

## The Craft of Research

based on *The Craft of Research* by  
W.C. Booth *et al*(1995) University of  
Chicago Press, Chicago. 294 pp.

*"those who can neither do reliable  
research nor reliably report on the  
research of others will find themselves  
on the sidelines of a world that  
increasingly lives on information"*

## **Presentation topics ...**

- ◆ Why do research?
- ◆ Benefits of writing and publication
- ◆ Understanding and connecting with readers
- ◆ Claims, evidence and arguments
- ◆ Hypotheses and conceptual models
- ◆ Research ethics

## Why do research?

Human society and the earth has been transformed by products of research and these changes will continue into the future

Without reliable, published research, individuals are held captive to what they alone see or hear and are locked into the "*opinions of the moment*"

Knowledge is power. "*By knowing when we trust the research of others, we free ourselves from those who seek to control our lives by controlling our beliefs*"

## Benefits of writing and publication

*"Providing good answers to difficult questions in ways that are useful to society is the principle responsibility of the scientific community"*

- ◆ Writing from the beginning of the project reinforces memory and induces larger patterns of meaning
- ◆ Providing good ideas the attention they deserve by disentangling them from personal opinions

## *Benefits of writing and publication (cont.)*

- ◆ Improving our scientific perspective as ideas are often more coherent in the "warmth of our minds" than they turn out to be when viewed in the reality of "cold print"
- ◆ Thinking in print: the better we write, the more critically we read
- ◆ Serves to cooperate with readers to form a "joint venture" in creating new knowledge

## Understanding readers

Writers must learn to view their work from the perspective of potential readers who seek:

- ◆ Entertainment through communication in a shared, mutually enjoyed topic
- ◆ Practical benefits through guidance in the solution of tangible problems
- ◆ Understanding through the intellectual quality of objective, logical treatment of evidence

## *Understanding readers (cont.)*

In return, writers ask that the reader be willing to:

- ◆ Accept new information and entertain new questions
- ◆ Change their beliefs in response claims built on convincing arguments and evidence
- ◆ Perform an action or modify their activities based on a proposed solution

*The expectations are listed in a progressive order that is achieved by presenting important findings through skilled communication*

## Connecting with readers: some advice

Never mind whether your style is graceful ...  
*though your work will be more admired if it is*

Do not feel compelled to pass amusing  
anecdotes ...  
*though readers enjoy them when it helps to  
communicate your ideas through example*

Do not be concerned that readers may not  
personally benefit from your writing ...  
*though many would be more pleased if it made  
them wealthy*



rather, the main objective of scientific writing is to ...

*"seek to communicate useful ideas supported by rigorous evidence in a logical manner that is understandable to a wide readership"*

## **A few hints to inexperienced authors**

Every author begins as a novice who may confuse anxieties with failure

Write as if most readers possess less background knowledge on your specific topic

Learn to recognize your own poor writing, especially where habits have replaced open reflection and disciplinary biases are substituted for sound argument

## *A few more hints to inexperienced authors*

Writing skills are acquired through practice and effort and even the most experienced authors encounter difficulties when writing about new topics

Seek informal review from more experienced authors realizing that the most severe critique may prove constructive

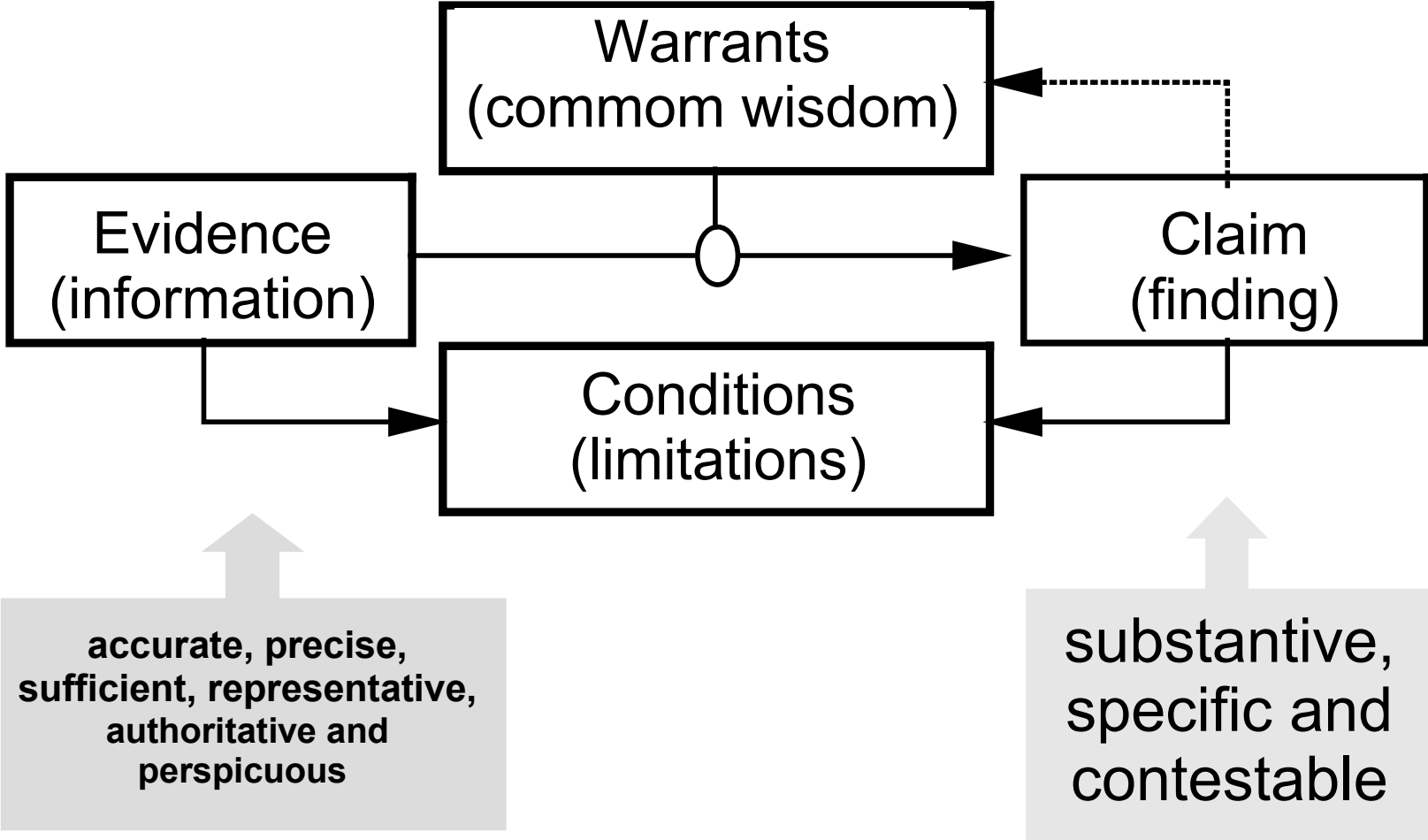
# Claims, evidence and arguments

The central element of a research paper is its major claim. Claims must be substantive, specific and contestable

Much of a paper consists of evidence (data) that supports the claim. Evidence is required to be accurate, precise, sufficient, representative, authoritative and perspicuous (clearly stated)

Warrants are the general principles that link claims and evidence. Qualifications stipulate limitations of scope or scale in arguments

# Evidence supports claims through warrants and conditions



## *Claims, evidence and arguments (cont.)*

The claims of others may be challenged by raising contradictions in either the evidence or underlying warrants

Scientists must not take challenges or raised contradictions personally as these are part of positive scientific discourse

Claims, evidence, warrants and stipulations constitute arguments. Avoid arguments based upon articles of faith and custom, as they require no objective evidence

# Conceptual Models in Scientific Research

Conceptual models serve to organize research approaches and direct data presentation

- ◆ Working Hypotheses. Wordmodels intended to direct specific experiments
- ◆ Mathematical Models. Linear, curvilinear and multivariate regression approaches
- ◆ Statistical Models. ANOVA approaches, particularly factorial arrangements
- ◆ Simple Conceptual Diagrams. Input-output, box and arrow or other diagrams
- ◆ Advanced Technical Diagrams. Routines that simulate natural phenomenon
- ◆ Interpretive Diagrams. Intended to capture the essence of a subject

## Working Hypotheses

- ◆ reductionist word models based on logic
- ◆ essential component of all research
- ◆ science as a chain of working hypotheses

**Global hypotheses** are more general, often a restatement of overall objectives

**Null hypothesis** is stated in the negative context and no longer considered essential

It is reasonable for one scientist to ask another "*How do your findings reflect on your working hypothesis?*"



## *Working Hypotheses (cont.)*

- ◆ should be stated as simply as possible but must be a complete statement
- ◆ intended to be either accepted or rejected

**H0:** *X regulates Y under Z conditions.*

**H1:** *Maize streak virus infects a greater proportion of the maize stand and reduces crop yields to a greater extent under continuous maize cultivation than in maize-legume rotation*

H1 may be summarized as *IF A AND NOT B THEN C AND D*

## *Working Hypotheses (cont.)*

Pitfalls to avoid in formulation of hypotheses:

- ◆ **Incomplete statements:** Maize streak virus is a serious problem.
- ◆ **Tautologies:** Maize streak virus infection results from incomplete control of plant viruses.
- ◆ **God-and-motherhood statements:** Sustainable agriculture results in long-term food security and reduction of maize streak virus.

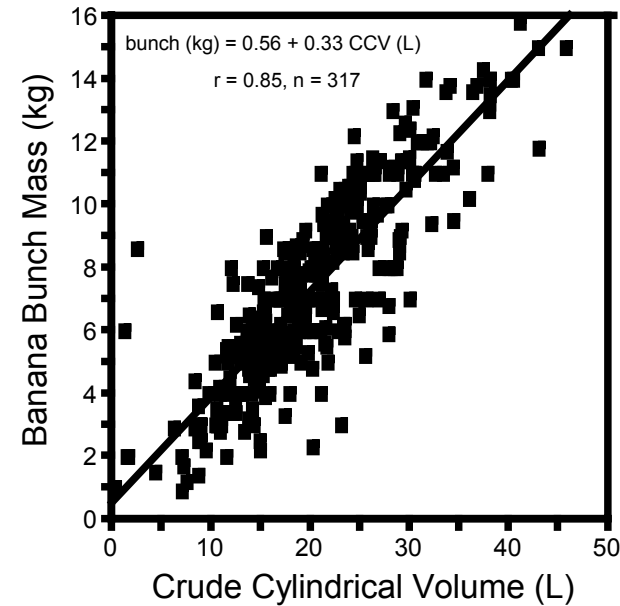
# Mathematical Models

- ◆ attempt to quantify cause and effect relationships
- ◆ cause is the independent variable and effect is the dependent variable
- ◆ a mathematical relationship must also be stated in more general terms as a working hypothesis
- ◆ may be simple or multivariate, linear or curvilinear
- ◆ selection of a function must be conceptually base

## Examples of Mathematical Models

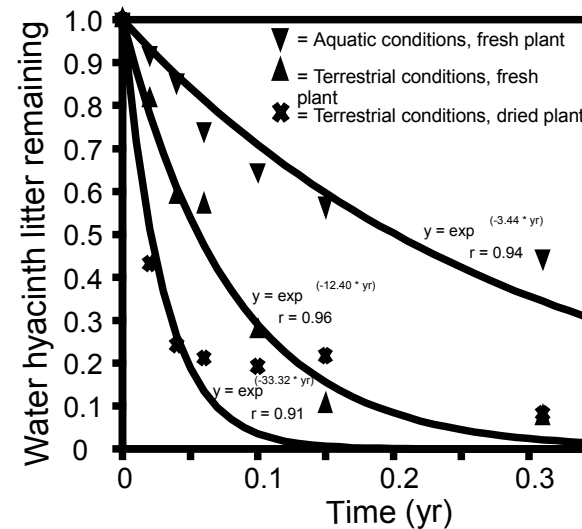
### Simple linear regression:

Banana bunch biomass may be accurately estimated from rapidly obtained allometric measurements (Woomer *et al.*, 1999a)



**Simple non-linear regression:** Litter decay of water hyacinth wastes follow first order exponential kinetics

(Woomer *et al.*, 1999b)



# Pitfalls in Use of Mathematical Models

- ◆ Low correlation does not necessarily mean lack of relationship
- ◆ High correlation does not necessarily mean cause and effect relationship
- ◆ Part-whole correlations may be trivial
- ◆ Extrapolation is tempting but dangerous, no prediction permissible beyond the range the independent variable

# Communicating evidence visually

Evidence may be communicated by its arrangement within Tables or Figures which:

- ◆ Present data objectively
- ◆ Identify independent and dependant variables
- ◆ Invite comparisons and interpretations
- ◆ Highlight key findings

## Tips on tables and figures

- ◆ Rely on tables to convey information about precise values and graphs to illustrate the relationships between variables
- ◆ Order independent variables in a manner that supports claims and arguments
- ◆ Limit the cases and data to those that demonstrate evidence, preferably no more than 12-15 items

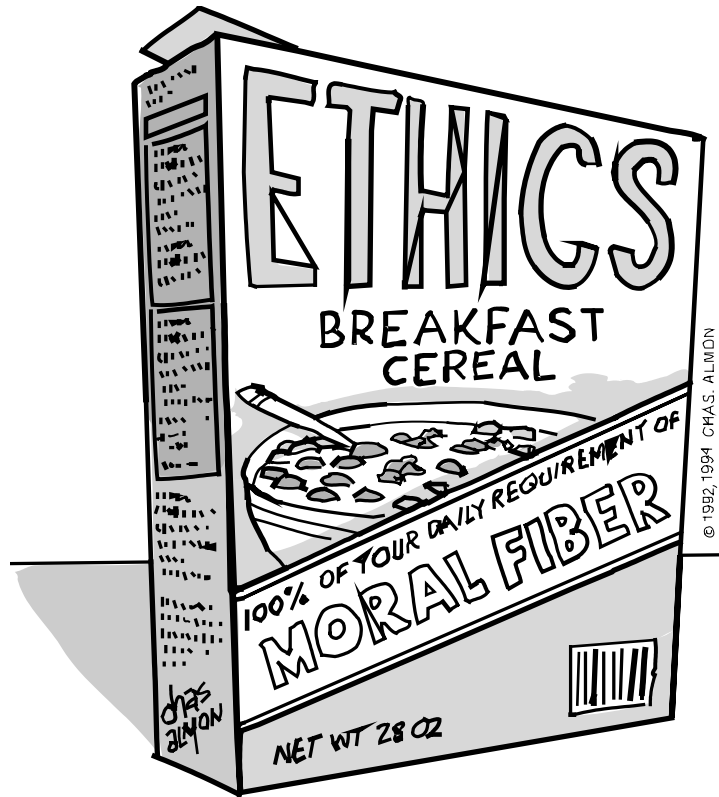
## *Tips on tables and figures (cont.)*

Minimize distracting elements such as elaborate fonts or unnecessary explanation and avoid encoding variables or treatments

Draw evidence and arguments in the text from information in Tables and Figures, do not simply repeat the data in text form

***Caution:*** Most software graphics packages were developed for business applications that seek to impress clients. Resist the temptation to incorporate graphics features that do not directly contribute to evidence and arguments.



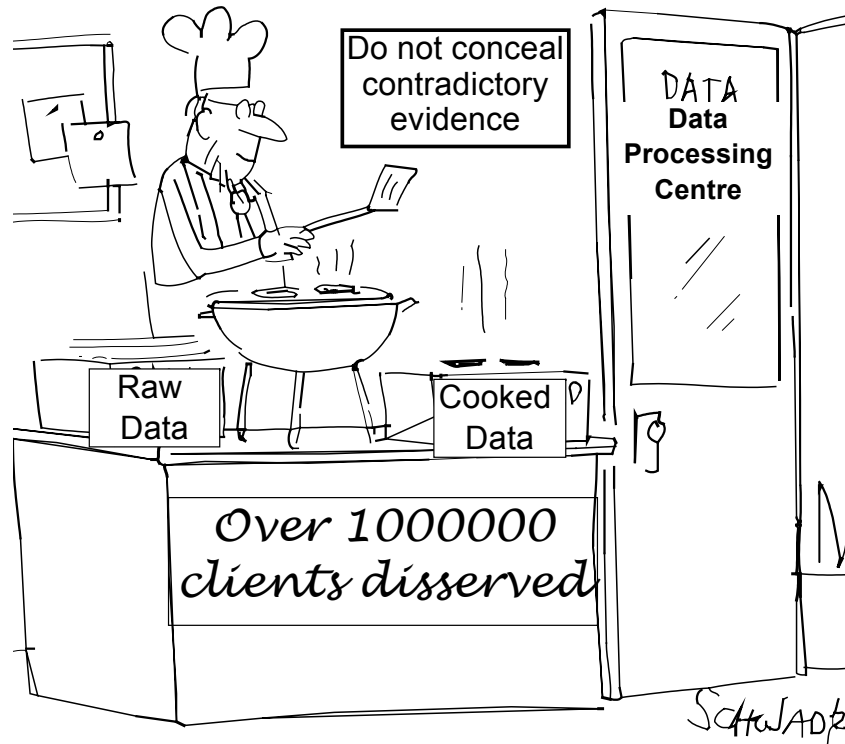


## Research ethics

Ethical researchers do not:

- ◆ steal by plagiarizing or claiming the results of others
- ◆ lie by misreporting sources or fabricating results
- ◆ destroy sources of information to the disadvantage of others
- ◆ submit data whose accuracy they have reason to question
- ◆ conceal objections they cannot rebut or oversimplify that which is legitimately complex

*Research ethics (cont.)*



*Researchers who fully acknowledge sources, cite contrary findings by others, recognize the limitations of their findings and assert claims only as strongly as warranted based upon uncertainty not only avoid moral dilemmas but also establish scientific credibility*