB (1–255)
Black	0, 0, 0
[illegible]	230, 159, 0
Sky blue	86, 180, 233
Bluish green	0, 158, 115
Blue	0, 114, 178
Vermillion	213, 94, 0

Figure 1 | Matching salience to relevance draws visual attention to important information. (a) Table with a row highlighted. (b) Segments of data in a plot emphasized with color.

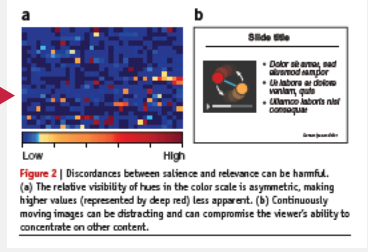
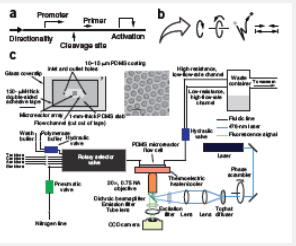
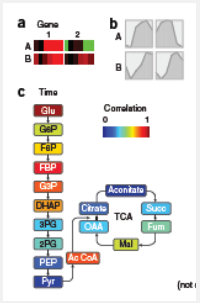


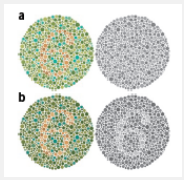
Figure 2 | Discordances between salience and relevance can be harmful. (a) The relative visibility of hues in the color scale is asymmetric, making higher values (represented by deep red) less apparent. (b) Continuously moving images can be distracting and can compromise the viewer's ability to concentrate on other content.

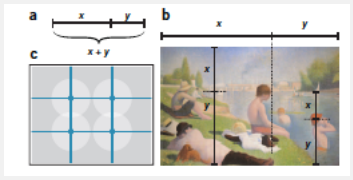
Additional topics covered by Bang Wong

- Color blindness
- Avoiding color
- Arrows
- Layout



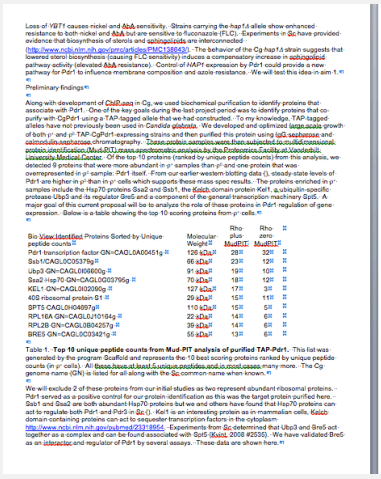






Bang Wong | *Nature Methods*

Applying some of these principles in other contexts



Loss of *YBT1* causes nickel and AbA sensitivity. -Strains carrying the *hap1Δ* allele show enhanced resistance to both nickel and AbA but are sensitive to fluconazole (FLC). -Experiments in Sc have provided evidence that biosynthesis of sterols and sphingolipids are interconnected (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1386483). -The behavior of the Cg *hap1Δ* strain suggests that lowered sterol biosynthesis (causing FLC sensitivity) induces a compensatory increase in sphingolipid pathway activity (elevated AbA resistance). -Control of *HAP1* expression by Pdr1 could provide a new pathway for Pdr1 to influence membrane composition and azole resistance. -We will test this idea in aim 1.

Preliminary findings

Along with development of ChIP-seq in Cg, we used biochemical purification to identify proteins that associate with Pdr1. -One of the key goals during the last project period was to identify proteins that co-purify with CgPdr1 using a TAP-tagged allele that we had constructed. -To my knowledge, TAP-tagged alleles have not previously been used in *Candida glabrata*. -We developed and optimized large-scale growth of both n+ and n- TAP-CgPdr1-expressing strains and then purified this protein using IgG-sepharose and calmodulin-sepharose chromatography. -These protein samples were then subjected to multidimensional protein identification (Mud-PIT) mass spectrometric analysis by the Proteomics Facility at Vanderbilt University Medical Center. -Of the top-10 proteins (ranked by unique peptide counts) from this analysis, we detected 9 proteins that were more abundant in n+ samples than n- and one protein that was overrepresented in n- sample: Pdr1 itself. -From our earlier western blotting data (), steady-state levels of Pdr1 are higher in n+ than in n- cells which supports these mass spec results. -The proteins enriched in n+ samples include the Hsp70 proteins Sse2 and Ssb1, the Kelch domain protein Ker1, a ubiquitin-specific protease Ubp3 and its regulator Bre5 and a component of the general transcription machinery Spt5. -A major goal of this current proposal will be to analyze the role of these proteins in Pdr1 regulation of gene expression. -Below is a table showing the top 10 scoring proteins from n+ cells.

Bio View Identified Proteins Sorted by Unique peptide counts	Molecular Weight	Rho-plus Mud-PIT	Rho-zero Mud-PIT
Pdr1 transcription factor GN=CAGL0A00451g	126 kDa	28	32
Ssb1/CAGL0C05375g	66 kDa	23	12
Ubp3 GN=CAGL0E06600g	91 kDa	19	10
Sse2 Hsp70 GN=CAGL0G03799g	70 kDa	18	12
KEL1 GN=CAGL0I02090g	127 kDa	17	3
40S ribosomal protein S1	29 kDa	15	11
SPT5 CAGL0H04697g	110 kDa	15	6
RPL16A GN=CAGL0J10194g	22 kDa	14	6
RPL8B GN=CAGL0B04257g	39 kDa	14	6
BRE5 GN=CAGL0C03421g	55 kDa	13	6

Table 1. -**Top 10 unique peptide counts from Mud-PIT analysis of purified TAP-Pdr1.** -This list was generated by the program Scaffold and represents the 10 best scoring proteins ranked by unique peptide counts (in n+ cells). -All these have at least 5 unique peptides and in most cases many more. -The Cg genome name (GN) is listed for all along with the Sc common name when known.

We will exclude 2 of these proteins from our initial studies as two represent abundant ribosomal proteins. -Pdr1 served as a positive control for our protein identification as this was the target protein purified here. -Ssb1 and Sse2 are both abundant Hsp70 proteins but we and others have found that Hsp70 proteins can act to regulate both Pdr1 and Pdr5 in Sc (). -Ker1 is an interesting protein as in mammalian cells, Kelch-domain-containing proteins can act to sequester transcription factors in the cytoplasm (http://www.ncbi.nlm.nih.gov/pubmed/23318864). -Experiments from Sc determined that Ubp3 and Bre5 act together as a complex and can be found associated with Spt5 (Kohli, 2008 #2535). -We have validated Bre5 as an interactor and regulator of Pdr1 by several assays. -These data are shown here.

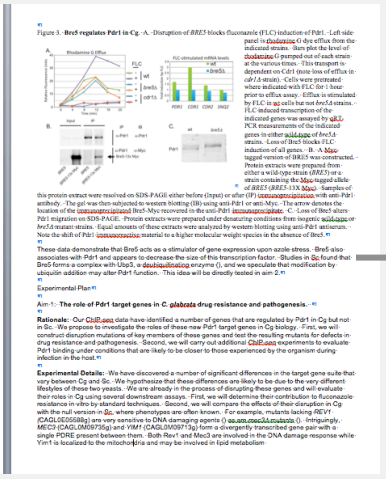


Figure 3. -**Bre5 regulates Pdr1 in Cg**. -A. -Disruption of *BRE5* blocks fluconazole (FLC) induction of Pdr1. -Left-side panel is rhodamine G dye efflux from the indicated strains. -Bars plot the level of rhodamine G pumped out of each strain at the various times. -This transport is dependent on Cdr1 (note loss of efflux in *cdr1Δ* strain). -Cells were pretreated where indicated with FLC for 1 hour prior to efflux assay. -Efflux is stimulated by FLC in wt cells but not *bre5Δ* strains. -FLC-induced transcription of the indicated genes was assayed by qRT-PCR measurements of the indicated genes in either wild-type or *bre5Δ* strains. -Loss of Bre5 blocks FLC induction of all genes. -B. -A Myc-tagged version of BRE5 was constructed. -Protein extracts were prepared from either a wild-type strain (*BRE5*) or a strain containing the Myc-tagged allele of *BRE5-13X Myc*. -Samples of this protein extract were resolved on SDS-PAGE either before (Input) or after (IP) immunoprecipitation with anti-Pdr1 antibody. -The gel was then subjected to western blotting (IB) using anti-Pdr1 or anti-Myc. -The arrow denotes the location of the immunoprecipitated Bre5-Myc recovered in the anti-Pdr1 immunoprecipitate. -C. -Loss of Bre5 alters Pdr1 migration on SDS-PAGE. -Protein extracts were prepared under denaturing conditions from isogenic wild-type or *bre5Δ* mutant strains. -Equal amounts of these extracts were analyzed by western blotting using anti-Pdr1 antiserum. -Note the shift of Pdr1 immunoreactive material to a higher molecular weight species in the absence of Bre5.

These data demonstrate that Bre5 acts as a stimulator of gene expression upon azole stress. -Bre5 also associates with Pdr1 and appears to decrease the size of this transcription factor. -Studies in Sc found that Bre5 forms a complex with Ubp3, a deubiquitinating enzyme (), and we speculate that modification by ubiquitin addition may alter Pdr1 function. -This idea will be directly tested in aim 2.

Experimental Plan

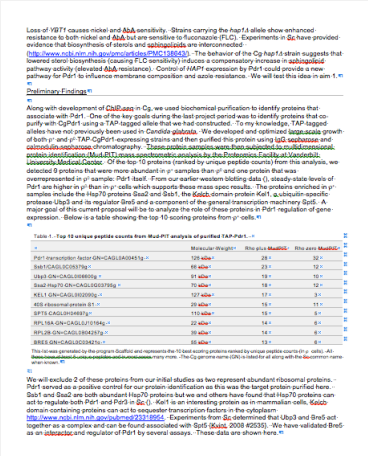
Aim 1: -**The role of Pdr1 target genes in *C. glabrata* drug resistance and pathogenesis.**

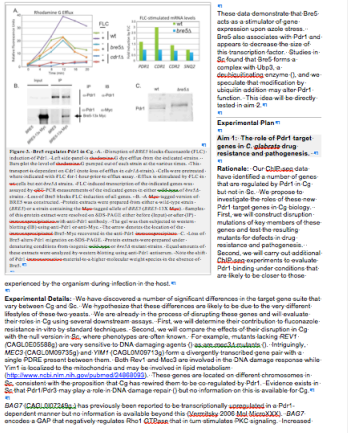
Rationale: -Our ChIP-seq data have identified a number of genes that are regulated by Pdr1 in Cg but not in Sc. -We propose to investigate the roles of these new Pdr1 target genes in Cg biology. -First, we will construct disruption mutations of key members of these genes and test the resulting mutants for defects in drug resistance and pathogenesis. -Second, we will carry out additional ChIP-seq experiments to evaluate Pdr1 binding under conditions that are likely to be closer to those experienced by the organism during infection in the host.

Experimental Details: -We have discovered a number of significant differences in the target gene suite that vary between Cg and Sc. -We hypothesize that these differences are likely to be due to the very different lifestyles of these two yeasts. -We are already in the process of disrupting these genes and will evaluate their roles in Cg using several downstream assays. -First, we will determine their contribution to fluconazole resistance in vitro by standard techniques. -Second, we will compare the effects of their disruption in Cg with the null version in Sc, where phenotypes are often known. -For example, mutants lacking *REV1* (CAGL0E05588g) are very sensitive to DNA damaging agents () as are *rev3*Δ mutants (). -Intriguingly, *MEC3* (CAGL0M09735g) and *YIM1* (CAGL0M09713g) form a divergently transcribed gene pair with a single PDRE present between them. -Both Rev1 and Mec3 are involved in the DNA damage response while Yim1 is localized to the mitochondria and may be involved in lipid metabolism.

Have to look hard to find the legends!

Applying some of these principles in other contexts





Solutions:

- Enclose images and their legends in boxes
- Difference in font size, background color

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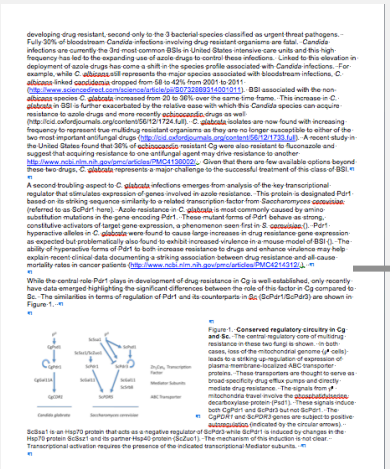
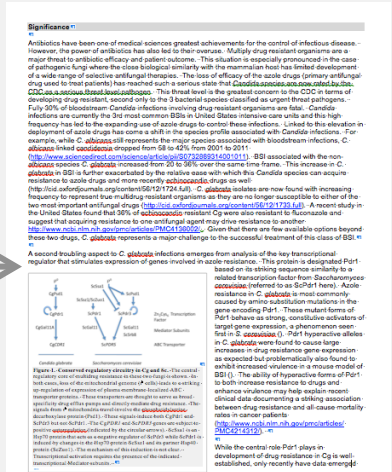
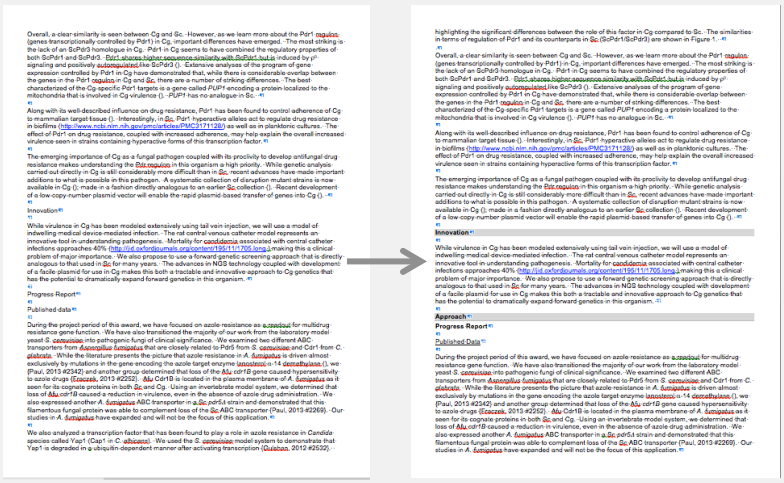




Applying some of these principles in other contexts



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