Planning and structuring your thesis or dissertation

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Engineering Research and Development for Technology
Thesis/Dissertation Writing Seminar
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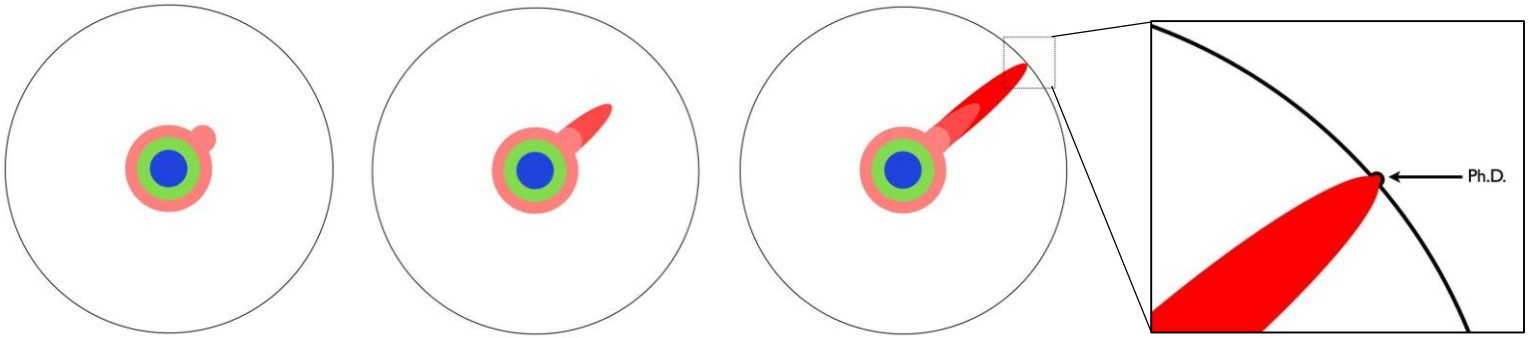
Outline

- Goals for your graduate degree
- The research cycle
- Thesis/dissertation structure

The road to a graduate degree



BSc **MSc** **PhD**

Matt Might. The illustrated guide to a PhD
http://matt.might.net/articles/phd-school-in-pictures/

Goals

- MSc thesis
  - Demonstrate ability to design and implement a research study
  - Demonstrate in-depth knowledge on a topic
  - Demonstrate the ability to think critically
- PhD dissertation
  - To contribute new knowledge, theories, or practices to your field
- Publication
  - To allow expert peer review of your work
  - To provide public access to your research
  - If it’s not published it didn't happen!

Embrace stupidity

“One of the beautiful things about science is that it allows us to bumble along, getting it wrong time after time, and feel perfectly fine as long as we learn something each time.”

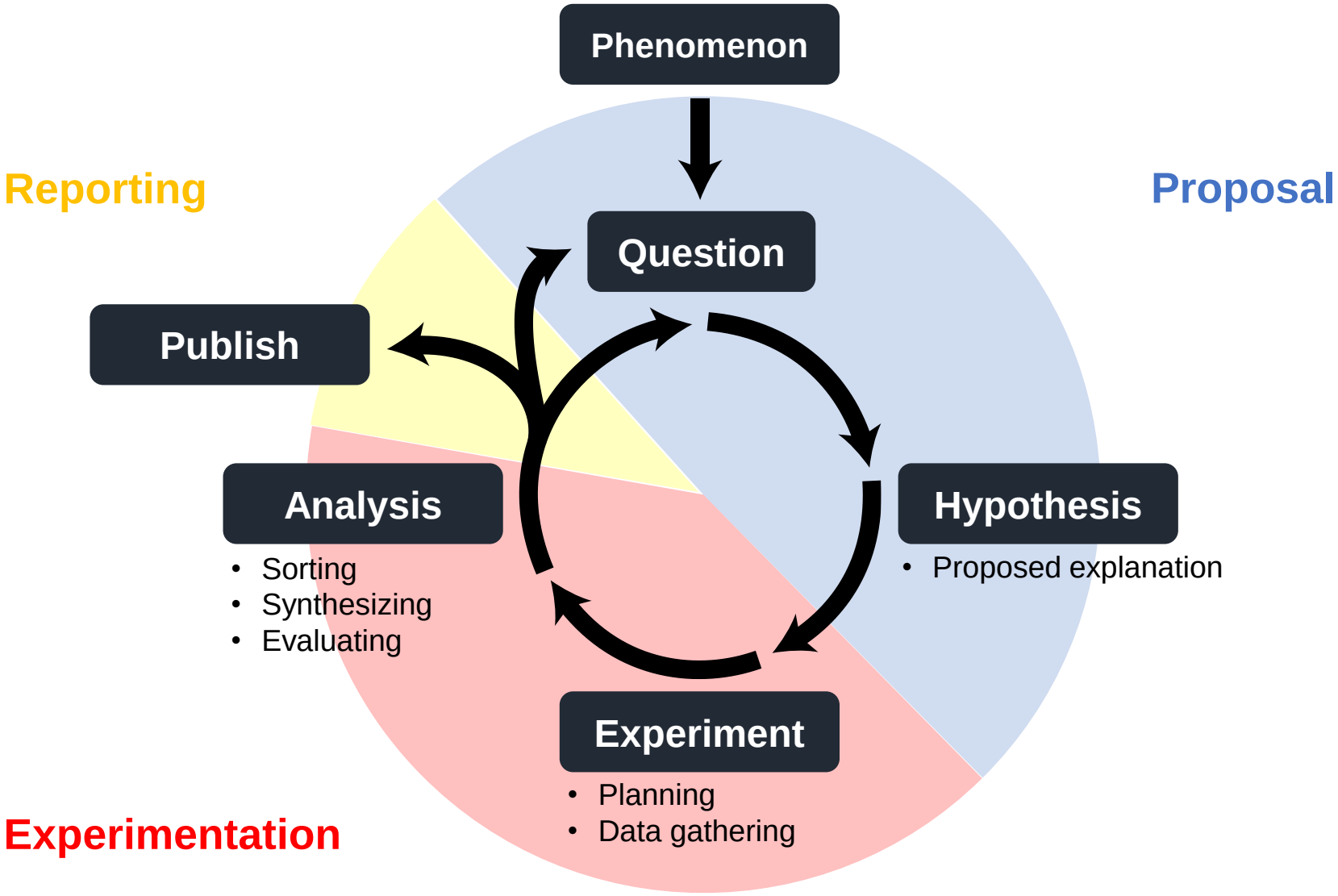
Schwartz M (2008) The importance of stupidity in scientific research. Journal of Cell Science 121:1771

Uphold ethical values

- To adhere to professional standards and integrity
- To honor the trust of the scientific community
- To serve the public
  - Findings directly affect the health and well-being of people
  - Findings used by policy makers to make informed decisions on important issues
  - New discoveries increase our understanding of the world around us
  - Taxpayers fund the grants that support our research

National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (2009) *On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition*. Washington, DC: The National Academies Press. https://doi.org/10.17226/12192

Follow the research cycle



Selecting a good thesis topic

Relevant	•A practical problem exists •(technology development, commercialization, social enterprise)
Significant	•Research gaps should be addressed in order to find a solution
Justifiable	•The objectives are clear and quantifiable
Feasible	•You have access to expertise, materials, funding, and time

Designing a good study

Measurability	• Can it be objectively quantified?
Replicability	• Can it be repeated?
Consilience	• Is it consistent with established facts?
Economy	• Is it simple and understandable?
Heurism	• Does it stimulate further investigations?

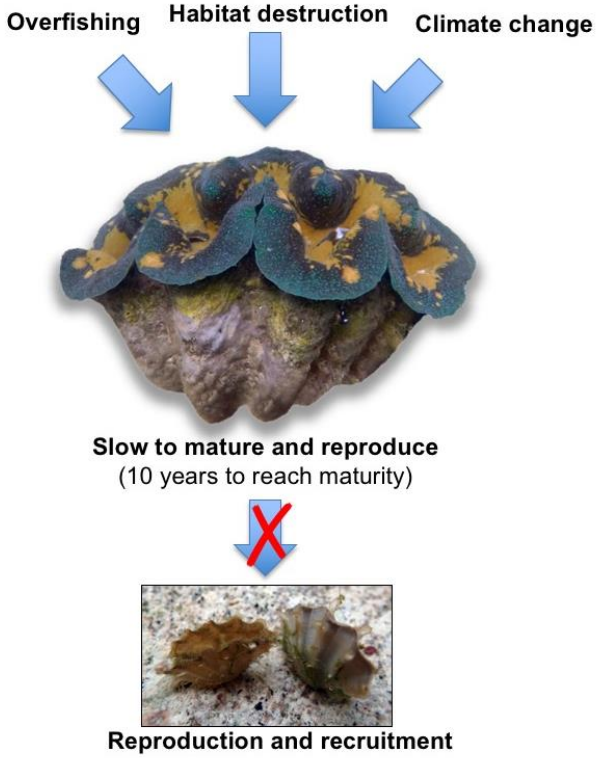
Example

Research question:
How will rising ocean temperature affect the growth and survival of giant clam larvae?

General objective:
To determine how giant clam larval growth and survival is affected by temperature.

Specific objectives:
1. To measure the effect of temperature on fertilization rate
2. To measure the effect of temperature on development
3. To measure the effect of temperature on larval survival

Considerations:
1. **Relevance:** Climate change is a pressing issue affecting our oceans.
2. **Significance:** The effect of ocean warming on different animals is not known.
3. **Justifiable:** Giant clams are endangered. Early life stages are critical in their survival.
4. **Feasible:** Budget is available for fieldwork and analysis; animals can be cultured; experimental setup exists; experiments can be completed in a few months.



Enricuso et al (2018) J Molluscan Studies 1–7. doi:10.1093/mollus/eyy051

Example

Practical problem:
- Technology development
- Commercialization or technopreneurship
- Social enterprise or social impact

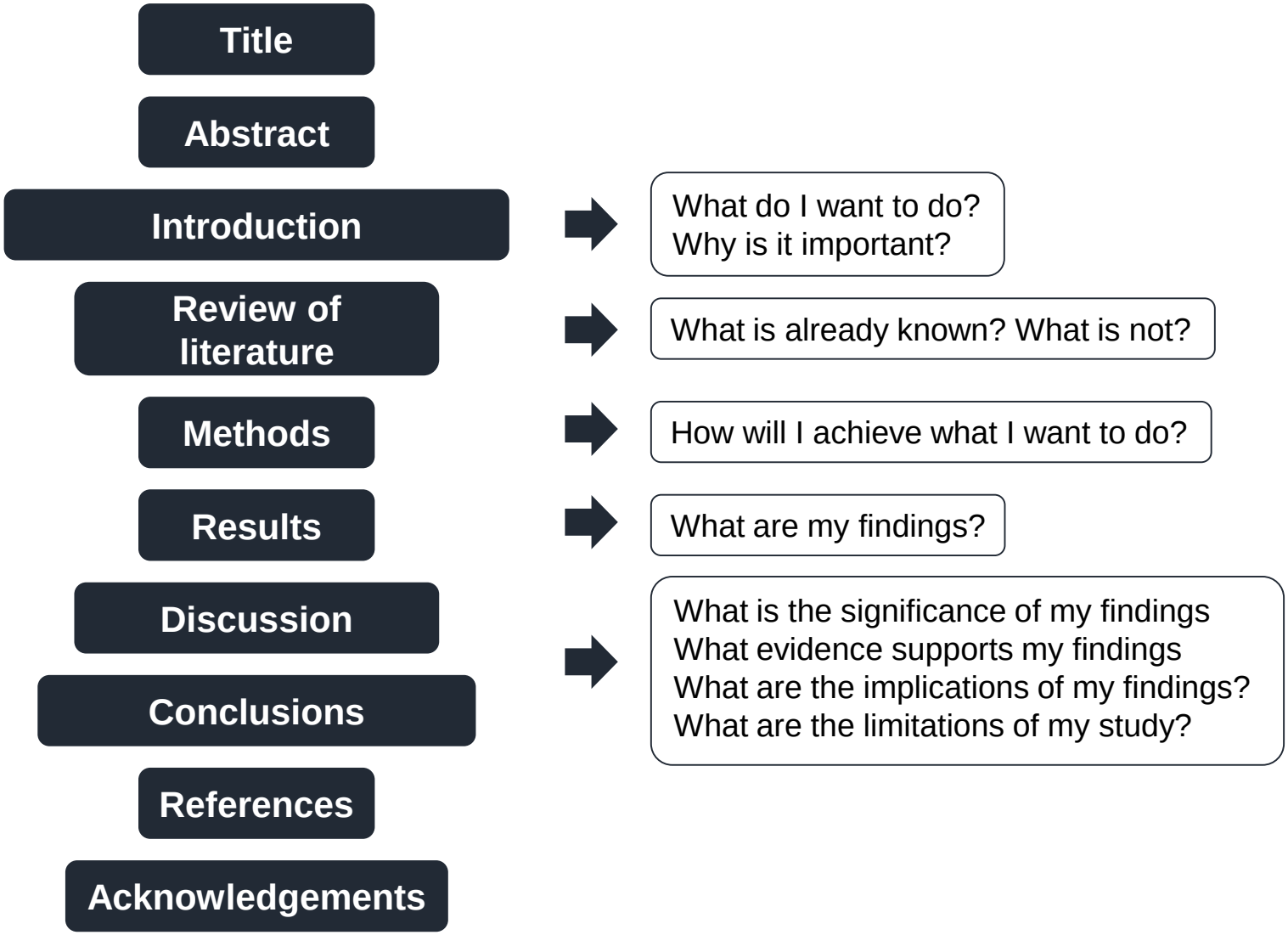
Research question:

General objective:
To determine

Specific objectives:
1. To measure
2. To measure
3. To measure

Considerations:
1. Relevance:
2. Significance:
3. Justifiable:
4. Feasible:

Thesis/dissertation structure



Title

- Gives the main idea of your topic using essential keywords
- Allow your thesis to be retrieved through database search
- Clear, concise, informative, attention-grabbing

Example

- Descriptive: what the study is about

Effect of seawater temperatures on larvae of the giant clam *Tridacna gigas* (Cardiidae: Tridacninae)

- Informative: conveys most interesting or surprising result

Elevated seawater temperatures affect embryonic and larval development in the giant clam *Tridacna gigas* (Cardiidae: Tridacninae)

Abstract

- Provides a concise overview of your thesis
- Presents most significant findings
- Between 200-300 words only
- Usually written last
- Usually is the only part of a paper read by most people

Parts of the abstract

- Rationale or background (1-2 sentences)
- The ‘hook’ (1 sentence)
- Your research question, objectives, or hypothesis (1 sentence)
- Short description of methods (2 sentences)
- Results (1-2 sentences)
- Main conclusions (1 sentence)

Tips for a concise abstract

- Put the most important information first in each sentence
  - High temperature resulted in no significant changes in larvae size but lower survival was observed.
  - High temperature resulted in low survival, although larval size was not affected.
- Make specific statements
  - Temperature affected survival.
  - Larvae did not survive above 33°C.
- Use the active voice
  - Survival was observed to be lowest at high temperature.
  - Survival was lowest at high temperature.
- Substitute one word for many
- Do not include in-text references

Example

ABSTRACT

Giant clams are the largest bivalve molluscs and play a key role in coral reef ecosystems. Almost all species are considered endangered or vulnerable to extinction, thus requiring intervention through culturing and restocking. Although successful culture techniques have been developed, the responses of giant clam embryos and larvae to environmental factors, such as seawater temperature, are not yet fully understood. In this study, fertilization, development and survival of *Tridacna gigas* larvae were observed at low (28 °C), medium (30 °C) and high (33 °C) seawater temperatures. Fertilization success was not significantly different between the water temperatures tested. At 28 °C, ciliated gastrulae appeared first at 12 h postfertilization (hpf) and trochophore larvae at 24 hpf. In contrast, more rapid development was observed at 30 °C and 33 °C, with ciliated gastrulae first appearing at 9 hpf and trochophore larvae at 18 hpf. Veliger larvae were observed after 48 h at 28 °C and 30 °C. No veligers were observed at 33 °C, but a greater proportion of embryos and larvae exhibited developmental abnormalities at this temperature compared with the other treatments. Larval survival was lowest at 33 °C at the 12 and 24 h timepoints, although there was no longer a significant difference across treatments after 48 h. Furthermore, post-settlement survival of juveniles subjected to different seawater temperatures for 22 d starting at 8 d postfertilization (dpf) was lowest at 33 °C. These findings reveal that higher water temperatures promote rapid progression through early development, but result in lower overall survival as a consequence of abnormal development and reduced post-settlement survival.

Rationale **Hook** **Methods** **Results** **Conclusions**

Enricuso et al (2018) J Molluscan Studies 1–7. doi:10.1093/mollus/eyy051

Introduction

- Background on the topic
- Brief review of current knowledge (key studies)
- Indicates gap in knowledge
- States aims and scope of your research and how it fills the gap
- Can include your hypotheses and an outline of the study

Goals of the introduction

- Establish your territory
  - What is the topic about?
- Establish a niche
  - Why does there need to be further research on the topic?
  - Develop a ‘hook’
- Occupy the niche
  - State the research questions
  - State study objectives
  - Make hypotheses

Example

Giant clams (Cardiidae: Tridacninae) are the largest marine bivalve molluscs and live in close association with corals throughout the Indo-West Pacific (Rosewater, 1965; Lucas, 1994; Neo *et al.*, 2017). These bivalves play key roles in coral reef ecosystems (Neo *et al.*, 2015):

• • •

However, the large, highly-prized shells and high meat biomass of tridacnines make them vulnerable to overexploitation (Bryan & McConnell, 1976; Hirschberger, 1980; Larson, 2016). The endangered status of giant clams and the extinction of local populations have spurred efforts to develop laboratory (LaBarbera, 1975; Jameson, 1976; Beckvar, 1981) and mass culture techniques (Heslinga, Perron & Orak, 1984; Heslinga & Watson, 1985) as a source of seed stock to replenish wild populations.

• • •

Here we investigate the effects of low, medium and high seawater temperatures, relative to ambient larval rearing temperature, on early development and post-settlement survival of the true giant clam *T. gigas* (Linnaeus, 1758). Responses to elevated seawater temperatures in the early life stages of *T. gigas* may provide insights into the possible impacts of thermal stress and supplement available information on the optimum conditions for mariculture and restocking.

What is the topic about?

Why does there need to be further research on the topic?

State the research questions
State study objectives
Make hypotheses

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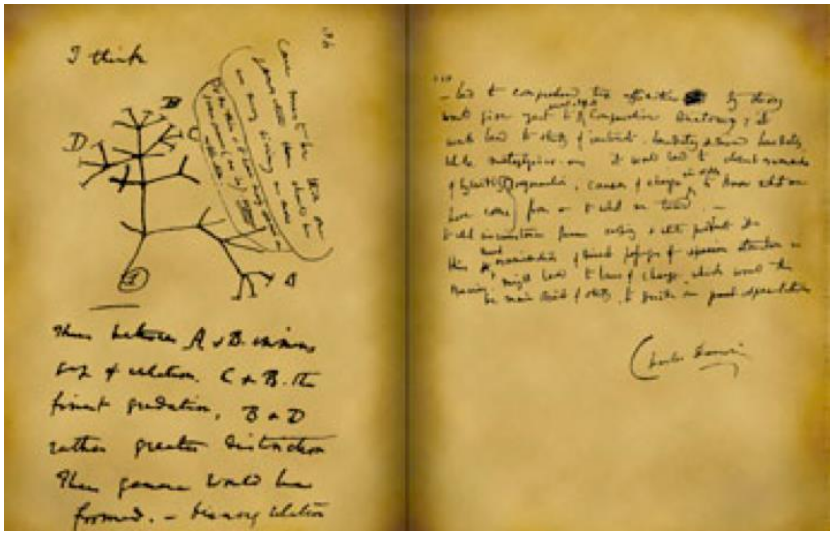
Literature review

- Gives readers background information on your study
- Evaluates previous research related to your topic
- Emphasizes knowledge gaps that your research will attempt to fill
- Organize into sub-sections

Methods

- Describes the process of data collection and analysis
- Organization should follow that of the results section
- Provide as much detail as needed for others to replicate or evaluate your results
- All this information should be in your lab notebook
- Use past tense



Example

Experimental conditions

Experiments were conducted in 40-l incubation tanks maintained at target temperatures of 28 °C (low), 30 °C (medium), and 33 °C (high). Submersible heaters (EHEIM Thermo control aquarium heater 300 W) were used to control and maintain the desired water temperatures. Illumination was provided by two 21W daylight LED lamps on a 12 h:12 h light-dark cycle. Water temperatures and light levels in the incubation tanks were monitored using submersible loggers (HOBO Pendant). The actual measured mean temperatures were 28.15 ± 0.02 °C (low), 30.25 ± 0.02 °C (medium) and 33.11 ± 0.02 °C (high). These mean temperatures will be referred to by the target temperatures mentioned above. Illumination in the incubation tanks was *c.* 80 µmol photons m^{-2} s^{-1}. Temperature levels were chosen based on the daily water temperature record at the hatchery facility of the Bolinao Marine Laboratory. The average temperature at the facility from July 2015 to August 2016 was 28.50 ± 0.07 °C, with a maximum recorded temperature of 33.20 °C.

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Results

- Presents your research findings
- Describe data shown in main figures or tables
- Include relevant statistical analyses
- Include a brief comment on the significance of key results
- Results and Discussion may be combined
- Place other data in the Appendix

Organizing your results

- Present data sequentially to correspond to each research question or hypothesis
- From most important to least important
- Group the methods together with the relevant results

Example

Fertilization success of *Tridacna gigas* embryos ranged from 85.56 ± 6.19% to 87.78 ± 2.94% (mean ± SE) and was not significantly different among the water temperatures tested (one-way ANOVA: $P > 0.05$; Fig. 2). However, progression through early developmental stages varied among water temperature treatments (Fig. 3). Ciliated gastrulae were first observed at 9 hpf at both 30 °C and 33 °C, while at 28 °C they were first observed at 12 hpf. Trochophore larvae first appeared at 18 hpf at both 30 °C and 33 °C, while at 28 °C these were first observed at 24 hpf.

Result 1
Figure 1
Statistical analyses

Result 2
Figure 2
Description of figure

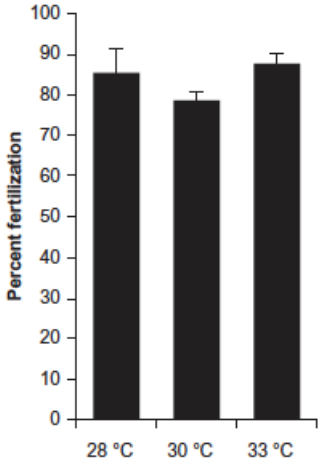

Fig. 2

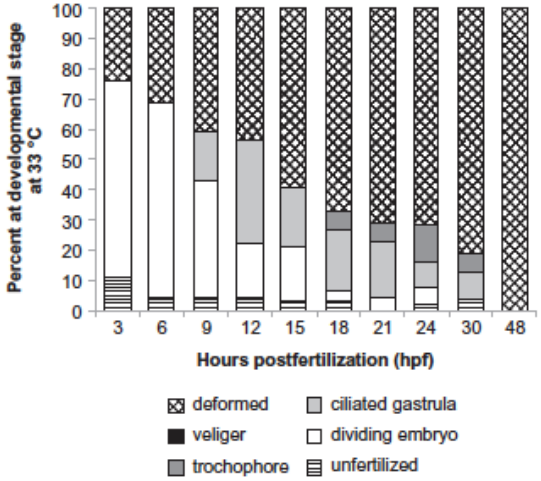

Fig. 3

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Discussion

- Establishes the significance of the key findings and relates them to existing research
- Stages of the discussion
  - Explain what your results mean
  - Relate results to previous research
  - Interpret your results in a wider context
  - Evaluate the significance of your data
  - Point out limitations of your study
  - Note questions that remain unanswered

What not to include

- Data that is not presented in the results section
- Results that are less significant
- Results that do not relate directly to your aims
- Tables and figures (these belong in results)

Organizing the discussion

- Follow the order in which aims or hypothesis are stated in your Introduction
- Start with the most significant results
- Logical pattern:
  - Summarize key findings
  - Explain how these relate to or confirm your aims
  - Compare results with previous research
  - Explain unexpected results
  - Discuss significance/implications
  - Note limitations and recommendations/future directions

Example

Fertilization success for *Tridacna gigas* was not significantly different at water temperatures ranging between 28°C and 33 °C. High fertilization rates were obtained for all treatments, suggesting that this temperature range was optimal for *T. gigas* fertilization. This has also been observed in *T. squamosa*, where fertilization success was higher at 29.5 °C than at 22.5 °C (Neo *et al.*, 2013). The positive relationship between temperature and fertilization success coincides with the period of peak spawning activity for giant clams, which tends to be highest in the mid to late afternoon, especially during summer, when water temperatures may reach 31 °C

Summarize key findings

Compare results with previous research

Discuss significance or implications

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Conclusions

- Emphasize that your research objectives have been achieved
- Emphasize the most significant results
- Note the limitations of your study
- Make recommendations for further research

Example

Taken together, our findings reveal that increased seawater temperature is detrimental to the survival of early life stages of the giant clam, *T. gigas*. This is particularly relevant in light of a climate change scenario where sea surface temperature is predicted to increase to levels that may inhibit development, recruitment and survival of giant clams in the wild. The present results suggest that regulating water temperature during early larval rearing may be an important consideration in optimizing mariculture conditions to enhance production of *T. gigas* seed stock.

Emphasize the most significant results

Thus, future studies comparing the responses of embryos, larvae and juveniles of different giant clam species or individuals from distinct environments will be important in understanding the potential impacts of ocean warming on clam growth and survival. In addition, the effects of combined multiple stressors to reflect actual environmental scenarios need to be studied, as such information will be vital in predicting the future of giant clams in a changing ocean.

Make recommendations for further research

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Overall expectations of your thesis

What did you do?	Have you clearly stated your research question & objectives?
Why did you do this?	What is the importance of this problem?
Has it been done before?	If yes, are you doing it in a different way?
What did you discover?	Is it what you expected to discover?
How reliable is this?	Can the study be replicated? Are the methods appropriate?
What conclusions can you draw?	Does the study make strong, well-supported conclusions?
What are the implications?	What does your discovery mean for your field of study?
What is unresolved?	Does the study open up other avenues for investigation?

In conclusion

- Clear writing starts with clear thinking.
- Decide what you want to say.
- Discuss your work with others.
- Read. A lot.
- Learn from every revision.
- Let go.
- Publish.

Shit Academics Say
@AcademicsSay

Follow

A good dissertation is a done dissertation. A great dissertation is a published dissertation. A perfect dissertation is neither.

5:08 AM - 23 Oct 2015

430 Retweets **625** Likes 

12 430 625

To learn more

References

- Burns, R 2000, *Introduction to Research Methods*, Pearson Education, Frenchs Forest.
- Craswell, G 2005, *Writing for Academic Success*, SAGE Publications, London.
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Online resources

- https://cgi.duke.edu/web/sciwriting/
- http://iwrite.unsw.edu.au/iwrite/ENGINEERING/Thesis/Tutorial-introduction.html

Thank you