

The Agricultural Meteorology Graduate Major at Iowa State University of Science and Technology

Adopted August 2014. Updated January 2024.

1 Introduction

Agronomy is the science and technology of producing plants that serve humans, using practices essential for maintaining and improving life. We commonly use the term *crops* to refer to these types of plants. Crops can be used for food, feed for livestock, fiber, fuel, and fossil-fuel alternative bioproducts.

Agricultural meteorology is one aspect of agronomy.

Scientists in the discipline of agricultural meteorology strive to understand the plant-soil-atmosphere continuum in agricultural ecosystems with an emphasis on how the atmosphere influences, and is influenced by, crops at a range of time scales.

The goals of the Agricultural Meteorology Graduate Major (AMGM) in the Department of Agronomy (DoA) at Iowa State University (ISU) are:

- to train new scientists to advance our understanding of the plant-soil-atmosphere system and its role for sustainable resource management; and
- to train new professionals who will help the farm industry use plant-soil-atmosphere system science in new management practices.

2 Enduring Understandings

Each student in the AMGM must master the following Enduring Understandings.

1. Science is characterized by the formulation, testing, and revision of hypotheses.
2. Conservation laws govern the fluxes of mass and energy among the soil, vegetation, and atmosphere.
3. Feedbacks exist between agricultural ecosystems and the atmosphere.
4. “Essentially, all models are wrong, but some are useful.” (*Box and Draper, 1987*)

An evaluation of student mastery of these Enduring Understandings is made at different points in the graduate curriculum (see Sections 4.4, 4.4.1, 4.4.2, and 4.5.1).

3 Learning Goals

Students who complete a degree in the AMGM will, in the process of constructing and defending a creative component, thesis, or dissertation, be able to:

- summarize scholarly work in an area of study, as demonstrated by a literature review.
- construct hypotheses and/or objectives that advance disciplinary knowledge, as demonstrated by proposed hypotheses and/or objectives.
- conduct quantitative research, as demonstrated by quantitative results.
- interpret research results and integrate them into existing disciplinary knowledge, as demonstrated by analyses and conclusions.
- clearly and accurately communicate research findings orally, visually (through the use of images and/or figures), and in writing.

These learning goals are assessed at comprehensive final oral examinations (see Sections 4.4.1, 4.4.2, and 4.5.3).

4 Graduate Degrees

The AMGM offers two graduate degrees: a master of science (MS) in agricultural meteorology; and a doctor of philosophy (PhD) in agricultural meteorology.

All graduate students *must* read ISU's Graduate College Handbook (GCH) in order to ensure that they understand their responsibilities and faculty responsibilities so that they can take full advantage of the opportunities available to them.

Faculty should review the GCH often in order to stay up-to-date on the requirements for graduate degrees. However, it is the student's responsibility to make sure that all requirements for a specific degree are met. Faculty act as "coaches" who advise, encourage, and advocate for students in their pursuit of a graduate degree.

The information provided in the document that you are now reading supplements but does not supersede the policies outlined in the GCH, as well as the specific policies of the DoA found on its website. The policy regarding optional and adjustable aspects are described here for the AMGM.

4.1 Admissions

Students who have earned an undergraduate degree in any physical or life science or engineering discipline are technically qualified to enroll in the AMGM. Prospective students must have: strong quantitative skills (calculus and fluency in some type of computer programming language); good communication skills in English; and a desire to study the physical aspects of the soil-plant-atmosphere continuum. Non-native English speakers must take the Test of English as a Foreign Language (TOEFL) exam. A faculty member in the AMGM must agree to work with the student before the student is admitted.

4.2 Enrollment

In order to be considered full-time, a typical graduate student (on a “1/2-time appointment”) must be registered for a minimum of 9 credits with a maximum of 12 credits each fall and spring semester. Since there is no difference in tuition between 9 and 12 credits, it is in the best interest of both the student and our department for the student to register for the full 12 credits each fall and spring semester. Consequently, students should register for the appropriate number of research credits that when added to the credits associated with courses the sum is 12. During the summer, graduate students should register for one credit of course work to remain full-time (GCH Section 3.2). Normally this credit will be in AGRON 599 or 699. If a graduate student is registered for more than one credit, then *additional* summer tuition will be assessed. In the semester of graduation, graduate students must be registered for at least one credit (GR ST 681B if no coursework is needed) (GCH Section 2.1.5).

Please see the DoA website for information regarding annual reviews, grievance procedures, and assistantship policies.

4.3 Program of Study and Program of Study Committee

The academic courses used to satisfy requirements for a graduate degree are listed on the student’s Program of Study (POS). The POS must be approved by the student’s POS committee which is made up of at least three faculty at the MS degree level. Two of these members must be faculty in the AMG (see Section 5). At the PhD level the POS committee must have at least five members: three of these members must be faculty in the AMG and at least one member must come from outside of the DoA. An “outside member” will provide a different perspective and serve as an intermediary between the POS committee and the Graduate College. The POS committee members can be tenured or non-tenured but each must be members of ISU’s graduate faculty. The chair of the POS committee is called the “major professor” and is the student’s adviser. The student and the major professor work together to assemble the POS and to choose the POS committee. For more information on the POS and POS committee, including edits to the POS committee, see the GCH.

Only one course must be included in the POS, AGRON 698 (Agronomy Teaching Practicum). It is well known that teaching can improve and polish important disciplinary concepts and communication skills. Hence all students in the AMG must have at least one teaching experience documented via AGRON 698. The *recommended* level of teaching at the MS level is to help with one course in one semester (either the fall, spring, or summer) each year. The level of involvement in teaching at the PhD level will depend on the career goals of the student, the source of funds supporting the student, and the teaching needs of the DoA.

Students are *strongly encouraged* to include the following courses in their POS:

- AGRON 505 (Environmental Biophysics);
- AGRON 577 (Soil Physics);
- one or more modeling courses, such as: MTEOR 508 (Numerical Weather Modeling); AGRON 518 (Microwave Remote Sensing); AGRON 525 (Crop & Soil Modeling); MTEOR 516 (Hydrologic Modeling and Analysis); MTEOR 552 (Climate Modeling); or AGRON 677 (Advanced Soil Physics);
- AGRON 605 (Boundary Layer Meteorology); and
- a course in statistics (STAT 587 is recommended).

Table 1: Timing of some courses relevant to agricultural meteorology.

<u>Fall (even years)</u>	<u>Spring (odd years)</u>	<u>Fall (odd years)</u>	<u>Spring (even years)</u>
AGRON 525	AGRON 505	AGRON 525	MTEOR 508
AGRON 677	AGRON 577	AGRON 605	AGRON 518
	MTEOR 516		AGRON 577
			MTEOR 552

See Table 1 for when these courses are normally offered.

There are some restrictions on the type of courses that can be included in the POS. One of the most important is the following. Only up to 9 credits of 400-level courses or up to 3 credits of 300-level and 6 credits of 400-level courses may be included on the POS. If a 300-level course is listed on the POS it must be outside of the major. “Outside of the major” would be any course other than AGRON courses. Any 400-level course may be used. If a student is considering a dual-listed course (offered as both a 400- and 500-level class) that is an AGRON course for their POS, the student can take either the 400-level or 500-level version. However, the preceding rules still apply. Only the courses needed to satisfy degree requirements must be listed on the POS. Students may decide to take additional courses.

4.3.1 National Weather Service Requirements

Many students in the AMGM may be interested in working for the National Weather Service (NWS) after graduation. Please be aware of these requirements for many NWS positions.

1. At least 24 semester (36 quarter) hours of credit in meteorology/atmospheric science including a minimum of:
 - (a) six semester hours of atmospheric dynamics and thermodynamics;
 - (b) six semester hours of analysis and prediction of weather systems (synoptic/mesoscale);
 - (c) three semester hours of physical meteorology; and
 - (d) two semester hours of remote sensing of the atmosphere and/or instrumentation.
2. Six semester hours of physics, with at least one course that includes laboratory sessions.
3. Three semester hours of ordinary differential equations.
4. At least nine semester hours of course work appropriate for a physical science major in any combination of three or more of the following: physical hydrology, statistics, chemistry, physical oceanography, physical climatology, radiative transfer, aeronomy, advanced thermodynamics, advanced electricity and magnetism, light and optics, and computer science.

Many AMGM students have earned a BS in meteorology, however, it is possible that a specific BS degree may not meet all of these requirements. If it is possible that an NWS position would be attractive in the future, students should consider courses that allow them to meet these requirements.

4.3.2 Interactions with POSC

The responsibilities of the POS committee (POSC) are specifically listed in the GCH and will not be repeated here. However, there is one additional requirement imposed by the AMGM and two things worth repeating.

First, students in the AMGM must meet with the entire POSC at least twice in the case of an MS degree, and at least three times for a PhD degree. Besides the final oral examination (see Sections 4.4.1, 4.4.2, and 4.5.3) and another for the preliminary exam in the case of the PhD (see Section 4.5.2), an additional meeting must be held near the beginning of the graduate program. At this meeting the student will introduce the area of research to be pursued, potential research questions and methods, and a proposed POS. The committee can at that time critically evaluate the plans and make suggestions.

Second, the major professor is unquestionably the student's primary point of contact, but it is wise for the student to periodically update the other POSC members in order to avoid surprises during the final oral defense.

Finally, it is critical that the student and major professor have a good working relationship. If this relationship is not functioning properly, then both the student and major professor should ask the other members of the POSC for help and support. If this step does not improve the situation, then the director of graduate education (DOGE) should be contacted.

4.4 Master of Science

According to the GCH the general requirements for an MS degree include:

- a minimum of 30 credits from academic courses and research activities;
- at least 22 credits earned at ISU;
- at least two-thirds of earned credits related to the major; and
- completion of a final oral examination.

Both non-thesis and thesis options for an MS degree in agricultural meteorology are available.

At the first POS committee meeting the student must also present a short written report on how the proposed research will help them master the Enduring Understandings (Section 2).

4.4.1 Creative Component

If the non-thesis MS degree is chosen, then the student must:

1. register for at least two credits of AGRON 599A (Creative Component, Agricultural Meteorology) that will be used to complete a "creative component;" and
2. pass a comprehensive final oral examination.

The creative component is work that presents "substantial evidence of individual accomplishment." The POS committee, led by the major professor and with input from the student, will specify the creative component, how it will be documented, and how it will be evaluated. The POS committee also has flexibility in determining the format of the final oral examination. However, it must include an evaluation of the student's mastery of the Enduring Understandings (Section 2). This evaluation could, for example, have the student point out how different aspects of the creative component show mastery of the Enduring Understandings.

4.4.2 Thesis

In the thesis option the student must:

1. pursue a research project culminating in a written thesis; and
2. pass a comprehensive final oral examination.

The thesis will be completed under the guidance of the major professor. A minimum of three research credits of AGRON 699 must be listed on the POS to account for work on an MS thesis. Normally several more credits of AGRON 699 are part of the POS. Students should sign up for these research credits to an extent appropriate for the amount of time that will be spent each semester conducting research. Typically one research credit corresponds to roughly four hours of research work per week. The thesis must detail how the research resulted in student mastery of the Enduring Understandings (Section 2). The thesis is submitted to the POS committee prior to the final oral examination. During the final oral examination, the student will present and defend the thesis before the POS committee. The presentation (also called the “exit seminar”) is open to the general public. The exam must also include an evaluation of the student’s mastery of the Enduring Understandings.

4.5 Doctor of Philosophy

The general requirements for a PhD degree include:

- a minimum of 72 credits from academic courses and research activities;
- at least 36 of these credits earned at ISU;
- completion of a preliminary oral examination;
- a written PhD dissertation; and
- completion of a comprehensive final oral examination.

Note that the 72 credits can include credits earned in pursuit of an MS degree. If an MS was earned at another institution, those courses earned at the other institution can be listed along with the ISU courses, but only if the POS committee determines that the courses are appropriate. It is in this case that the “36 credits at ISU” requirement becomes relevant.

4.5.1 Qualification Exam

A *qualification exam* can be used to evaluate whether a student has mastered certain core disciplinary information and is therefore qualified to pursue a PhD. The Graduate College suggests but does not require that a graduate major administer a qualification exam. The faculty of the AMGM have decided that students must take and pass a qualification exam once the student has declared the intention to pursue a PhD. The qualification exam must be passed before taking the preliminary exam. All AMGM faculty and graduate students are strongly encouraged to attend the qualification exam. The goals of the qualification exam are the following.

ensure student mastery of Enduring Understandings The qualification exam is used to determine whether or not the student has mastered the Enduring Understandings (Section 2).

develop student communication skills It is imperative that students be able to communicate effectively, both in the spoken and written word. The qualification exam is designed to provide another formal opportunity for the student to improve their communication skills.

encourage student-faculty and student-student interaction Students often receive the vast majority of mentoring from the major professor. While this is extremely important, mentoring from other faculty in the AMGM who are not members of the POS can also be valuable. While many students will take one or more classes from other faculty members, there are some faculty that will not have much contact with the student. The qualification exam is another opportunity for student-faculty interaction. Furthermore, other students in the AMGM can benefit from participating in the qualification exam through the discussion that will reveal the essence of agricultural meteorology. By participating in the qualification exam of other students, students will be better prepared for their own oral examinations and potential qualification exams.

ensure quality The faculty have the responsibility to ensure the quality of the AMGM. One way to do this is to only allow students that are able to master the Enduring Understandings to continue in the major.

provide opportunities for faculty engagement Faculty in the AMGM should remain active in the major. Members who do not have students in the major or who are not serving on the POS committee of students in the major can remain active by participating in the qualification exam.

continuous evaluation of the AMGM The qualification exam provides an opportunity to think carefully about what it means to be a competent scientist in agricultural meteorology. The faculty should regularly review how the educational and training programs in place address these competencies and how these competencies are being assessed. One way to do this is through periodic critical reviews of the major's Enduring Understandings (Section 2) which can occur during the qualification exam.

The format of the qualification exam is as follows. The student will produce a written report that demonstrates their knowledge of the Enduring Understandings. A student should work closely with their major professor to integrate the subject of the report with the student's proposed dissertation research. The report could take many forms. Examples include: the report of an independent study or course project; an initial draft of a chapter of the proposed PhD dissertation; or the draft of a paper that has or will be submitted to a scientific journal. If the student has come from another university the report must present research completed at ISU and not at the previous institution (such as an MS thesis) so a complete assessment of the student's own capabilities can be made. This report will be submitted to the faculty of the AMGM for review. The student will then make an oral presentation to faculty and students in the AMGM that summarizes and defends the written report. The oral presentation must also include a discussion of the relevance of the Enduring Understandings (Section 2) to the student's research program.

After the oral presentation, the faculty of the AMGM will meet to determine whether or not the student passed the exam, and whether the student can re-take the exam if the student failed. A quorum for the vote is defined as follows: the number of AMGM faculty must be greater than the number of AMGM faculty serving as the student's major professor(s); and one of the AMGM faculty present must be the DOGE. Specifically, if the student has only one major professor, then there must be at least three total AMGM faculty and one must be the DOGE. If the student is being co-advised, then a minimum of five total AMGM faculty must attend and one must be the DOGE. The faculty

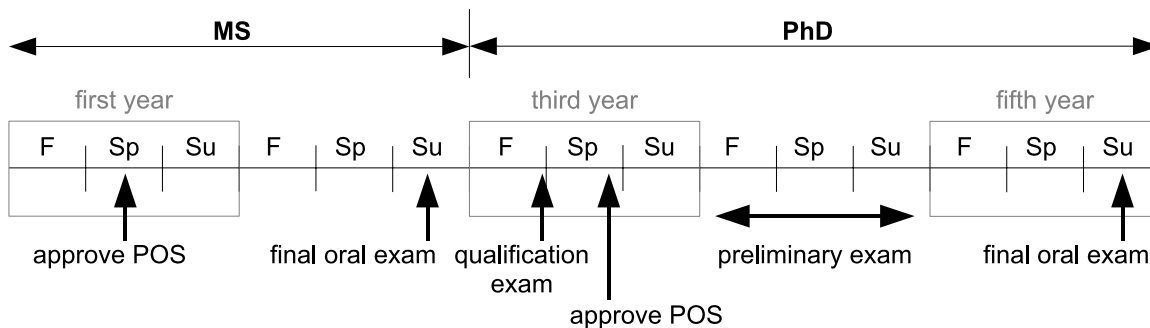


Figure 1: Timeline for the completion of consecutive MS and PhD degrees. F = fall semester, Sp = spring semester, and Su = summer.

will provide written feedback to the student, suggesting areas where improvement is needed and a course of action. The qualification exam can be taken only two times during a student’s graduate career at ISU. The faculty will also evaluate the entire curriculum of the AMG (and especially the Enduring Understandings in Section 2) in light of the results of the qualification exam.

If a student who had entered the PhD program without an MS degree takes the qualification exam and fails the exam, the student can: take the qualification exam again, if so allowed by the faculty; or continue their graduate career in pursuit of an MS degree. In the latter case, the student could take the qualification exam one more time after an MS degree has been completed.

Once a student passes the qualification exam she/he is now called a “PhD candidate.” While there is little (if any) functional difference (e.g., tuition) between PhD students (students pursuing a PhD in a graduate major who have not yet passed the qualification exam) and PhD candidates, the title is significant.

4.5.2 Preliminary Exam

The preliminary exam consists of a defense of the student’s proposed dissertation research to the POS committee. The exam consists of both a written (report on proposed dissertation research) and an oral (presentation and defense of proposed dissertation research) portion. If the student fails the preliminary exam, the POS committee must also decide if the student can re-take the exam. The preliminary exam can only be taken twice.

4.5.3 Doctoral Dissertation and Final Oral Exam

A minimum of three AGRON 699 credits are required for the PhD dissertation. Normally 20 or more 699 credits appear on the POS. The student presents and defends the dissertation during a comprehensive final oral examination. The dissertation presentation (also called the “exit seminar”) is open to the general public. At the end of the exam, the student may choose to critically examine the Enduring Understandings and advocate for either modification, addition, subtraction, or maintenance of the current list.

4.6 Timeline for Graduate Degrees

A timeline for the completion of consecutive MS and PhD degrees is shown in Figure 1. A timeline for a student who has completed an undergraduate degree and intends to pursue a PhD degree, but does not intend to pursue an MS degree, is shown in Figure 2. The first timeline assumes that two

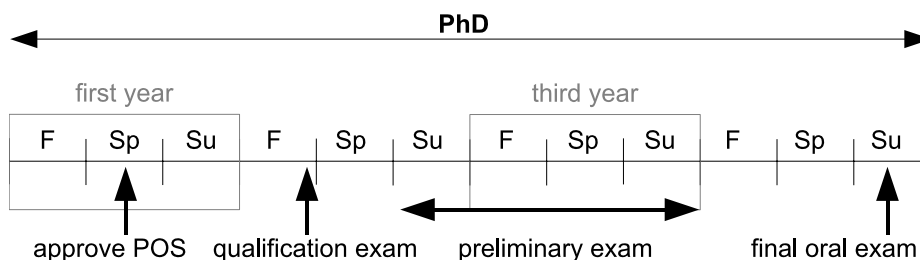


Figure 2: Timeline for the completion of a PhD degree without a prior MS degree. F = fall semester, Sp = spring semester, and Su = summer.

years are needed to complete the MS, three years to complete the PhD, and the graduate program is initiated at the beginning of a fall semester. The second assumes four years are needed to complete the PhD. Actual timelines will vary from student to student for various reasons. Figures 1 and 2 are meant to be used as guidelines: the events should occur within the semester indicated, but the AMGM does not impose specific deadlines. On the other hand, there are some deadlines enforced by the DoA and the Graduate College, such as the approval of the POS by the end of the second semester.

If a student enters ISU with the intent to earn a PhD and has not yet earned an MS, the student can either complete an MS degree first before completing the PhD degree, or immediately pursue the PhD. Many students will benefit from the experience of completing an MS thesis. At the MS level the topic addressed in the thesis is in most cases established by the major professor. The student conducts research on this topic with a significant amount of supervision and guidance. At the PhD level the dissertation should contain research questions and hypotheses that have been formulated by the student. In this case the major professor works with the student to make sure the questions and hypotheses are consistent with the resources that are available to conduct the research.

Specific deadlines *not* discussed in this document include: the completion of the final exam (GCH); and the date after which courses may not be listed on the POS (GCH).

5 Faculty in the Agricultural Meteorology Graduate Major

The faculty of the AMGM are: S. V. (Sotirios) Archontoulis; W. A. (Bill) Gallus, Jr.; W. J. (Bill) Gutowski; J. L. (Jerry) Hatfield; B. K. (Brian) Hornbuckle (DOGE); F. E. (Fernando) Miguez; D. P. (Dennis) Todey; A. (Andy) VanLooche; and I. N. (Ian) Williams.

Appendix

A Admissions Criteria

The AMGM voted on February 11, 2022, to not require the Graduate Record Examination (GRE) for admission. A growing number of graduate programs at ISU and other universities have also dropped the GRE requirement (*Langin, 2019*).

Miller et al. (2019) investigated the relationship between GRE scores and the completion of the PhD for 27 physics graduate programs. The following data were collected for the years 2000

to 2010: undergraduate GPA, GRE Quantitative score (GRE-Q), GRE Verbal score (GRE-V), the GRE Physics Subject Test (GRE-P), graduate GPA, whether the PhD was earned or not, the start and finish years, demographic information, and the NRC rank of the graduate program. They found that, of the data collected, program rank was the strongest predictor of PhD completion. The higher the program rank, the more likely it was that students would complete the PhD. They also found undergraduate GPA to be the best admissions predictor of PhD completion, and noted that admissions committees should realize that, on average, public university GPAs are about one-third of a letter grade lower than private universities (Rojstaczer, 2019). Miller et al. (2019) found no significant relationship between GRE-V or GRE-P and PhD completion when considering all students. Undergraduate GPA and GRE-Q were about equally predictive of PhD completion, with, of course, significant uncertainty. For example, the 95% confidence interval for the probability of PhD completion for a male student with an undergraduate GPA of 3.0 ranges from 0.39 to 0.82 with a mean value of 0.63. For a female student the range is 0.31 to 0.78 with a mean value of 0.56. For an undergraduate GPA of 4.0 this interval is 0.51 to 0.91 for males (mean of 0.77) and 0.42 to 0.87 for females (mean of 0.70). Similar ranges were found for GRE-Q scores. The authors warn against the use of minimum cut-off scores because: test anxiety is real; the test is not gender or race neutral; preparation for the GRE has an impact on performance (and not all students are mentored properly to prepare); the test is a single data point collected on a single day; and the standardized format of the exam is not well-aligned with what students will actually do in a PhD program. They believe research excellence is a function of mentoring, experience before and in graduate school, and other factors such as initiative, conscientiousness, accurate self-assessment, and communication skills.

In order to best evaluate the application materials of potential graduate students, faculty in the AMGM are encouraged to consider *all* of the following factors.

- Undergraduate record, which includes both overall GPA, curriculum relevance and rigor, the trend in GPA over the student's academic career (e.g., did it improve after a rough start), and the reputation of the undergraduate institution.
- Letters of recommendation.
- Previous research experience through, for example, independent study, honors projects, or summer programs.
- GRE-Q and GRE-V scores, if provided.
- A personal statement that illustrates the student's motivation for pursuing a graduate degree.
- Leadership skills, potentially illustrated in extra-curricular activities.

B Charles N. Brown, Sr. and Verna H. Brown Scholarship

Charles and Verna Brown both graduated from Iowa State University in 1924. Their children and spouses, all Iowa State graduates, established the Charles N. Brown, Sr. (ISU '24) and Verna H. Brown (ISU '24) Scholarship in their honor. Students who receive this scholarship must meet the following qualifications.

1. The student shall be a citizen of, or a permanent resident of, the United States. (A foreign student who plans to remain in the United States could qualify.)

2. The student shall be pursuing a graduate degree in agricultural meteorology.
3. The student shall provide, for the judgment of the scholarship committee, evidence of academic and research ability to achieve a degree in agricultural meteorology.

A qualifying recipient may receive the scholarship more than one time.

Each year earnings from the scholarship endowment will be distributed among all of the current qualifying graduate students in the AMGM, before the start of the spring semester. Qualifying students are those who, by December 1 of the previous year, have:

- either an approved POS (MS students), or passed the qualification exam (PhD students);
- will be a student in the AMGM that year; and
- wrote a thank-you letter if they received the scholarship previously.

Scholarships for PhD candidates will be one-third higher in amount than other qualifying graduate students. The funds can be used for anything related to graduate work. For example, they could be used for student fees, or travel, or a new computer, or an instrument, or specialized training. The thank-you letter to the Brown family must describe how the funds were used. The faculty of the AMGM can decide, based on the thank-you letter, whether a qualifying student will receive the next scholarship disbursement. A student who does not receive a scholarship one year will be included in the scholarship disbursement the following year as long as they meet the above criteria.

References

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