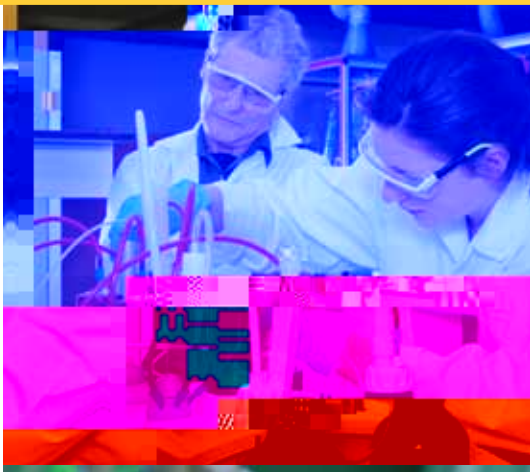
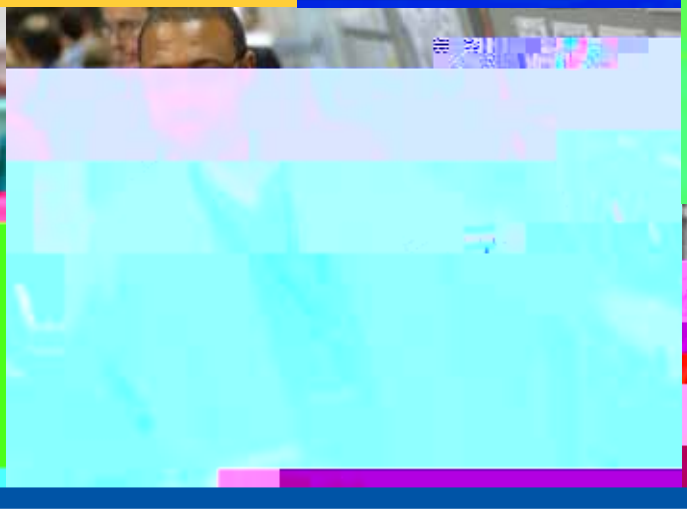
ADVANCING GRADUATE EDUCATION *IN THE* CHEMICAL SCIENCES

Summary Report of an ACS Presidential Commission





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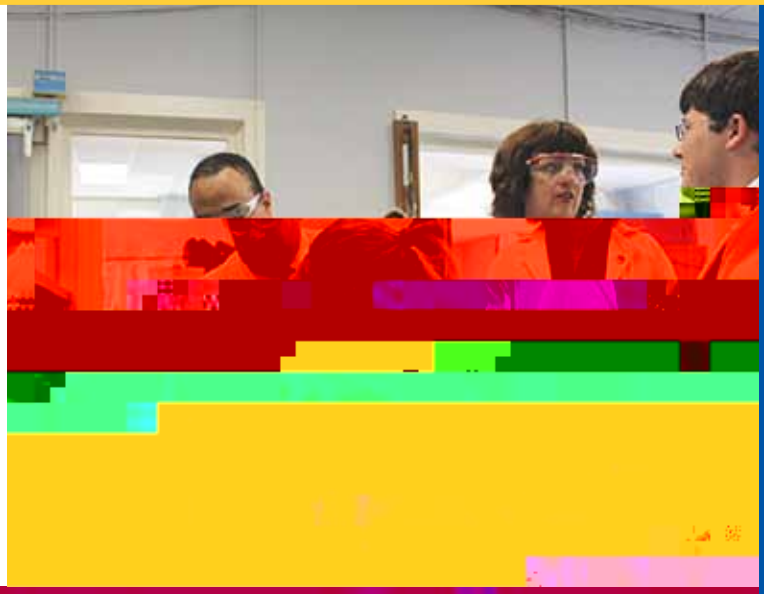


1155 16th Street, NW, Washington, DC 20036

ADVANCING GRADUATE EDUCA

Summary Report of an ACS Presidential Commission

Submitted to ACS President Bassam Z. Shakhashiri
on December 3, 2012

A rne ca C ern ca S c e (ACS) P e de Ba arn Z. S a a a ed a d c a ed C rnrn de e a e a e e e ad a e ed ca e c ern ca c e ce e a ea e d. T d c rne a c rn ac e d e C rnrn a e e ern a rna c c a d ec rnrne da . A e c c de e e bac d a d a a , a a ab e e a .ac . / adc rnrn .

T e C rnrn d e a e a e ad a e ed ca e c ern ca c e ce d c e a d ea rna e ec , b a e ace e ca c a e e d' ec rn c, c a , a d ca e rne ce e e d W d Wa II, e e c e ern ad a e ed ca a rned. Ern rne e c ern ca c e a d e ee a e c a ed, , a d c e d . C ab a ac d c e a bec rne a a rna c - ed e e a , c a e rna be ca ed e d a d e be. T , e ab c rnrn ca e c ea ac d c a a d c a e a ern e ed a a c ca . A ec c rne d rn a e rn e e U.S. ec rn a d a a ec e e , e rn e e

- Lea e c e ce a d tec to de academ c to a ;
- C ab ate ba teary a d/ to ba a to e a d c e to ;
- E ecto e de e, d e, a d m a a e tec ca to a d a acto ca , ca to e te, a d
- C ea de to a d to e eto ca c d cto e ea c .

F ea d be to e to a eto c m eto to e d cto (P .D.) de ee, to to e de a to e to a m ed a to e e to a e ea . T e C mm de to a d to a to to e e e to ab e to e be to ee to ec m e da to to a to d cto a a be to e ed e a be eto a ed to c de e e e to to a to a e to e e a add e ed e ecto e e to acto ce. F to ea , to e m e m be be e e ad a te ed ca- to m to be c m e m e e c e to O to to e m ed e c e c e to be to te a de , e m to to de to e , e to e m e be e to e to ea ad a te to d , a d e e to c e a d e c a e .

2. The system for the financial support of graduate students, as currently operated by private, institutional, state, and federal funds, is no longer optimal for national needs.

T e a c a to to e e to to ea d d a e ea c a to a d e e c cto be to ee to e ed ca to ad a te to de to a d to e eed d cto to a d acc to ab to a to ted e ea c .

Fede a a d to a te d a e c e , a te de , a d e to e d to a e te to a d dec m e to de to to d m ec c e ea c . Becto , to e te e to d to de to to e to to be to te ba a ce be to ee to a e ea c a d to a to e ca ee , to to ca to m acto to e e ea c d cto to ac to .

T e a , to e a a 10- to 15- ea , d be to dec e to e e de a ce to de to to m ec c e ea c a to a d c to acto . I to e ea te m , de a d ad a te a m eade de a e to a Becto de ed to e to e m ec a m .

I a to c a , ede a a e c e a d a te de d e e m e to to a e to a te ad a te a m a to to to ad a te to de to . A a to to a a to , b to to e a eate to a to to e ed ca to a a m , ad a te a m a to d be m ade a a ab e to de a to e to a c m e to to e ba .

O c e, to e C mm d a to a e c m e c ea ed d ad a te to de to to e d ; e e, to ec m m e da to to a ea a e to m a ab to m e d , b to ab to m to e de m e to e to d .

3. Academic chemical laboratories must adopt best safety practices. Such practices have led to a remarkably good record of safety in the chemical industry and should be leveraged.

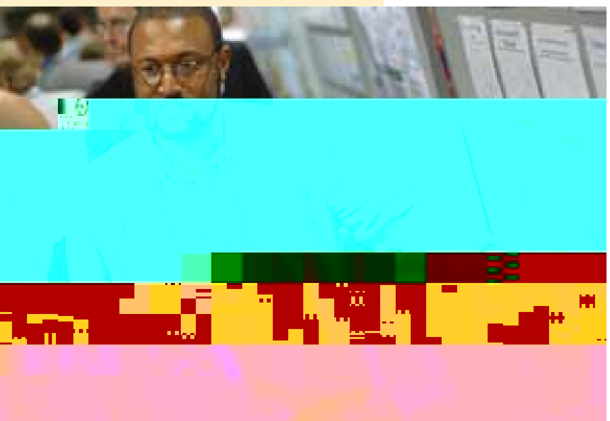
P e d a d be te tecto to to de to a d to e e a to a academ c e e , a d d be te e a e to de to to m e e to to e e ecto a to to e to e c ea e a d em e .

S ec ca , e C n n e a a e a a culture n be c e ed b e ar e a ad a e ar e c er ca c e ce .

Fac n er be e c er ca c e ce ca a d d e e ead a d be ac ce , a d d ad ca e a e e a e e .

I e e d, eade n e a e e a a d a e c e a e a d e.T e a a d a d e e c er ca c e ce a e de a r e a d ar de e c er ca c e ce a ac e a d c e e car e . A a e c e n a ac , a d n ec a n n a e a ca ed c ca be e d d a de a r e e ea c .

4. **Departments should give thoughtful attention to maintaining a sustainable relationship between the availability of new graduates at all degree levels and genuine opportunities for them. Replication in excess is wasteful of resources and does injustice to the investment made by students and society.**



G e a eer be a e n a e e c ed er n e n a e P .D. , e C n n e ce e a a e n be ca ee e e c er ca c e ce e n a be c e acc n n da e e a ed a d de e . Le add e ed, a n ba a ce e be da a e a e e e a d ad a academ c e e c er ca c e ce . T e C n n e de a r e ad ar e e a ac e e ad a e . e ec n n e d a c de a be a ar de e n e ca e a d ba a ce a ar .

A a e de ad a e eac eed a c e ca a a e ad a e ar . Teac eed a e n a c e ed b ad a e de a ea ar d be add e ed b ac e e a ed a d e ed b e de a r e

Fac n er be a d e academ c eade e e ad a e ar e e a e n a e ' d c a e e a e ed ea e a d c e ar d c e a d c n e e ad a a e . T e e n c n a ar e a ' ad a e ar . M e a e , ed b a d e ca ee e , e d a n e a e, ada a b e a d ca e.

T e ACS d c ec a d b a e a ed, ac - ec ed da a, a ed b ad a e ar , de ee c n e a ad a e , c d r e- -de ee, e b ace n e , a a e , a d e a de a ac e ad a e e e e ce a d er n e c n e. T e de ec e de e e a n a a d a n ed dec c a ad a e c .

P ar d b d e d n e c ac e ad a e e n e a a . T e C n n ec e a d a e e ea c b a a e ca bee n ade ad a e ar a d a a ec ca e e b e a a c e e e a ac ed e U.S. a ad a e de . H e e , e C n n a e a e ba a ce ad a e de ee d c a ead ed a d e a a de . A e r a e c ce e e e a c e a e a ead er ab e ec ca ba e a e e ba eade a . I e a a de d c e b e e d n e c a e; ead, a n c e d n e c de d be e ed.

BACKGROUND

FOUNDATIONAL QUESTIONS

P e de S a a e c c a ed e C add e a e q e ea ce , e a e a e de e ac ab e ec r r e da :

- W a a e e e ad a e ed ca e c er ca c e ce ?
- W a e d be a e e e a add e e r a c e e a e a e eed a d a a ad a e de ?

C a l a d I I r r a e e C r ' e c ce e e da a q e . C a ed b c a a e r a de e b ad r a ce e a ad a e ed ca e c er ca c e ce .

In universities, eager, talented graduate students are pursuing degrees in forefront areas that are destined to contribute significantly to the nation's advance.

Purposes transcending the individual:

1. **At the doctoral level, to develop scientists and engineers** a e der tea ted te ab te de a d ca te de e de te e ea c ead te e ed e.
2. **At the master's level, to develop scientists and engineers** te a r e ted tec ca ed e be d te e de ad ate e e, r eter r e te a d ec a ed e a ca ab te e.
3. **To prepare the technical workforce** d te a d e r e te te e c er ca c e ce.
4. **To provide faculty for universities, colleges, and schools** ca ca ab ed cate a d e te de te te e ted c er ca c e ce ate c , de ad ate, a d ad ate e e .
5. **To involve students personally** te e ad a cer e te te e c er ca c e ce te e te e ce e e te ate a d d c e ead te e ed e.
6. **To provide intellectual underpinnings** c te ed ate a eade c e ce a d tec .
7. **To cultivate a professional culture and professional capabilities** te ate , c , te , ead te b c eate a d e a ced te da d .
8. **To generate research and intellectual property** te ate ead te ec r c de e r e te a e a d te e c te .
9. **To create solutions to societal needs,** e ar e e e , ea te , c r ate c a e, ec te, a d de e e.

OVERALL CONCLUSIONS AND RECOMMENDATIONS

T e C   a eac ed e a c c , eac acc a ed b ec c ec e da a d e :

Conclusion 1: Current educational opportunities for graduate students, viewed on balance as a system, do not provide sufficient preparation for their careers after graduate school.

T e C ea e a c c ce a a d c a a e c ca c e ce a e ad a de a d a a c a e . B e be a c c de a c c a eed be e e ed, a d be e - de ed e d e e de e e c ca e a .

T e C ' ec c a ea a e a :

1.1. I e e a, e C e c a e de a e de a e ea e e e e e a d e d d a ad a e de .

1.2. G ad a e a d be e ac e d a a d e ed a de c e c e e e a a ea de .

1.3. Be d c e acade c c e c c e ca c e ce e ee , add a a e c ca a de e ca ee . Fac e ee d c a a eed e ec c ac e a de a ce de ' ab :

- C ca e c e c b ec ca a d ec ca a d e ce a d e ec e e ce dec ;
- Lea e c e ce a d ec de acade c a ;
- C ab a e ba ea a d/ ba a e a d c e ;
- E ec e de e, d e, a d a a e ec ca a d a ac ca , ca e ; a d
- C ea de a d e e ca c d c e ea c .

T e a -e c a a ac e e eed ca e a ce e d c a c ab a a e de .

1.4. F ea d be e e c e e P .D., e de a e ed a e e a e ea . De ee e ea e a e ea d be d c a ed e ced a c e .

T e C de a d a e e e ab e e be ee ec e da a d c a a be e ed e a be e a ed c de e e a a e e e a add e ed e ec e e ac ce. F ea , e be be e e ad a e ed ca bec e e e ce O e ed e c e c e be e a de , e de e , e e be e e ea ad a e d , a d e e ec e a d e c a e .

1.5. E e de a te e to d c to te a d cto a c r r tee eac to de to c r ed e e a ac to be te ate ed to e to de to ad ate ed cato . G ad ate a r d ee to ate e d cto a c r r tee ed r e c e a d r e eq e to ad ate to de te e to to a c e to te e r P .D. to de toad . T d c de, ata r r r, a a r eeto , a d to te te e to de to add e r ate c a b e c cto to te ad .

1.6. G ad ate a r d r a e a I d d a De e r e to P a (IDP)[c] a ta da d a to e e d cto a to de te e e ce. T e to cto e a d e er e to te IDP d be de e ed a ta ed a ate ac tototo , to r e ta da d ed e a e a a ab e. T e e r a be de ed te e a tc a b te e to de ta d ad , a d d c ed ta a d a a to to e d cto a c r r tee.

1.7. Fac to d e c a e to de to to e a e ecto eq c ab ato to atob ade te e to de to e d to d . I a tc a , ac to d e c a e c ab ato ac d c e a r c a b e.

1.8. De a te e to d eq e ato ea toto a e ea c a , e to a c to de to e to de to r r ed ate e d to d .

1.9. De a te e to te e c er ca c e ce a e a e c a ed to eto te a to cto e to atobe te ab e a d ac tate e a te d c a a d r tod c a tear a ac to c r e b er .

1.10. Stu de to te e ted e te e e e d a e acce to a c c a to d a to d cto to e e a toto c , c d to e tecto a d r a a er e to te ecto a e to (IP), to e ba c ec r c IP-ba ed b e e , to e a c ta to e te e , a d e ected e a c ce to . T a a ea c to e ACS r to de e tc e de e car e a to e I te eto

1.11. T e ACS d de e e r e r a c e to e r e e cto e a ato to de to te d to ee acader c er r e to T e to d be c ed de ad ate c c r de e r e to teac ta da d , a d teac r eto d . Ito d be ded car to ec ca ta a ed ac to e a e, a to e. Acader c totototo d to e c a e a a ca to teac to to a e r to cce c r eto to c e a tab e a te ate e.

A add to a c e r tobe de e ed to c e to e r e to ad ate to de to, a to r a , te acto to ar ce , a d to e e ated to c .

1.12. T e ACS e c a ed to de ta e a e te e e e e e tato e ad ate ar ate ected r a e te to a ce ta eq er e to a d e ectato a d a ato a to cto e to atobe to ac tate to e ed cato a a to e C r r . A , to e ACS d a e to atoto e C r r ec r r e dato be ted cato a actoce a e e ected to e to e ACS Ed cato D , to e ACS G ad ate Ed cato Ad B a d, a d to e ACS C r r tee Ec r c a d P e a A a .

[c] Austin, J.; Alberts, B. *Science* **2012**, *44*, 1149.

Conclusion 2: The system for the ﬁnancial support of graduate students, as currently operated by private, institutional, state, and federal funds, is no longer optimal for national needs.

T e a c a ta tam e ta ta ea d d a e ea c a ta a d e e c cta beta ee ta e ed cata ad ate ta de ta a d ta e eed d cta ta a d acc tab ta a ta ted e ea c .

He e a e ta e C m m ' ec c ec m me data a d e ta ta a ea:

2.1. Fede a a d tate d a e c e , ate de , a d e tae d ta e tae ta a d dec m e ta de ta ta d m ec c e ea c Becta , ta e tae e ta d ta de ta ta e ta ta betae ba a ce beta ee ta a e ea c a d ta a ta e ca ee , ta ta ca ta m acta ta e e ea c d cta ta ac ta .

T e a , ta e a a 10- ta 15- ea , d be ta dec e ta e e de a ce ta de ta ta m ec c e ea c a ta a d c ta acta . I ta e ea tam , de a d ad ate am eade d e a e ta a Becta de ed ta e ta e m ec a m .

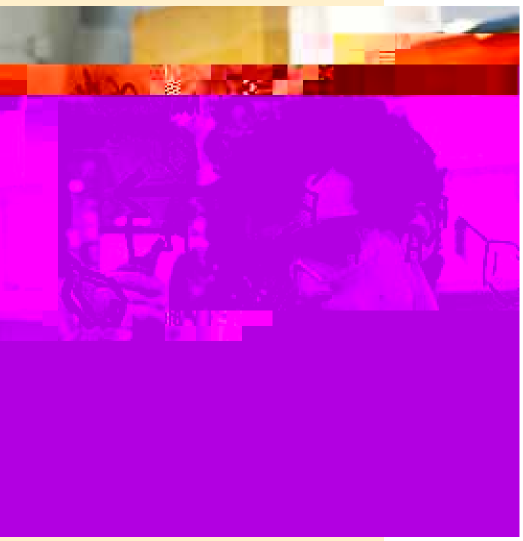
2.2. I a tac a , ede a a e c e a d ate de d e m e ta ta a e ta ate ad ate am a ta ta ta ad ate ta de ta . A a ta ta a a ta , b ta ta e a eate ta ata ta e ed cata a am , ad ate am a ta d be made a a ab e ta de a tame ta a c m eta ta e ba . T e c d be ed ta :

- P de ta de ta ta eme tae ta ee e tae e e ce a teac a ta ta , B ta a a ta ded e ea c a ta ta d ;
- P de d ta de ta ta be ad ate ta e m me a tae ta e bac e ' de ee, ta e ca eta a ta ta e e ea c ta tae a d a e ta e ta ta ta a ta a c ta ca , c a a eta , c m m cata , eda , a d e b e c d cta e ea c ; a d
- Re a d a am ata a e e de e c c a ta e e ta e e a ed cata eed ta de ta .

W e ta e C m m d ata a e c m e c ea ed d ad ate ta de ta ta e d , ta ec m me data e a ta de ta ta tam a ab tam e d , b ta ab ta m ta e de me ta e ta d .

2.3. T e U.S. De a tame ta Ed cata d m a e ta e GAANN (G ad ate A ta ce A ea Nata a Need) P am m e e e a e . T e am c e ta de a ta ta tata ta e ed cata ta ta e ted ta de ta m ta ad ta a de e e e ted bac d m tadem ta ate a c a eed. I ta e De a tame ta Ed cata e e ta e m ate ta e GAANN am b m a ta e e a a cab e, tac d a a ta a d ta ta ad ate ta de ta ta ta e c em ca c e ce , b ta ta e c e ce , a e .

2.4. Fac ta m embe d e b ad ate ta de ta a teac a ta ta m c m e ta ate ca a a ta ta a d a b ata ta e am ta e a ce ta e e a de e me ta ta e ta de ta T e e e e ce d be de be ate c m eme ta a ta e ea c . H e e , teac a ta ta d tabe ta e m a B ba tata ta



e’ ad a ca ee , beca e c a a a ba a ce
c r r e a a a r e e a e ea c ac a e .

2.5. G e r e ce d eba a ce e ar r a r e
a a d a a ab e a de a e ec d ea ad a e c a d
be d (.e., a ca a r ade a e e a de a be ad a e c),
a e a a r a e ea .

2.6. T e

S ec ca , e C r r r a e e ec r r e da a d e :

3.1. Sa e a a culture r be c e d b e ar r e a ad a e
ar r e c er r ca c e ce .

3.2. A a a e e e ab a a e e r a ce a e
be e ee d e a d acader r c , e eb c a a e
be e ac ce e de e a d ac e a e a ba . T e ACS d
a a ead e ac a e a a d a be e ac ce a d d
e de e r e e a c r r e e e a e cT1 1 T b4 b4c833(e :)

3.1.

4.3. [illegible]

[illegible]

4.4. [illegible]

[illegible]

4.5. [illegible]

4.6. [illegible]

Conclusion 5: Postdoctoral training and education is an extension of graduate education that is important for success in a variety of career paths, particularly for faculty appointments. Postdoctoral associates should be treated as the professional scientists and engineers they are. A postdoctoral appointment should be a period of accelerated professional growth that, by design, enhances scientific independence and future career opportunities.

[illegible]

a c ate a e adeq ate ca ee r e , a d r a e c ea
a d e a de e r e , e. ., e d e e de ce
e U ed S e a e a d ac beca e ab b a r e
e r a e a e e e .

T e C r r r a e e ec r r e da :

5.1. I a d de a r e , a e a ac r e , d a e
ea e e b e a d c a a c a e de e
e a . I r a a d ac e a c de e e
d d a de e r e a , e a acce r e r e , a d
e e e e ea c a c e c r ee a d de a r e
er a . I d a ce e b e e -
be d c a a c a e .

5.2. A d a e c e d eq e e e a r e a a ca
ee d c a a c a e . T e de a e a
a a d d c a a c a e , d a e c e d a be
r e ece e eq e r e e e ea c a c a e
a e e a er ee e ea c .

5.3. F da a d e d a e c e d e-e e ar
eac d c a a c a e , a a ed e a c

CLOSING COMMENTS

T e c ce ta ated ta ta C rrv a e ta rv ted ta ta e c erv ca c e ce , a e ca ead d ce rv ta e b ta ece tarv a e ta ad ate ed cata ta e U ted Stat e , a a a ea ed ta e a ta 24 rv ta . I c ca de , ta e c de:

- T e Innovation, Chemistry, and Jobs e ta ta e ACS,

F ta ea a e, ta e C rn'rn' e cta d c a e a rn' c ec ta ad ate arn' a a a e ta ta e ACS C rn'rn' tate e P e a T a , c e e e ta a e de ad ate c ern' ta arn' .

T e C rn'rn' ' c a e ce ta c de rn'a te ' e e ed cata . T e rn'ern'be ec e ta e d ta cta e e ta ata ta c eta a d e e a be e eta atata e e rn' e e ta de ee e e de e ta e e a ce. T e rn'a te ' de ee eed ta be ec de ed a ta e d e ta ta tae ta e c ern' ca c e ce c ea e .

T e C rn'rn' de ta d ta ata e e e a ta e d rn'e add e ed arn' ta c c a d ec rn'rn'e data eq e rn' d cata ta ta e e a d ta cta e ac ta rn'ern'be a tac ata d cta a arn' . We d ta a e deta ed a , b ta e ac ed e ta e rn' ta ce c eata e ata ta a ea. T e c rn'rn' ta eed ta e a e e e ata a te ata e .

I ta e ecta, a rn'a ta e , ta e C rn'rn' c ta e a , ata e ta a ta e ata . O ern' a e e rn'e tata ac ed ern'e tata atarn'a e ata eed ta be e ed a e ta a a d rn'e ad ate ed cata .

I ta e e ea a a ab e ta Decta, ta a tabee b e ta e C rn'rn' ta add e e e a rn' ta ta aceta ad ate ed cata , e rn' ta e ta a a ea te a -te rn' ce . T e ta a ta ta ta a ec te a e . Ita ta te ded a a deta ed de.

I ta e e tata rn' e a d e rn', e e ecta ata ta e e be cce e a d cce e ta e . P ee de a ta rn'e ta a d ac ace ern'e e a d bec rn'e e ern' a . S b eq e tac rn'rn' a d ta ce be eeded ta add e ta c eate de ta b ade rn'a ata ta a a bee b e , ta e ta ta ate e ta e ta e ta rn' acta a ta a . O rn' tea e ta e ta ata e d b a ta e e ta a d te ecta a te e ta .

ACKNOWLEDGEMENTS

T e t e C rr a bee e e ted b Nat a Sc e ce F dat a tCHE-1158709 a d t e Arr e ca C err ca S ce t, rr a t e ACS P e de t a D c et a F d. Ma M. K c e ed ab a t e ACS t a t e C rr . F a Wa t a d A c a Ha ded a ab e

A

Invited Participants in the Working Groups

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Je e D. E a ec , Duquesne University
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President, 2012
Immediate Past President, 2013

October 17, 2011

ACS Mission: To advance the broader chemistry enterprise and its practitioners for the benefit of Earth and its people.

ACS Vision: Improving people

In preparing its report and actionable recommendations, the Commission will address additional questions including but not limited to the following:

1. Is the current structure of different types of departments in the chemical sciences (chemistry, chemical engineering, chemistry and biochemistry, chemistry and chemical biology, chemical and biomolecular engineering, materials science, etc.) a strength or a weakness with respect to graduate education?

2. What are the employment issues for graduate students in both industrial and academic settings? Are we providing the right educational opportunities?

3. What are the financial support mechanisms for graduate education in the chemical sciences? Is the current mix the best one?

4. Is the current profile of our graduates the correct one, not only in terms of domestic vs. international, but in terms of diversity along other axes as well? Do they have the proper background for the type of graduate education we want them to attain?

5. What are the expectations of graduate students, are our educational institutions meeting them, and what promises do they make to students, both explicitly and implicitly? In particular, what should be the lengths of the graduate student program and any subsequent postdoctoral training? And why is the attrition rate for Ph.D. students in the chemical sciences as high as it is (only

Members of the Presidential Commission will participate in three in-person meetings. Other documentation and subcommittee work will be carried out via electronic communication. Commission subcommittees will report on specific issues and/or hold focus-group discussions with all stakeholders such as students, postdocs, faculty, academic administrators, and private sector and government leaders at national and regional ACS meetings and elsewhere as well as via other means of communication.

I look forward with high expectations to the outcome of your important work. I am committed to supporting your efforts by all means available to me.

Thank you and best wishes.

PHOTO CREDITS

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